



# 2016 Post Election Audits

IN MARYLAND

# Background

- The 2016 was the first year that Maryland used a statewide paper voting system.
- The voting system captured and stored images of all ballots cast in the election. This meant that the election results could be audited at a ballot level while also eliminating the need to physically handle the voted ballots.
- We piloted 3 audit methods after the 2016 primary election

## What is an audit?

- A comparison of 2 independently produced results that are derived from the same data.

## Why audit election results?

- To protect and ensure the integrity of the election process
- To verify and confirm the accuracy of the voting systems reported results
- To ensure that the voting system is accurately tabulating ballots
- To ensure that the winners of each contest are called correctly
- To increase confidence in the election results

## What types of audits did Maryland pilot after the 2016 primary election?

- Ballot level audit applying risk limiting principles – The sample size of ballot images was determined by the margin of victory in the contest and the ballot images were tabulated manually.
- Fixed percentage audit – 100% of all ballot images in 1% of randomly chosen precincts were manually tabulated.
- Independent Automated Software Audit – Relied solely on independent software to tabulate the ballot images.

# Ballot Level Audit Applying Risk Limiting Principles

- Consulted with Dennis McGrath, PhD, a statistician and professor at the University of Baltimore.
- Dr. McGrath selected the contest with the smallest margin of victory.
- Dr. McGrath used Dr. Philip Stark's publicly available tools and formulae to determine the number of ballot images to review and which ballot images to review.
- The ballot images and associated Cast Vote Records were placed into batches and were manually reviewed and tallied in teams of 2.

# Fixed Percentage Audit

- Consulted with Dr. Dennis McGrath
- Dr. McGrath applied statistical methodologies to ensure that each ballot cast in the county had an equal chance of being selected, regardless of the precinct size.
- Based on the number of votes cast by precinct, Dr. McGrath assigned a range for each precinct in each county.
- The local election officials used a ten-sided dice to roll a six-digit number and selected the precinct that fell within that range.
- Ballot images from that precinct were put into batches and tallied manually
- The total for the precinct was compared to the voting systems precinct result report.

# Independent Automated Software Audit

## Pre-Election

- Ballot PDFs were sent to the vendor for the purposes of creating the ballot definition files (oval positions)
- Voting System's zero reports by precinct were also provided to the vendor

## Post-Election

- Local election officials sent voted ballot images to the vendor
- Vendor provided the State Board of Elections the independent result reports for comparison
- State Board of Elections sent the vendor precinct level voting system result reports
- Vendor provided 4 different audit reports by county – Comparison of Cards Cast, Comparison of Ballots Cast by Precinct, Comparison of Votes Cast and Contest Discrepancy Threshold report

And?



# Ballot Level Audit Applying Risk Limiting Principles

- Is unpredictable because it is dependent on the margin of victory in any given contest.
- Is complex and requires the assistance of a statistician.
- Would be extremely difficult to implement statewide because of the highly variable number of ballot images that must be reviewed.
- The planning process cannot begin until the day after the election
- Local election officials cannot accurately budget or anticipate staffing needs for this type of audit because the number of ballot images to audit is unknown until after the election
- A close margin could necessitate an almost complete manual re-tabulation of the ballot images
- Human error required an additional review of the ballot images and the Cast Vote Records

## Fixed Percentage Audit

- Does not generate a high level of confidence because only ballot images from a single or small number of precincts are audited
- Requires the assistance of a statistician
- Is unpredictable because the size of the randomly selected precinct is unknown
- Raises the question of effectiveness and thoroughness because a small precinct (15 ballots) could be selected when hundreds of thousands of ballots could have been cast in that county
- Human errors could require a 2<sup>nd</sup> or 3<sup>rd</sup> manual review of the ballot images

# Independent Automated Software Audit

- Re-tabulates 100% of the ballot images using tabulation software that is different than the voting system
- Maximizes the use of technology in election administration (a Maryland legislative mandate)
- Requires very little resources from state and local election officials
- Can be completed prior to election certification deadlines
- Eliminates the subjective and error-prone human element
- User friendly

# What criteria guided Maryland in the selection of an audit method?

- Maximize the technological functions of the new voting system
- Minimize human error and eliminate chain of custody issues by using securely stored ballot images, rather than actual voter paper ballots
- Minimize the use of valuable staff time at the local election office in the days following the election
- Complete the audit prior to legally binding certification and swearing-in deadlines
- Be conducted at the ballot-level
- Be independent of the primary voting system

For all the reasons mentioned...

Maryland selected to use an independent automated software audit for the 2016 general election. The vendor selected to perform this audit was the Clear Ballot Group.

This audit confirmed the accuracy of the voting system and we discovered a lot more.

What additional discoveries were made as a result of the tools provided with the independent automated software audit?

