Voting System Anomaly Root Cause Analysis Template v2.0

Root Cause Analysis for:

VV40ECT-192, -213: VxScan Unable to Save CDF Logs - Rev. 1
VxSuite, Version 4.0 and EAC Certification #VXS4

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Introduction

This RCA documents investigation into an anomaly in saving logs in CDF format from VxScan, which was noted in the following discrepancy reports:
- **VV40ECT-192: VxScan SC-11-009 Fails to save CDF logs**
- **VV40ECT-213: VxScan Unable to save CDF logs**

The reports noted that in two VxScan units, attempts to save the logs failed, even though this was successful on other units and previously in the same unit. Investigating this issue was important for identifying when log exports might fail and preventing these failures. That would lead to more consistent successful data exports.

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: September 3, 2025	Time of Anomaly: 5:10pm
Place of Anomaly: SLI, Wheat Ridge, CO	Person identifying Anomaly: Jessica Myers, VotingWorks
Expected Results of actions leading up to anomaly: VxScan logs are successfully exported in CDF format, saving files onto a USB drive inserted into the system and not reporting any errors.	

Detailed description of the event / anomaly:

The anomaly first occurred in VxScan unit SC-11-009. While trying to save CDF logs onto a USB stick, a "Failed to Save Logs" message was displayed, saying "cdf-conversion-failed." It was noted that the other VxScan devices saved CDF logs without issue, and that saving logs on SC-11-009 also previously worked.

This same anomaly was reported again for VxScan units SC-11-008 and SC-11-009, and this time the logs were inspected and included the error message: "No space left on device." Formatting the USB stick allowed the unit to save CDF logs, but using that same stick on a second machine led to the same failure in exports seen earlier.

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

1. Leave the VxScan machine on and running without a reboot for 5 consecutive days.   It can be used during this time normally, scanning ballots with any election package.
2. At the end of the 5 days, attempt to save CDF logs according to standard procedures within the Election Manager or System Administrator menus. Watch for errors to appear.

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	9/3/25, 5:10pm Mountain Time	SLI reports the anomaly with one VxScan unit.	Jessica Myers, VotingWorks	In VxScan unit SC-11-009, while trying to save the CDF logs, a "Failed to Save Logs" message displays along with "cdf-conversion-failed." It was noted that other devices were saving fine, and that this unit previously worked. VotingWorks staff prioritized it for investigation in the following weeks, noting that it likely is related to software handling logs.
2	9/23/25, 4:45pm	SLI reported the same anomaly with two VxScan units, one of which was the same as before.	Jessica Myers, Arsalan Sufi, VotingWorks	In VxScan unit SC-11-008, while attempting to save the logs in the CDF format, the file failed to save. The logs were inspected to have the error message: "No space left on device (os error 28)".

				The tester deleted 8GB worth of data on the USB stick and tried to export CDF logs again, but it failed. The tester then used another USB stick, formatted it on VxAdmin and was able to successfully export the CDF on machine SC-11-008. Then using the same USB stick on SC-11-009, exporting CDF logs failed. Logs were shared with VotingWorks. VotingWorks reprioritizes the investigation higher due to the repeated reporting.
3	10/20/25	VotingWorks identifies and patches the root cause in software related to logging.	Drew Hayes, Adam McManus, Arsalan Sufi, VotingWorks	It was found that ever since adding an audio integration to VxScan, there were an excessive amount of logs polling audio status that were being added to VxScan log files. Software changes were implemented to cut log sizes significantly by: (1) removing a spammy log that provides no utility from all VxScan log files, and (2) coalescing logs that are repeated in quick succession, indicating how many repeats there are without actually logging each individually. This also reduces spam in the logs. These two changes can be seen in the open source code in the following respective pull requests: ● https://github.com/votingworks/vxsuite-complete-system/pull/482 ● https://github.com/votingworks/vxsuite/pull/7424

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:
Jessica Myers, Head of Compliance
Arsalan Sufi, Head of Software
Drew Hayes, Product Manager
Adam McManus, Production Engineer

Describe the data gathering process:

Jessica Myers initiated the investigation and exchanged information with SLI upon learning of the reported anomalies. Arsalan Sufi started the high-level investigation that identified log sizes as a root cause, while Drew Hayes did the detailed investigation to isolate the parts of the code that were not optimized to handle writing to the log files. Adam McManus and Arsalan Sufi investigated specific solutions in code to reduce the size of log files, and they implemented the final software patches.

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

The investigation used a basic "Five Why's" strategy, asking a series of questions that pointing to a root cause in software:
- Why would CDF logs fail to save some of the time?
- Why would error logs say there was not enough space for saving logs?
- Why would log files be excessively large?
- Why does one particular log file have excess size?
- Why are some logs spamming the logs?

A more complex fault tree analysis was not needed due to early elimination of hardware causes and logs indicating issues in particular parts of the logging software.

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 root cause for this error was two-fold:
- First, a spammy log was introduced in v4.0.2 for audio status polling, resulting in generally larger `vx-logs.log` files.
- Second, the log files for this anomaly show that the VxScan unit in question was left running for a long period of time without a reboot, at least 5 days. Under typical circumstances, machines will be rebooted at least once every 24 hours. Whenever a machine is rebooted, the `vx-logs.log` file is rotated, meaning the existing file is compressed and a new file is created. This limits the size of any one `vx-logs.log` file. The VxScan unit in question did not benefit from the log rotation and compression.

Because of the two triggers mentioned above, there was a `vx-logs.log` file on the VxScan that was 789MB in size, uncompressed. This is in our default VotingWorks format. In order to export logs in CDF format, VotingWorks software has to convert the log files from VotingWorks format to CDF format. Converted log files are staged in the machine's `/tmp` directory. The partition containing the `/tmp` directory is 1GB in size. Because CDF is more verbose than the VotingWorks format, the 789MB file in VotingWorks format was larger than 1GB in CDF format. The conversion process accordingly failed with the following log under the hood: `Error: Failed to write CDF log to /tmp/tmp-807-QDGgqeENu1zQ/vx-logs.cdf.log.json: No space left on device (os error 28)`. The "No space left on device" is referring to the machine's partition containing the `/tmp` directory, not the USB drive. There is ample space elsewhere on the machine and on the USB drive being copied to.

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Corrective Action(s)

To remedy the root causes described above, software updates have cut log sizes significantly. This was done by:
- Removing a spammy log that provides no utility from all VxScan log files, and
- Coalescing logs that are repeated in quick succession, indicating how many repeats there are without actually logging each individually. This also reduces spam in the logs.

These changes can be seen in the open source code in the following respective pull requests:
- https://github.com/votingworks/vxsuite-complete-system/pull/482
- https://github.com/votingworks/vxsuite/pull/7424

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 VxScan software was updated and tested according to standard development procedures, verifying smaller log sizes that can be exported in CDF format without issues. Although a solution was found, log files will continue to be monitored in case further software changes have to be made.