



Voting System Anomaly Root Cause Analysis Template v2.0

Root Cause Analysis for:

VV40ECT-98: OVERVOTES TRIGGERED ON SCANNERS - REV. 2
VxSUITE, VERSION 4.0 AND EAC CERTIFICATION #VXS4

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Introduction

This RCA documents investigations into unexpected overvotes detected during the standard 104 hour test of continuous operation with Element and SLI Compliance, according to test requirements VVSG 2.7-B and 2.7-C. Several hours into the test, result reports included unexpected overvote counts. An investigation explored whether any hardware or software issues could have caused these overvotes, or if it was an artifact of the test methodology itself.

After this anomaly detection, and during the 104 hour test, a change in test procedure and technical investigation into a reproduction of the issue identified the root cause: in rare cases, rescanning of previously imprinted ballots can result in unexpected overvote interpretation on VxCentralScan. The root cause analysis confirms that this issue was specific to the test methodology and not an issue that would occur during typical voting system use.

Anomaly Description

Complete all sections. Descriptions must be as detailed as possible, while being clear and concise since the anomaly is the source of the entire RCA. This detail should include a complete list and/or description of the “symptoms” of the anomaly and the conditions present which the symptoms occurred.

<u>Date of Anomaly:</u> April 8, 2025	<u>Time of Anomaly:</u> 10:15pm
<u>Place of Anomaly:</u> Element, Longmont, CO	<u>Person identifying Anomaly:</u> Tabitha Lehman, VotingWorks
<u>Expected Results of actions leading up to anomaly:</u> The 104 hour continuous operational test was expected to run with predictable known vote tallies each hour, as recorded in tally reports. No overvotes were expected, because no pre-filled hand-marked ballots had overvote marking patterns. VxCentralScan units would be able to rescan ballots without issue up to 4 times before retiring the ballots, while also imprinting identifiers on the ballots in different locations after each scan. The imprinted marks would lie in the margins outside the timing marks.	

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Detailed description of the event / anomaly:

Pre-filled hand-marked paper ballots used during the test were identified to have variable left & right printer margins due to unexpected print variability from the ballot printing supplier. Upon inspection, these ballot margins did not meet the [VotingWorks margin specifications](#) as the print variability reduced margins below the space required to imprint outside of the timing marks on ballots. The testing team identified that some ballots were imprinting unique identifiers partly over timing marks as a result of this margin inconsistency when scanning & imprinting using VxCentralScan. The testing methodology included scanning and imprinting these ballots four times, which resulted in some scanned images having imprinted unique identifiers over the timing marks. These particular scanned images with imprinted identifiers over timing marks would occasionally lead to overvotes at an unpredictable and rare rate.

This methodology is not reflective of typical system use as the following would be different in a real election:

- Ballots would have margins printed to specification to ensure that imprinted unique identifiers are not imprinted over timing marks.
- Imprinted ballots would never be rescanned (and re-imprinted).

This issue was only detected on one of the VxCentralScan units: the unit connected to Fujitsu fi-8170 with the fi819PRB imprinter and not the unit connected to the Fujitsu fi-7600 with the fi760PRB imprinter. The fi760PRB supports imprinting of wider paper than the fi819PRB imprinter – the fi760PRB can imprint up to A3 wide paper whereas the fi819PRB imprinter can imprint up to only A4. The additional supported imprinting width (in this case, up to letter width not A4 width) reduces the likelihood that the fi760PRB would imprint over the timing marks printed on ballots with imprecise margins.

If the anomaly is repeatable, provide step by step instructions to recreate it:

- Prepare ballots with smaller margins than defined in the [VotingWorks margin specifications](#), with less than 5mm of space between the timing marks and the outside edges. This is to increase the chance of imprinting over a timing mark.
- Scan and imprint a batch of up to 30 hand-marked paper ballots in the VxCentralScan unit fi-8170 with fi819PRB imprinter.
- Repeat scanning and imprinting this same batch of ballots, but oriented in different directions up to 4x (rotating 180 degrees, flipping over), to increase the chance of interpreting a repeated-imprint ballot as an unexpected overvote.
- Analyze the vote tallies and count overvotes.
- Repeat scanning new batches of ballots up to 4x as needed until issue is reproduced.