# Folds through write-in area resulted in votes

<input type="radio"/> or write-in: <b>Write-in panel</b>	<input type="radio"/> or write-in: <b>Click Here</b>	<input type="radio"/> or write-in:	<input type="radio"/> or write-in:
<input type="radio"/> or write-in:	<input type="radio"/> or write-in:	<input type="radio"/> or write-in: AB1-AB1-001+742442-1.tif Choice Judge of the Circuit Court Circuit 2 Write-in Vote For 2 Party None Precinct AB1 4 - Page 1 CounterGroup AB1 OvalDensity 16.80 ZoneDensity 7.42	<input type="radio"/> or write-in: Judge of the Circuit Court Circuit 2 Vote For up to 3 <input type="radio"/> Kathleen G. Cox <input type="radio"/> Leo Wayne Dymowski <input type="radio"/> Keith R. Truffer <input type="radio"/> or write-in: <input type="radio"/> or write-in:
<input type="radio"/> or write-in:	<input type="radio"/> or write-in:	<input type="radio"/> or write-in:	<input type="radio"/> or write-in:
<input type="radio"/> or write-in:	<input type="radio"/> or write-in:	<input type="radio"/> or write-in:	<input type="radio"/> or write-in:

Note: Maryland tabulates write-in votes whether the oval is filled in or not



Official Ballot  
 Presidential General Election  
 November 8, 2016  
 State of Maryland, Baltimore County

BS 4 - Page 1

**Instructions**

**Making Selections**

Fill in the oval to the left of the name of your choice. You must blacken the oval completely, and do not make any marks outside of the oval. You do not have to vote in every race.

Do not cross out or erase, or your vote may not count. If you make a mistake or a stray mark, you may ask for a new ballot.

**Optional write-in:**

or write-in:  
 Ann L

To add a candidate, fill in the oval to the left of "or write-in" and print the name clearly on the dotted line.

**President and Vice President of the United States**  
 Vote for 1

Donald J. Trump  
 New York  
 and  
 Michael Pence  
 Indiana  
 Republican

Hillary Clinton  
 New York  
 and  
 Tim Kaine  
 Virginia  
 Democrat

Gary Johnson  
 New Mexico  
 and  
 Bill Weld  
 Massachusetts  
 Libertarian

Jill Stein  
 Massachusetts  
 and  
 Ajamu Baraka  
 Georgia  
 Green

or write-in:

**Representative in Congress**  
 District 3  
 Vote for 1

Mark Plaster  
 Republican

John Sarbanes  
 Democrat

Nnabu Eze  
 Green

or write-in:

**Judge of the Circuit Court**  
 Circuit 3  
 Vote for up to 2

Kathleen G. Cox

Leo Wayne Dymowski

Keith R. Truffer

or write-in:

**U.S. Senator**  
 Vote for 1

Kathy Szeliga  
 Republican

Chris Van Hollen  
 Democrat

Margaret Flowers  
 Green

or write-in:

**Judge, Court of Special Appeals At Large**  
 Dan Friedman  
 Vote Yes or No  
 For Continuance in Office

Yes

No

**U.S. Senator**  
 Vote for 1

Kathy Szeliga  
 Republican

Chris Van Hollen

**Judge, Court of Special Appeals At Large**  
 Dan Friedman  
 Vote Yes or No

Vote All Sides



**!**  
 Do not cross out or erase, or your vote may not count. If you make a mistake or a stray mark, you may ask for a new ballot.

**Optional write-in**

or write-in:  
 Ann L

To add a candidate, fill in the oval to the left of "or write-in" and print the name clearly on the dotted line.

Gary Johnson  
 New Mexico  
 and  
 Bill Weld  
 Massachusetts  
 Libertarian

Jill Stein  
 Massachusetts  
 and  
 Ajamu Baraka  
 Georgia  
 Green

or write-in:

**Judge of the Circuit Court**  
 Circuit 3  
 Vote for up to 2

Kathleen G. Cox

Leo Wayne Dymowski

Keith R. Truffer

or write-in:

