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Voting System Anomaly Root Cause Analysis Template v2.0

Root Cause Analysis for:

VV40ECT-100: VxScan Received "Ballot Is Jammed In The Scanner" Error For VxMark Ballots
VxSuite, Version 4.0 and EAC Certification #VXS4

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Contents

Introduction

This RCA describes the causes of jam errors when VxMark ballots were fed into VxScan, 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. Investigation of this anomaly was important because it contrasted with past designs to make VxScan compatible with VxMark machine-marked ballots, as well as past tests that did not surface this error. This cross-compatibility between VxMark and VxScan was not a critical feature of the VxSuite system, because VxMark ballots could always be scanned centrally in VxCentralScan. However, it was an original part of the 104 hour test methodology due to the lack of errors found in it previously. It would have to be resolved before officially intending for this feature

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.

Date of Anomaly: April 7, 2025	Time of Anomaly: 8:42am
Place of Anomaly: Element, Longmont, CO	Person identifying Anomaly: Chris Pedersen, VotingWorks
Expected Results of actions leading up to anomaly: The 104 hour test was to be set up according to pre-defined procedures, where machine-printed ballots from VxScan would be fed into VxScan for tallying. No jams, rejections, or other errors were expected to occur with this process if following appropriate procedures for use and maintenance.	

Detailed description of the event / anomaly: During the first hour of the 104 hour test, 10 VxMark ballots were fed into VxScan. They were rejected an estimated 20 times with a "paper jam" error displayed. No unusual methods of inserting the ballots were noted. All VxScan ballots were eventually able to be scanned, but it did not go smoothly as expected based on past internal testing.
If the anomaly is repeatable, provide step by step instructions to recreate it: ● Prepare a printed ballot from VxMark on compatible thermal paper (8 by 13.25 in). ● Feed the ballot into VxScan with an appropriate corresponding election definition. ● Repeat the above process if needed to reproduce the ballot rejection error.

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. Ballot jam errors and rejections are reported for VxMark ballots going into VxScan.	Chris Pedersen, VotingWorks	Plans were made to analyze how the test staff are inserting the VxMark ballots into VxScan, in case that was an issue. Conditions during these errors were noted, including the cold temperature of 50°f, relative humidity 25-30%, in case that contributed to the anomaly. Discussions were started with the wider VotingWorks team to potentially swap units, change test procedures, and/or change product use specifications.

2	4/7/25, 10:51am	Scanning VxMark ballots on a swapped VxScan unit produced similar errors, with large numbers of rejected VxMark ballots again.	Chris Pedersen, Jessica Myers, VotingWorks	Since the evidence was that this was a larger issue that could not be immediately resolved, the plan was to cut the feature of scanning VxMark ballots in VxScan and instead scan VxMark ballots in VxCentralScan in the 104 hour test. Adjustments to the test methodology were made to account for this. Discussions on how to adjust documentation were begun. Plans were made to investigate causes of the anomaly, including various paper characteristics, paper insertion orientation, and environmental conditions. Plans were made to look at records of past tests, including paper samples from previous tests.
3	4/7/25, 2:30pm	The anomaly was shown to be reproducible separately in VotingWorks facilities when applying extreme skew with certain ballot sizes.	Matt Roe, VotingWorks	Several preliminary results were noted from attempts to reproduce the issue: ● Extreme skew upon insertion could lead to jam errors. ● It could not be reproduced on 11"L ballots when cut to 8"W in any case ● It could be reproduced with 22"L ballots when cut to 8"W in any case — and it did not need to be thermal paper nor skewed ● When inserting 22"L ballots, the error message and rejections appeared reproducing in cases that were clearly not real, physical jams. ● It could be reproduced with 22"L ballots without adjusting for length for the 11" ballot definition. The results started to suggest problems with the jam detection features for specific paper sizes. Plans were made to investigate the logic for jam detection of different paper lengths. It was noted that VxMark ballots (13.25”L) were longer than the VxScan ballots (11”L) for this 104 hour test.
4	4/7/25, 3:26pm	Further testing at VotingWorks facilities clarified the logic for when ballots are rejected by VxScan.	Jonah Kagan, Matt Roe, Chris Pedersen, VotingWorks	Testing confirmed that legal sheets cut to 13.25” could jam if the VxScan election definition was configured for certain maximum allowable paper lengths. Results showed: ● Max paper length: 10.25" - Always jams ● Max paper length: 10.5" - Occasionally jams ● Max paper length: 10.75" - Never jams The VxScan jam logic sets the max paper length to 0.5” less than the paper length in the election definition. So when configured for 11”L letter ballots, the max paper length internally is set to

				10.5”, which seems to potentially be the exact unluckiest length for the 13.25" ballots. The precise VxMark paper stock used in past passing tests was measured again, which revealed undercut paper lengths closer to 13”L, not 13.25”L. The shorter length explained why the past tests never triggered a rejection. The VxMark paper length at Element/SLI was measured again, confirming that it was 13.25”L, which would be rejected.