Chronology of Events / Timeline

Provide a detailed chronology of the events leading up to, and following, the anomaly. Add additional events if necessary.

ID	Date/Time	Description	Entity Org/person	Result / Notes
1	4/7/25, 8am Mountain Time	104-hour continuous operation test begins, starting according to original plans, including VxCentralScan units scanning and imprinting the same ballots up to 4x in different orientations.	Chris Pedersen, VotingWorks	No tally issues or overvote problems detected at the start. VxCentralScan had no reported issues. Issues were reported with VxMark ballots not being scanned properly with VxScan, which was resolved and is covered in another Root Cause Analysis document. The 104-hour test procedure was then updated to scan VxMark ballots with VxCentralScan 1x each, while continuing to scan the other pre-filled hand-marked paper ballots 4x each.
2	4/8/25, 12am	1st day tests and maintenance cleanings conclude. Transitions into 2nd day tests.	Tabitha Lehman, Jessica Myers, Chris Pedersen, VotingWorks	No tally issues or overvote problems reported.
3	4/8/25, 9:15pm	Overvote anomaly was reported by testing staff, and ballots were inspected for causes.	Tabitha Lehman, VotingWorks	No markings in bubbles were identified to cause overvotes. No specific ballots were found to be anomalous. It was noted that these overvotes occurred during hot cycles. To further narrow down causes, plans were made to: <ul style="list-style-type: none"> • Collect the logs/CVRs; look at the CVRs • Take the ballots and rescan on another VxCentralScan unit • Work with SLI to identify root causes to analyze the test methodology, given that it differs from elections operations in certain key steps, particularly related to rescanning ballots in VxCentralScan. The large number of ballots handled also posed challenges in narrowing down sources of the overvote. • Review the cleaning procedures with test staff to eliminate dirty hardware as a cause.
4	4/9/25, 3:50am	4 more overvotes reported in Contest 1 during a warm cycle.	Jessica Myers, VotingWorks	Units cleaned again with wipes. It is noted that this issue is only seen with the smaller fi-8170 scanner.

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5	4/9/25, 7:54am	Inspected and cleaned the VxCentralScan fi-8170 scanner and imprinter more thoroughly.	Chris Pedersen, VotingWorks	<p>Ink smudging and buildup in the VxCentralScan unit and imprinter did not appear to be out of the ordinary. Rollers looked fine, although having some debris. Units were then cleaned fully, including sensors, which previously were not cleaned. Cleaning actions were:</p> <ul style="list-style-type: none"> • Sprayed all parts of the unit with canned air to clear out already loose debris. • Cleaned the sensors with a swab. • Went around the edges of the glass with a swab to dislodge any accumulated paper dust and debris. • Used canned air to blow out debris. • Wiped the glass and the ribbing on the infeed. • Canned air again • Used a cleaning sheet <p>CVR data was collected to analyze further over the next hours.</p>
6	4/9/25, 11:28am	Tally reports show 4 overvotes during a cold cycle, during a batch of rescanning in 4 orientations.	Chris Pedersen, VotingWorks	Issue may be seen in both warm and cold conditions.
7	4/9/25, 3pm	CVRs were analyzed, and attempts were made to reproduce the issue separately in another unit in VotingWorks facilities in San Francisco, California.	Jessica Myers, Ben Adida, Matt Roe, VotingWorks	<p>CVR analysis showed consistent patterns of the few found overvotes, for Contest 1, for Option 1 (spurious) and Option 3 (marked), despite no visible marks on ballots for both options, and no apparent consistent cleaning/dirtiness issues in the scanner. This gave more evidence this may not be a hardware issue, nor cleaning issue, and did not require swapping out hardware. Software and the test methodology would be investigated further.</p> <p>Attempts to reproduce the issue separately in San Francisco with different ballots initially did not work, with all scans occurring normally even when rescanning 4x. However, rescanning 5x did reproduce the same overvote issue twice. Overall, this showed that in rare cases, a previously imprinted ballot can be interpreted incorrectly.</p> <p>It was noted that only the small scanner may see this issue, because it has less room laterally in both directions to imprint. The larger scanner has more room laterally in both directions on the bigger imprinter, as it supports imprinting wider paper sizes. This issue had not come up previously because of how rare it is and the lack</p>