**U.S. Senator**  
 Vote for 1

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 Republican

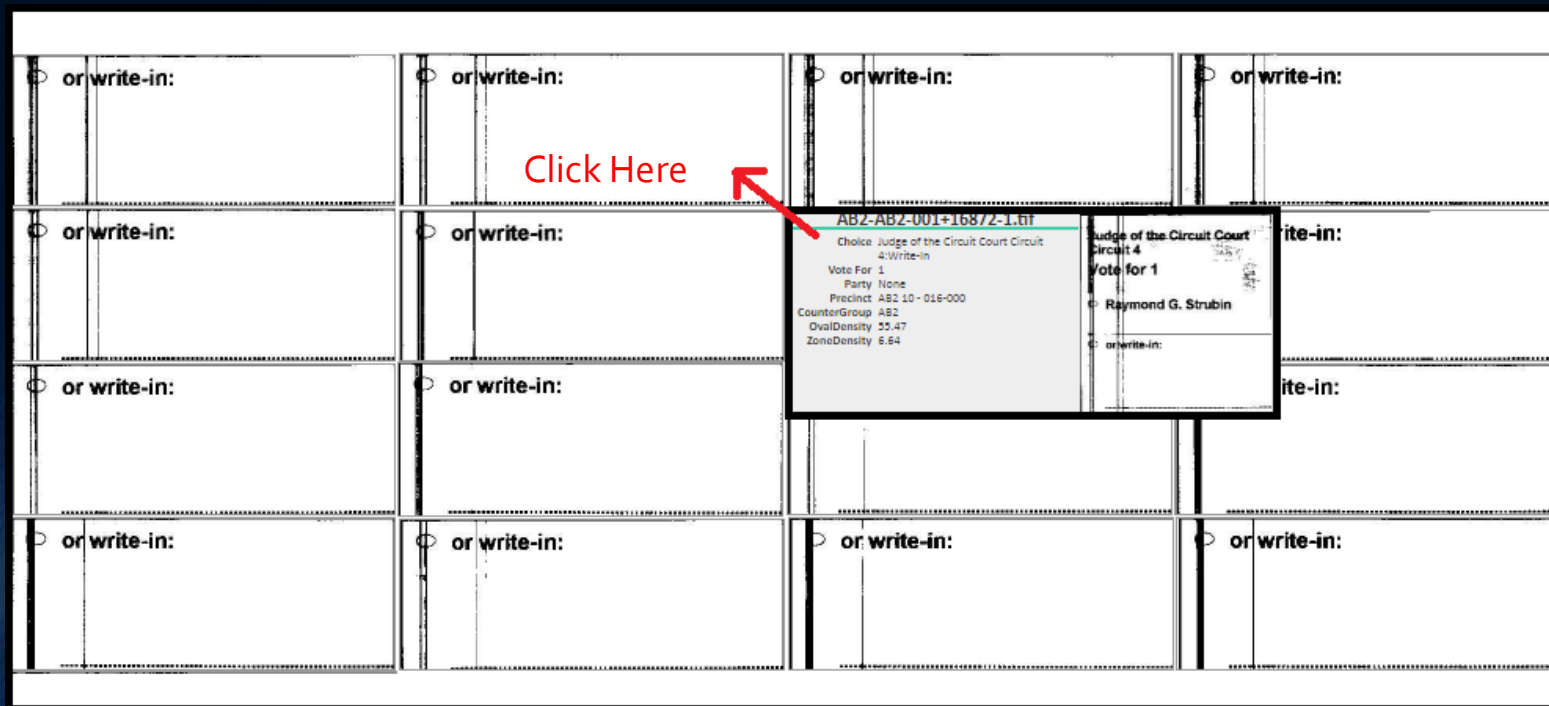
Chris Van Hollen

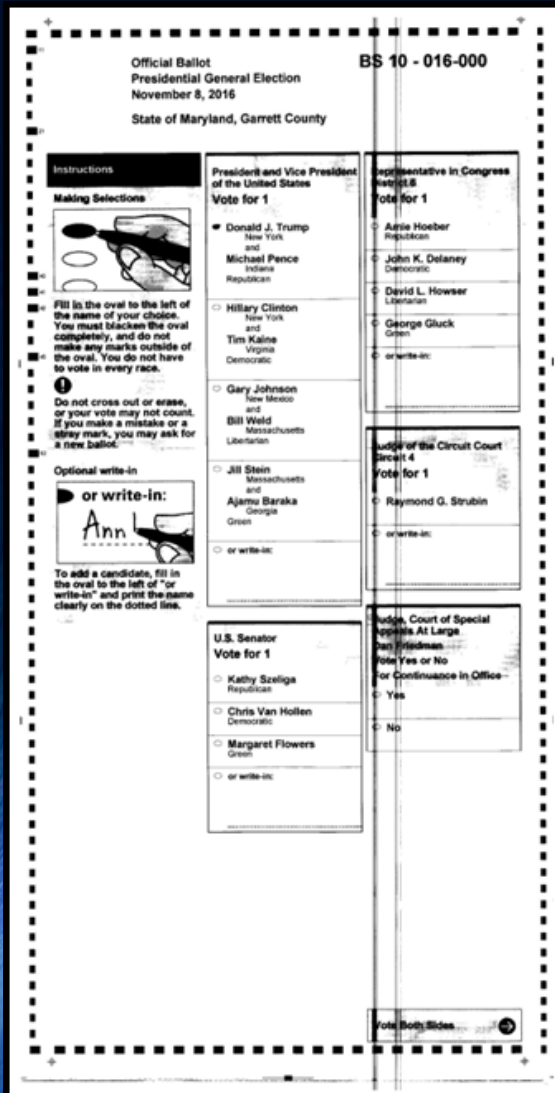
**Judge, Court of Special Appeals At Large**  
 Dan Friedman  
 Vote Yes or No

The ability to see the full ballot allowed us to see the fold clearly

This issue was identified prior to certification and was corrected

# Residue and scratches on the scanner lens resulted in overvotes





The voting systems Cast Vote Record export showed the overvotes but without the visual representation of the ballot, this issue would have been difficult to identify

Cast Vote Record	President - Vice Pres (1)	U.S. Senator (2)	Rep in Congress (3)	Judge of the Circuit Court	Judge Special Appeals A
16869	Trump-Pence (10001003.	Kathy Szeliga (10002003.	Amie Hoeber (10008003.	<i>Darrell Walters</i>	undervote
16870	Trump-Pence (10001003.	Kathy Szeliga (10002003.	Amie Hoeber (10008003.	Raymond G. Strubin (100	Yes Dan Friedman (1003
16871	Trump-Pence (10001003.	Kathy Szeliga (10002003.	undervote	undervote	undervote
16872	Trump-Pence (10001003.	undervote	undervote	undervote	undervote
16873	Trump-Pence (10001003.	Kathy Szeliga (10002003.	Amie Hoeber (10008003.	Raymond G. Strubin (100	Yes Dan Friedman (1003

The ability to see the full ballot allowed us to see the lines clearly. This issue was identified prior to certification and was corrected