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:
Chris Pedersen - Operations & Prototyping Support Technician
Jessica Myers - Head of Compliance
Matt Roe - Head of Product
Jonah Kagan - Software Engineer
Describe the data gathering process: Chris Pedersen initiated the process because he was present in-person at the first hours of the 104 hour test when the anomaly was discovered. He used his knowledge of VxSuite products to eliminate known procedural causes for the ballot jams first and communicated data to the wider VotingWorks team. Jessica Myers coordinated responses to the findings as the main liaison to SLI Compliance. Matt Roe and Jonah Kagan joined the investigation as evidence mounted that software was involved in the “jams” or rejections of VxMark ballots. As product and software experts, they they reproduced similar anomalies in VotingWorks facilities outside of Element/SLI using various paper types and sizes, reviewed past test data of VxMark ballots being scanned through VxScan, and analyzed the ballot jam detection/rejection algorithm currently being

used in VxScan software. They completed the data gathering process by narrowing down specific causes for the SLI rejections of paper cut to a specific length.
Describe which methodology(s) is used to conduct the root cause analysis: Initially the RCA followed a simple fault tree analysis going from simpler to more complex causes, exploring first procedural and then product-based causes of the ballot jam errors. The potential procedural faults related to paper handling when inserting in VxScan but then was ruled out. Product-based causes then focused on hardware and software faults, ruling out isolated problems with a single VxScan, environmental influences, and calibration issues. The remaining product-based faults to explore were related to the paper inputs and the software that analyzed the paper inputs to flag it as a jam or not. The "5 Why's" technique then was used to guide investigations about the software, leading to a string of deeper connected questions, for example: ● Why does the software report jams? ● Why does the software report a jam when there is not a physical paper jam? ● Why do long ballots of any type – both thermal paper and regular – paper trigger the jam error? ● Why do some ballots of long lengths trigger the jam error, and some do not? ● Why does the VxMark ballot length cause a jam in this test with a shorter VxScan ballot, when it did not in similar previous tests? These questions guided the experiments and data collection that eventually identified the root cause of the anomaly.

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.

EAC (Election Assistance Commission) Root Cause Analysis

Software analysis identified that the error message surfaced during anomaly detection can happen in one of two cases:

1. When the document scanner reports a paper jam
2. When the document scanner detects paper longer than the max paper length

This finding suggested that the document scanner was detecting paper longer than the max paper length as a real paper jam was not happening.

VxScan software sets the max length of the document to 0.5” less than the paper length in the election definition. The max length is set shorter than the actual length of the paper to address issues identified in previous internal testing when scanning two sheets back to back where only the second sheet is rejected. Previous internal testing of this setting identified no negative side effects across all election definitions and ballot lengths.

VxMark ballots are specified to be 13.25” in length. For an election definition with 11” hand-marked paper ballots, this creates a condition where the expected max paper length is less than the length of VxMark ballots.

Previous internal testing of VxMark ballot stock did not identify this issue. Upon investigation of paper stock used in previous internal tests, the investigative team identified that ballot stock used in internal testing was imprecisely cut by the VxMark ballot provider resulting in paper that was 13” in length – not 13.25”. Paper used during the 104 hour continuous operation test was measured to be the expected 13.25”.

Further investigatory analysis confirmed the following when the document scanner max paper length is set to 10.5”:

- 13” paper does not trigger the paper jam error
- 13.25” paper occasionally triggers the paper jam error (aligned with anomaly detection)
- 13.5” paper always triggers the paper jam error

Overall, this investigation concluded that:

- This issue is specific to election definitions with 11” hand-marked paper ballots as it is the only definition where max paper length is less than VxMark ballot length.
- 13.25” ballots (as specified) occasionally trigger the paper jam error via exceeding max paper length.
- This issue was not identified during internal testing due to use of 13” VxMark ballots that were improperly cut by VotingWorks’ paper vendor.

Corrective Action(s)

VotingWorks decided not to support scanning of VxMark ballots on VxScan, and this capability was removed from the scope of the continuous operation test. The technical data package will be updated to reflect that VxMark ballots should be scanned by election officials using VxCentralScan only.

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.

The technical data package will be updated to specify that VxMark ballots should be scanned by election officials using VxCentralScan only.