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				of need to rescan previously imprinted ballots, which does not happen in real-world elections.
8	4/9/25, 5pm	Current overvote count is 17. Alternate VxCentralScan units were brought to rescan the same batches of ballots that had overvotes to compare results.	Tabitha Lehman, VotingWorks, with SLI	An alternate VxCentralScan reproduced the issue once outside the main test, outside the chamber. CVRs and logs were not saved initially, so attempts were made to rescan the batches again repeatedly until an overvote could be reproduced. This took several tries to rescan batches. Then the CVRs were saved for analysis. This overall also demonstrated the rarity of the issue, given that the same batch did not always produce overvotes.
9	4/9/25, 8:58pm	The test protocol was changed to account for previous discoveries and to eliminate the risk of overvotes due to rescanning previously imprinted ballots.	Jessica Myers, VotingWorks, with SLI	Each VxCentralScan ballot would now only be scanned 1x before retiring the ballot, ensuring that each ballot is not already imprinted before scanning. At this point in the test there were enough ballots available to accommodate this change.
10	4/9/25, 11:51pm	Tally report totals are all accurate.	Jessica Myers, VotingWorks	Plans were made to continue the test with the modified methodology. It was noted that minor ink spot buildup occurred on both VxCentralScan scanners, but that these did not affect scanning or imprinting.
11	4/11/25, 5:55pm	Test is complete at the end of the week and cleaned up.	Chris Pedersen, VotingWorks	No overvote issues detected since implementing the new test methodology.

Investigative Team and Method

This section shall describe how the investigative team is assembled by the voting system manufacturer, who it consists of, and how it gathers the data to be used in the analysis. Include the RCA method employed by the manufacturer in conducting the analysis and why this method was used.

Names and Positions of members of the investigation team:
Tabitha Lehman - Customer Success Manager
Jessica Myers - Head of Compliance
Chris Pedersen - Operations & Prototyping Support Technician
Ben Adida - Chief Executive Officer
Matt Roe - Head of Product
Describe the data gathering process:
<p>Tabitha Lehman, Jessica Myers, and Chris Pedersen were all present in-person at Element with SLI Compliance during the 104-hour test, to support issues that may have arisen. Tabitha was present when the overvote issue was first identified, and initially gathered and shared data with the rest of the VotingWorks team, ruling out invalid ballot markings as a cause. The three support staff continued to rule out other procedural causes, including environmental causes and various cleaning issues.</p> <p>Ben Adida joined the investigation to help analyze partial logs from the test when the issue was discovered. The consistency in errors, although rare, helped further suggest that physical hardware issues were not at fault.</p> <p>Matt Roe joined the investigation to reproduce the issue on separate offices in San Francisco and investigate the procedural artifacts related to rescanning ballots on VxCentralScan multiple times. His analysis in a separate location with other ballot types drilled down on the root cause as related to the imprinter marking on top of timing marks.</p> <p>Issue Detection</p> <p>Unexpected overvotes were detected by the testing team during multiple result reporting checkpoints throughout the 104 hours continuous operation test. These unexpected overvotes were determined by the testing team to be part of cast vote records created by one</p>

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of the VxCentralScan units included in the test: the VxCentralScan connected to the Fujitsu fi-8170 using the fi-819FRB imprinter. As part of the original test procedure, ballots were scanned and imprinted four times on VxCentralScan.