# Double Pull Issues on high speed scanners

This is when the scanner picks up 2 ballots and scans them as 1

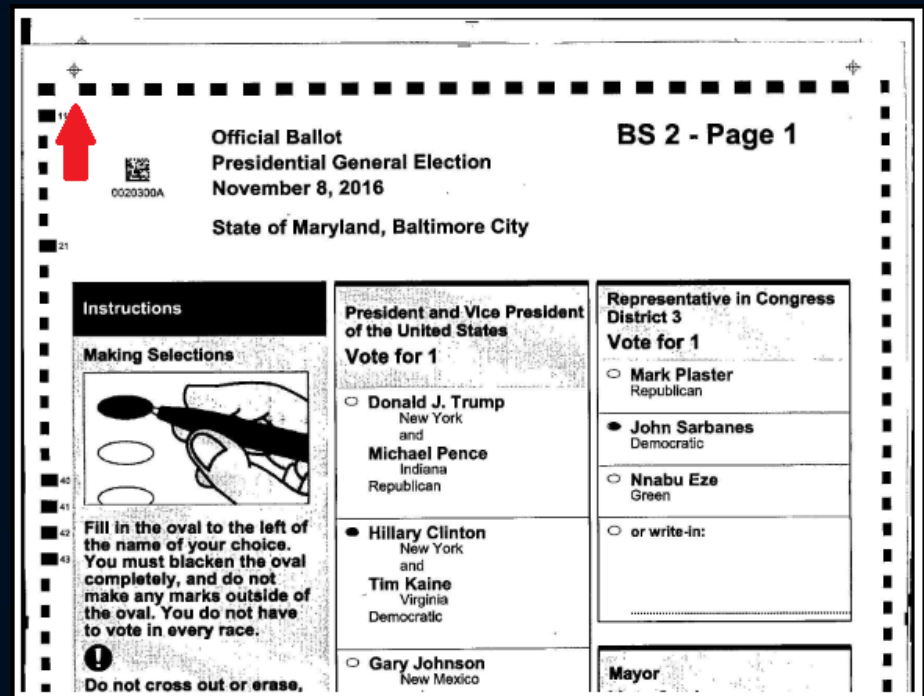
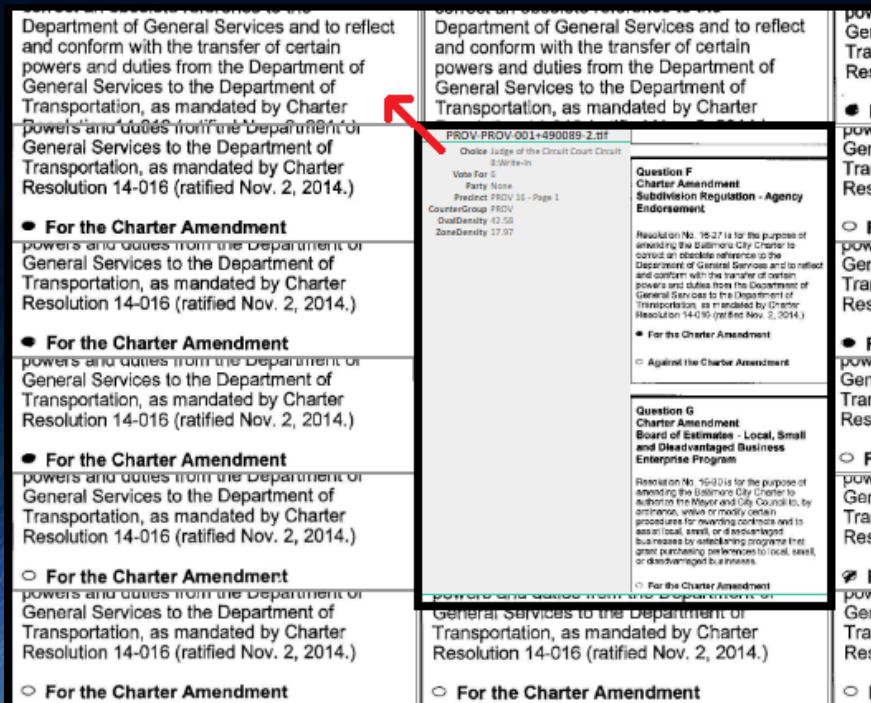
**What we expected to see when looking at write-in votes for Judge of the Circuit Court**

<input type="radio"/> or write-in:	<input type="radio"/> or write-in:	<input type="radio"/> or write-in:	<input type="radio"/> or write-in:
Department of General Services and to reflect and conform with the transfer of certain powers and duties from the Department of General Services to the Department of Transportation, as mandated by Charter Resolution 14-016 (ratified Nov. 2, 2014.)	<b>AB1 AB1 001+159233-2.HIT</b> Choice Judge of the Circuit Court Circuit 2 Write-In Vote For 2 Party None Fracture AB1 B - Page 1 CourseGroup AB1 OvalDensity 85.06 ZeroDensity 4.08	Judge of the Circuit Court Circle 1 Vote For up to 5 • Sharieth S. Arroy • Audrey J. Sylvia Cantion • Michael A. DiPietro • Karen "Chaya" Friedman • Wanda Kayes Howard • Cynthia H. Jones <input type="radio"/> or write-in: <input type="radio"/> or write-in: <input type="radio"/> or write-in: <input type="radio"/> or write-in:	powers and duties from the Department of General Services to the Department of Transportation, as mandated by Charter Resolution 14-016 (ratified Nov. 2, 2014.)
<input checked="" type="radio"/> For the Charter Amendment		<input checked="" type="radio"/> For the Charter Amendment	<input checked="" type="radio"/> For the Charter Amendment
powers and duties from the Department of General Services to the Department of Transportation, as mandated by Charter Resolution 14-016 (ratified Nov. 2, 2014.)		<input type="radio"/> For the Charter Amendment	<input type="radio"/> For the Charter Amendment
<input checked="" type="radio"/> For the Charter Amendment		<input checked="" type="radio"/> For the Charter Amendment	<input checked="" type="radio"/> For the Charter Amendment
powers and duties from the Department of General Services to the Department of Transportation, as mandated by Charter Resolution 14-016 (ratified Nov. 2, 2014.)		<input type="radio"/> For the Charter Amendment	<input type="radio"/> For the Charter Amendment
<input checked="" type="radio"/> For the Charter Amendment		<input checked="" type="radio"/> For the Charter Amendment	<input checked="" type="radio"/> For the Charter Amendment
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<input type="radio"/> For the Charter Amendment	<input checked="" type="radio"/> For the Charter Amendment	<input checked="" type="radio"/> For the Charter Amendment	<input type="radio"/> For the Charter Amendment

