



Voting System Anomaly Root Cause Analysis Template v2.0

Root Cause Analysis for:

**VV40ECT-157: VxSCAN WITH APC BATTERY IS NOT CAPABLE OF SUSTAINING POWER FOR AT LEAST 2
HOURS - REV. 1
VxSUITE, VERSION 4.0 AND EAC CERTIFICATION #VXS4**

**VOTINGWORKS
548 MARKET ST, STE 53001
SAN FRANCISCO, CA 94104-5401**

OCTOBER 8, 2025

Contents

Introduction..... 1

Anomaly Description..... 2

Chronology of Events / Timeline..... 3

Investigative Team and Method..... 4

Findings and Root Cause..... 6

Corrective Action(s)..... 7

Solution Management..... 8

Introduction

This RCA documents an investigation into an anomaly of a commercial off-the-shelf uninterruptible power supply (COTS UPS) not sustaining 2 hours of backup power for VxScan. The UPS was an APC brand Back-UPS Pro, model BN1500M2, rated for maximum power output of 1500VA/900W. This power rating is higher than the VxScan measured power consumption of approximately 40W. During test runs with fully charged APC UPS units, backup power to VxScan fell short of the required 120 minutes, lasting about 80-95% of the target time. Analysis of the root cause was important to identify and address energy use issues with either the UPS or VxScan.

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> July 10, 2025	<u>Time of Anomaly:</u> 10:09am
<u>Place of Anomaly:</u> SLI, Wheat Ridge, CO	<u>Person identifying Anomaly:</u> Jessica Myers, VotingWorks
<u>Expected Results of actions leading up to anomaly:</u> Powering a VxScan unit using a fully charged APC BN1500M2 UPS unplugged from mains should sustain power to VxScan for 2 hours. This expectation was based on previous testing of a smaller UPS (APC 850VA) on the VxScan v3 version.	
<u>Detailed description of the event / anomaly:</u> Multiple test runs were done as follows. A fully charged UPS was plugged into mains power. A VxScan unit running the production software was plugged into the UPS and powered on. To simulate power outage, the UPS was unplugged from mains power, so that it was powering the VxScan unit itself with 120VAC. The VxScan remained on while scanning a ballot every 20-30 minutes, while observers tracked the time that it stayed on. The VxScan unit and UPS units turned off between 98-113 minutes, falling short of the target 120 minutes.	

EAC (Election Assistance Commission) Root Cause Analysis

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

1. Charge the APC BN1500M2 UPS overnight, or at least 8 hours. This could be used or new UPS units.
2. Plug the UPS into 120VAC mains power.
3. Plug the VxScan unit running the production software into the UPS 120VAC output outlet, and power the VxScan on.
4. Unplug the UPS from mains power, and start timing. Scan sheets every 20-30 minutes.
5. Observe when the VxScan unit and UPS unit turn off, if earlier than 2 hours.

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	7/10/25, 10:09am Mountain Time	SLI reports anomalies with two trials of the APC BN1500M2 UPS only supplying 98 minutes of backup power to VxScan. VotingWorks analyzes the details.	Jessica Myers, VotingWorks	Initial questions clarified test procedures and unit details. VotingWorks requested more data on other UPS and VxScan units, to identify if these were anomalies for the particular test units, or for the broader UPS and VxScan combination itself.
2	7/11/25, 9:15am	SLI reports similar data for new UPS units, where they supplied about 113 minutes of backup power to VxScan.	Jessica Myers, Matt Roe, VotingWorks	Plans were made to try to reproduce the anomalies within VotingWorks. Old records of UPS tests were consulted for comparison. Reviews found that the lead acid battery APC UPS designs could have degraded performance from predicted ratings depending on age, previous use, and environmental conditions.
3	7/17/25	VotingWorks reproduces the anomaly, and also finds the UPS can turn back on after powering off and can continue powering the VxScan for the remaining time to 2 hours. Discussions were made to compare to alternative UPS models.	Matt Roe, Jesse DeWald, VotingWorks	Power consumption of VxScan was confirmed to be about 36-40W, lower than the UPS rated maximum power. The observation that the APC UPS still had power remaining after shutoff suggested a root cause with the power detection and shutdown functions of the UPS. Documentation for the UPS suggested a level of unreliability or unpredictability in power use and UPS function