Root cause analysis consisted of the following activities:

- Analyzing test methodology and supplies
- Adjusting test procedure
- Reproducing the issue outside of the test procedure
- Analyzing image interpretation data from the reproduced case

Describe which methodology(s) is used to conduct the root cause analysis:

Root cause analysis followed a fault tree analysis pattern, looking at potential causes in hardware (across 2 VxCentralScans), software, and test methodology. Of these three branches of faults, methodological causes were primarily investigated due to known procedural issues that could potentially cause scanning errors, such as cleaning and paper handling. This led to attempts to reproduce the issue separately for more in-depth analysis of ballot images and interpretation.

The ballot images from the VxCentralScan unit that originally identified this issue were unavailable for analysis while the 104 hour continuous operation test continued. VotingWorks however analyzed the original images from a second VxCentralScan unit outside of the test procedure that reproduced this issue.

Analysis of how VxCentralScan interpreted these ballots images confirmed the hypothesis that imprinted identifiers over timing marks cause rare unexpected overvotes when rescanned. Upon first reproduction of the issue, the “5 Why’s” methodology helped focus on the root cause. The first question was: “Why was an overvote detected?” The answer was that a specific contest was misinterpreted on a ballot with previous imprints over timing marks.

An example of an unexpected overvoted ballot image is included below where the write-in candidate option in the first contest was incorrectly interpreted as a mark and therefore considered an overvote.

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Boleta de prueba
Demostración de NASS y NASED
29 de enero de 2025
Washington, CORRIENTE CONTINUA

Test Ballot
NASS & NASED Demo
January 29, 2025
Washington, D.C.

Instrucciones
Para votar:
Para votar, llena completamente el óvalo junto a tu elección.
Para votar por un candidato por escrito:
Para votar por una persona cuyo nombre no está en la boleta, escribe el nombre de la persona en la línea "Candidato por Escrito" y llena completamente el óvalo junto a la línea.

Instructions
To Vote:
To vote, completely fill in the oval next to your choice.
To Vote for a Write-in:
To vote for a person whose name is not on the ballot, write the person's name on the "Write-in" line and completely fill in the oval next to the line.

Las mejores elecciones en la televisión
Best Elections on TV
Vota por 1 / Vote for 1

☐ The West Wing
☐ Veep
☐ House of Cards
☐ Parks and Recreation
☒ Scandal
☐ Candidato por escrito / Write-in

El mejor monumento conmemorativo de Washington D. C.
Best D.C. Monument/Memorial
Vota por 1 / Vote for 1

☐ Lincoln Memorial
☐ MLK Jr. Memorial
☐ Vietnam Memorial
☐ Washington Memorial
☒ World War II Memorial
☐ Jefferson Memorial
☐ Candidato por escrito / Write-in

La mejor película electoral
Best Election Movie
Vota por 1 / Vote for 1

☐ Bulworth
☐ Dave
☐ Election
☐ Napoleon Dynamite
☒ Wag The Dog
☐ All The President's Men
☐ Candidato por escrito / Write-in

Página / Page
1/2

Voltea la boleta y continúa votando
Turn ballot over and continue voting

Ballot Style 1
Precinct: Precinct 1
Language: Spanish (ES) / English

Deeper “Why’s” followed, starting with, “Why was the first contest interpreted incorrectly?” Following this line of questioning, VxCentralScan interpretation analysis of this image specifically determined that:

- The write-in candidate bubble was interpreted off-center to its real placement, which caused the bubble outline to be treated as a voter mark.
- The write-in bubble was interpreted off-center because the interpreted timing mark grid was interpreted off center from printed bubble placement.
- The timing mark grid was interpreted off center because the timing marks were interpreted as larger than they actually were.
- Timing marks were interpreted as larger because of the imprinted unique identifier over the timing marks.

The following images demonstrate these interpretation analysis findings for this image. Interpreted timing mark size is shown in red; interpreted grid points are shown in pink; and the expected bubble placement is shown as offcenter by the misaligned rectangle. The definite mark interpretation is also demonstrated by the 8.17%, which exceeds the 7% threshold set for this test.