**What we saw when the scanner had multi-feed issues**

Hovering over the multi-feed ballots showed different contests than the one we expected to see

The ability to see the full ballot allowed us to see that more than one ballot was scanned



This issue was identified prior to certification and was corrected

What kinds of questions can be answered using an independent automated software audit that are challenging, if not impossible, to answer without one?

There is a large number of overvotes in the Presidential contest. Why would voters show up to the polls and vote for more than one candidate for President?

Contests Report

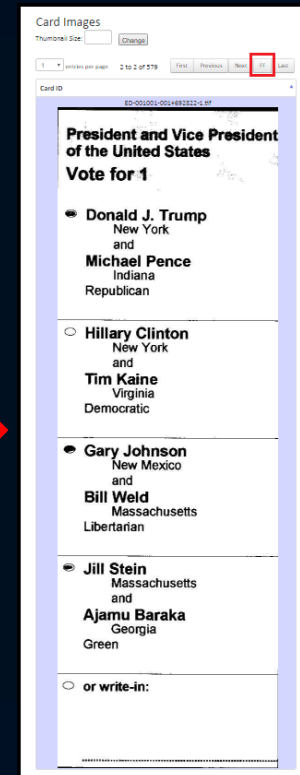
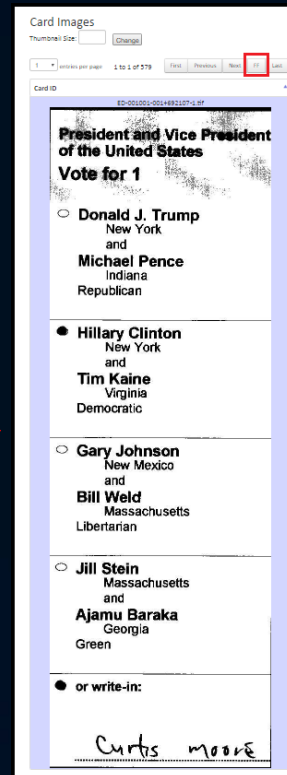
Precinct: All Counter Group: Election Day, N Box: All Change Show / hide columns

Contest	# Precincts	# Ballots	Voted	Blank Voted	Over Voted	Over Voted %	Margin	Margin %	Winner(s)
President - Vice Pres	235	234,452	232,166	1,707	579	0.25%	15,344	6.61%	Clinton-Kaine
U.S. Senator	235	234,452	229,180	5,185	87	0.04%	10,226	4.46%	Chris Van Hollen
Rep In Congress Congressional District 7	60	55,584	54,117	1,435	32	0.06%	10,695	19.76%	Elijah Cummings
Judge Of The Circuit Court Judicial Circuit 3	235	234,452	189,863	44,007	582	0.25%	26,816	9.12%	Kathleen G. Cox, Keith R. Truffer
Judge Special Appeals At Large	235	234,452	190,320	44,105	27	0.01%	107,566	56.52%	Yes Dan Friedman
Question 1	235	234,452	208,396	26,012	54	0.02%	81,302	39.02%	For The Constitutional Amendment
Question A	235	234,452	200,072	34,360	20	0.01%	104,226	52.09%	For The Proposed Charter Amendment
Question B	235	234,452	215,409	18,976	67	0.03%	119,929	55.68%	For The Bond Issue
Question C	235	234,452	212,924	21,477	51	0.02%	112,608	52.89%	For The Bond Issue
Question D	235	234,452	213,750	20,674	28	0.01%	113,184	52.95%	For The Bond Issue

10 entries per page 1 to 10 of 20

First Previous Next FF Last CSV Print Table

Contest	# Precincts	# Ballots	Voted	Blank Voted	Over Voted
President - Vice Pres	235	234,452	232,166	1,707	579
U.S. Senator	235	234,452	229,180	5,185	87



After reviewing the overvoted ballot images, we were able to determine that they were true overvotes.

There is a large number of undervotes in the Presidential contest. Why would voters show up to the polls and not vote for any Presidential candidate?