EAC (Election Assistance Commission) Root Cause Analysis

				<p>for loads as low as VxScan. Runtime estimates for the BN1500M2 are not given for loads <90W.</p> <p>Testing of a lower loads on the UPS at about 22W also led to early power shutoff at 99 minutes, about the same as the 40W VxScan load.</p> <p>Past records of alternate UPS models confirmed possible alternatives to using this APC UPS. In March 2025, the Goldenmate 1000VA/600W LiFePO4 UPS showed it could provide backup power to VxScan for about 3 hours, even when continuously scanning, with a more reliable estimate of time remaining from its battery. It also is listed for UL and FCC certification, and it showed no concerning RF emissions when tested in April 2025 at Nemko, San Diego.</p>
--	--	--	--	--

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
Matt Roe, Head of Product
Jesse DeWald, Head of Hardware

EAC (Election Assistance Commission) Root Cause Analysis

Describe the data gathering process:

Jessica Myers initiated the investigation upon receiving the reports from SLI. Matt Roe and Jessica reproduced the anomaly, while Matt and Jesse DeWald investigated all records and documentation for this UPS and other UPS models. Matt confirmed the root cause in the APC UPS for the power consumption level of VxScan.

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

The investigation used a “Five Why’s” strategy combined with a fault-tree analysis. The starting question was, “Why would the VxScan unit power off earlier than expected?” The high-level fault branches to investigate were if this was a unit-specific issue or a broader system design issue with this combination of UPS and VxScan. Additional data were collected on other UPS and VxScan units, including both old and newly purchased UPS devices, both internally at VotingWorks and at the external test locations. Data confirmed the anomaly generally, even though the backup time might vary somewhat, and it ruled out the theory that it could be a unit-specific fluke.

Additional investigations probed why the APC BN1500M2 would shut off early when powering VxScan. Documentation confirmed that this model, though sized theoretically to supply enough power to VxScan for 2 hours, supplied unreliable power at low loads. Additional testing and review of past data corroborated the documentation. Questions that were asked in this branch of the fault tree included:

- Why would the backup power time vary unit-to-unit? (usage affects battery quality)
- Why does the power turn off even when the UPS has power remaining?
- Why does the APC UPS not estimate runtimes accurately for the power level consumption level of VxScan?

The answers to these questions honed in on the unreliability of this lead-acid UPS model for VxScan.

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 of the anomaly was found to be twofold:

1. The APC UPS has lower runtimes for lower power loads than the rated capacity would suggest. It is unpredictable for loads <90W.
2. The APC UPS shuts off early when it is not completely discharged, for lower loads <90W.

A key finding was that, at low loads (<10% rated load, or <90W for the BN1500M2 model) the UPS signals battery shutoff earlier than when it is actually dead, whereas at higher loads the UPS signals battery shutoff closer to when the battery is actually dead. Documentation confirmed that this model, though sized theoretically to supply enough power to VxScan drawing 40W for 2 hours, did not have an official runtime estimate for loads <90W. According to APC, their lead-acid UPS models like this one are not rated for lower loads like this and can behave unpredictably at that level. They also are very inefficient when powering loads <10% of their maximum power rating. Internal tests confirmed that the APC models could turn back on and power VxScan after initially shutting off during backup power testing, suggesting unreliable detection of remaining UPS battery power at low loads.

Corrective Action(s)

The APC UPS is being replaced with another COTS UPS model that was previously tested to supply enough backup power to VxScan for more than 2 hours. In March 2025, the Goldenmate 1000VA/600W LiFePO4 UPS showed it could provide backup power to VxScan for about 3 hours, even when scanning, with a more reliable estimate of time remaining from its battery. The Goldenmate model also is listed for UL and FCC certification, and passed pre-certification electrical tests in April 2025 at Nemko, San Diego. The UPS also improves the user experience when compared to the APC model due to lighter weight, simpler interface, and lack of required preliminary setup before use.

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.

Management largely involved documentation and procurement:

- Updating public documentation and training plans for VxScan to account for the new Goldenmate UPS instead of the APC UPS.
- Supplying the Goldenmate UPS to customers instead of the APC UPS in the VxScan system production process.