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☐

Parks and Recreation

25

☒

Scandal

26

☐

27

☐

28

☐

Candidato por escrito / Wri

24

☐

Parks and Recreation

25

☒

Scandal

26

☐

27

☐

28

☐

Candidato por escrito / Wri

0.19%

98.56%

58.27%

83.46%

8.17%

n1osea86l

4ivd60it8

fgoomwow1

153u0klz7

Write-In 0

☐

Candidato por escrito / Write-in

For reference, the process VxCentralScan follows to interpret values is outlined in this [TDP document](#).

Findings and Root Cause

Describe the findings of the investigation and explain the root cause(s) based on these findings. If the RCA results in findings that are not directly related to the root cause of the anomaly, these should also be captured as manufacturer product/process improvement steps in an effort to improve the voting system.

The investigation findings ultimately hinged on analyzing the original test methodology for this 104 hour test, compared to the actual product use in real elections. To understand this better, the original planned test methodology is first described here. The 104 hour test was intended to follow previously defined procedures for scanning large numbers of ballots, including two VxCentralScan scanners that can scan batches of ballots rapidly. Both VxCentralScan units were planned to make 31,200 scans each of pre-filled ballots at specified hours and quantities, across all 104 hours. All ballots were expected to strictly follow VotingWorks margin specifications, such that the imprinted marks would lie in the margins outside the timing marks. In order to attempt to reduce waste and avoid using 62,400 total sheets of paper in the test, the VxCentralScan units were planned to rescan ballots up to 4 times before retiring the ballots, while also imprinting identifiers on the ballots in different locations after each scan.

This rescan methodology differed from an actual election, where there would be just one scan per ballot, resulting in one imprinted mark on the margins of the ballot after scanning. The original rescanning methodology made the system more susceptible to scan misinterpretation due to the possible presence of imprinter marks over timing marks.

Root cause analysis determines that:

- In rare cases, rescanning of ballots that previously imprinted unique identifiers over timing marks can result in incorrect interpretation of ballots – specifically resulting in unexpected overvotes.
- This issue is specific to the original test methodology and test supplies. The issue should not occur during typical voting system use in a real election, because elections should never rescan previously scanned and imprinted ballots.

Corrective Action(s)

Corrective actions apply to the testing methodology and to the production software:

Testing:

- The test methodology for VxCentralScan continuous operational tests was updated to scan and imprint all ballots just once, as it would be in a normal election. This avoids the test-specific artifact of imprinting over existing imprint marks.
- Ballots were supplied to account for this increased number of ballots needed for testing.

Software:

- VotingWorks plans to implement a software mitigation for this issue for the next tested version 4.0.2, in the rare case that timing marks are written over with other marks before scanning and not rejected. The mitigation will better identify the correct location and size of the timing marks by successively shrinking over-large timing marks. Using a scoring algorithm for matching a timing mark image, the software should shave off each of the four edges as long as doing so improves the score and does not make the timing mark too small in that dimension. Had that mitigation been in place for the ballot scan shown above, the timing mark size and position would have been correctly identified.
- In the event of recount scenarios in the field that require rescanning previously scanned and imprinted ballots, the system continues to support this without any issues when proper print margin requirements are followed. In addition, when proper print margins are not followed or are out-of-spec, then the software mitigation described above applies and improves the scanning of ballots with imprints made over timing marks.

Solution Management

The purpose of this section is to manage the corrective action(s) moving forward. This should detail all process changes to manage those corrective actions, and steps taken to ensure the actions eliminate the anomaly over time.

Process changes were applied to testing and software management as follows:

Testing Processes

Procedures for 104 hour continuous operational testing involving the normal function of VxCentralScan units were simplified, specifying that VxCentralScan should only scan ballots during this test that are either:

- new and previously unscanned, and/or
- have no imprinted identifiers on it, if allowed.

An appropriate number of test ballots must be prepared to account for this requirement. Rescanning ballots during this simplified test only could be allowed if the imprinter is not used.

Software Processes

Software mitigations described above have been recorded in an issues list for incorporation into the next production app version 4.0.2.

No corrective actions are needed for changing operational processes in actual elections, noting that in the event that an election does require rescanning these ballots, the system still supports this if the ballots meet the documented margin requirements. The software mitigation would still help in situations when users breach the ballot margin requirements.