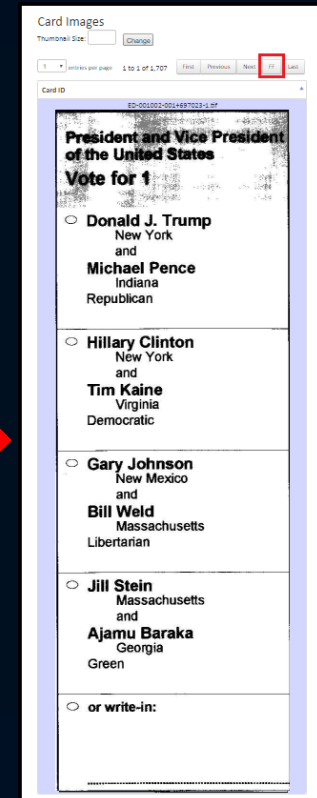
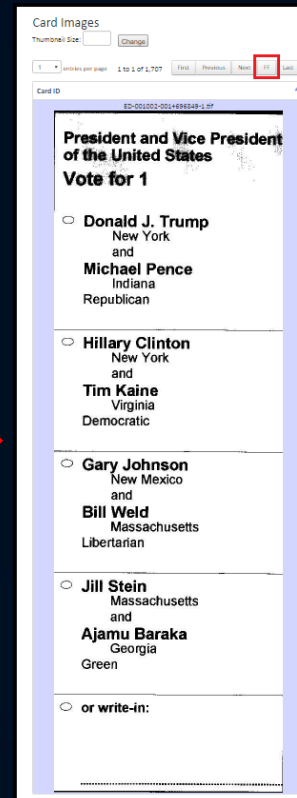
Contests Report

Precinct: All Counter Group: Election Day X Size: All

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Judge Of The Circuit Court Judicial Circuit 3	235	234,452	189,863	44,007	582	0.25%	26,816	9.12%	Kathleen G. Cox, Keith R. Truffer
Judge Special Appeals At Large	235	234,452	190,320	44,105	27	0.01%	107,566	36.32%	Yes Dan Friedman
Question 1	235	234,452	208,386	26,012	54	0.02%	81,302	39.02%	For The Constitutional Amendment
Question A	235	234,452	200,072	34,360	20	0.01%	104,226	52.09%	For The Proposed Charter Amendment
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10 entries per page 1 to 10 of 20

Contest	# Precincts	# Ballots	Voted	Blank Voted	Over Voted
President - Vice Pres	235	234,452	232,166	1,707	579
U.S. Senator	235	234,452	229,180	5,185	87



After reviewing the undervoted ballot images, we were able to determine that they were true undervotes.



There is a large number of blank ballots cast. Why would voters show up to the polls and decide to cast blank ballots?

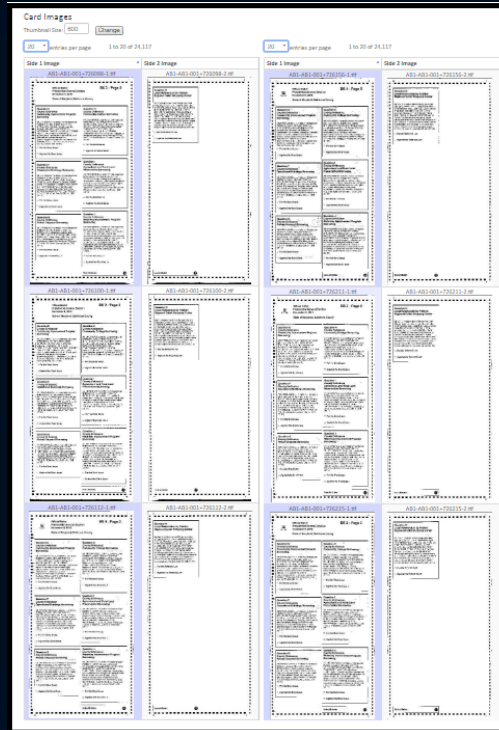
### Dashboard

#### Election Data

Election Phase	closed
Ballot type	ESS2
Approx ballot image dimensions	8.5" x 17.0"
# Card styles	14
# Contests	20
# Choices	56
# Parties	5
# Counter groups	6
# Precincts	248
# Precincts and card styles	3472

#### Ballot Scanning Operations

Scan date	2016-11-11
Tabulation date	2016-12-01
Tabulator software version	Version 1.3.2 2016-10-12 16:04:57
# Scanners	1
# Boxes scanned	247
# Precincts scanned	247 out of 248
# Cards automatically adjudicated	759,661
# Pages judged to be non-ballots	0
# Unreadable cards (3.31% rate)	26,006
# Pages scanned (ballots and non-ballots)	785,667
# Cards that are fully blank	24,117



### Drop Offs

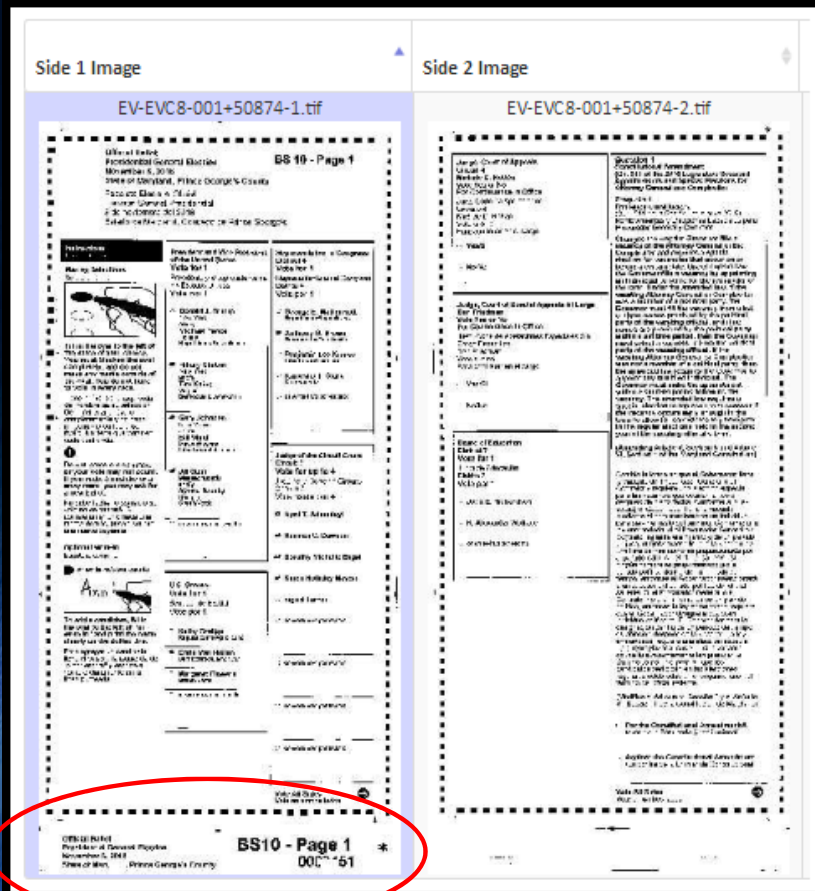
Contest	# Precincts	# Ballots	Voted	Blank Voted	Over Voted
Question 1	247	393,147	347,850	45,209	88
Question A	247	393,147	332,666	60,454	27
Question B	247	393,147	358,590	34,454	103
Question C	247	393,147	354,123	38,947	77
Question D	247	393,147	356,000	37,097	50
Question E	247	392,516	356,734	35,700	82
Question F	247	392,516	353,077	39,357	82
Question G	247	392,516	350,152	42,312	52
Question H	247	392,516	354,928	37,497	91
Question I	247	392,516	352,290	40,142	84
Question J	247	392,516	355,644	36,827	45
Question K	247	392,516	341,515	50,434	567

1st contest on page 2 →

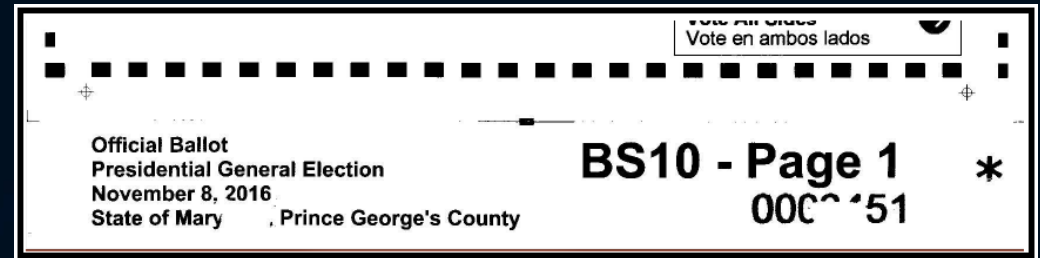
last contest on page 2 →

What else can an independent automated software audit identify?

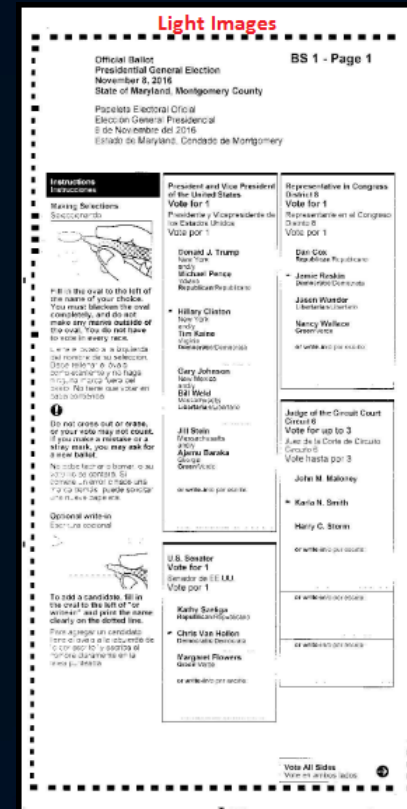
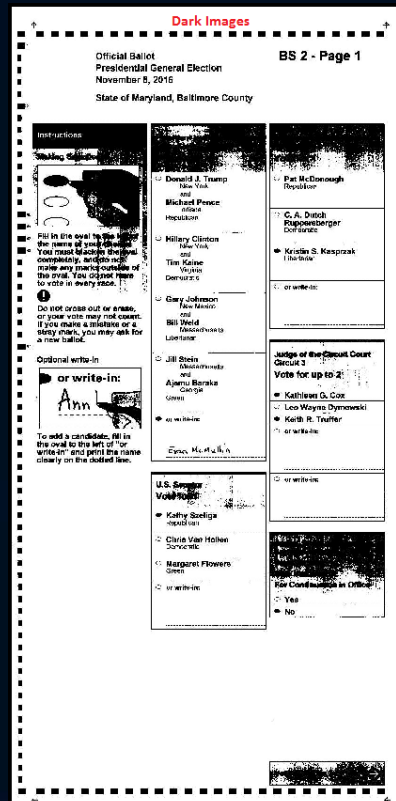
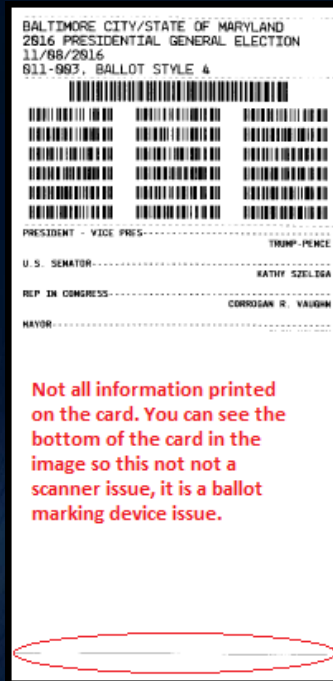
# Identify voting locations where additional poll worker training is necessary



During the review of the unreadable ballot images, the vendor discovered that the stubs had been scanned. The stub should have been removed by the poll worker prior to scanning.



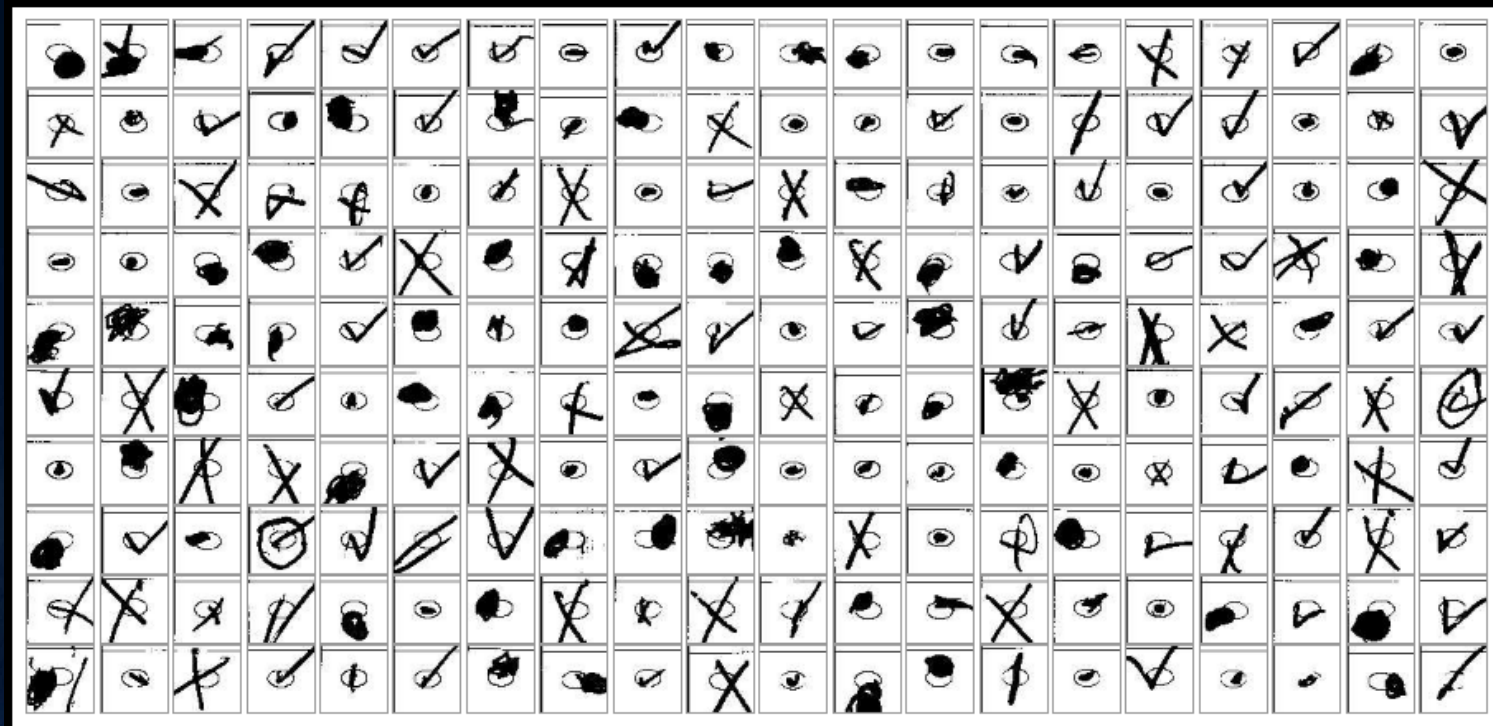
# Identifying equipment issues



These issues were discovered by the vendor during the review of unreadable ballots. In all these cases, the voting system tabulated the ballots correctly.

Anything else?

You can easily see the interesting ways that voters mark their ballots



## And...

- Helps resolve recount issues or allows for more targeted recounts
- Informs election administrators on issues with ballot design that lead to voter confusion (high percentage of voter error)
- Can assist election administrators in evaluating how certain precincts are doing

# What about the future?

- Use the technology to analyze Logic & Accuracy images to identify and address issues with voting equipment prior to an election.
- Include an algorithm that can detect ballot images that are longer than expected to programmatically identify ballots scanned with stubs and double pull issues.
- Compare the voting system cast vote records and the independent automated software audit cast vote records to identify differences at the ballot level.



Questions?