



Voting System Anomaly Root Cause Analysis Template v2.0

Root Cause Analysis for:

**VV40ECT-77: VxSCAN ELECTRICAL FAST TRANSIENT (EFT) FAILURE WITH ANKER UPS - REV. 2
VxSUITE, VERSION 4.0 AND EAC CERTIFICATION #VXS4**

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Introduction

The purpose of this RCA document is to describe a failure of VxScan used with the Anker Solix C300 uninterruptible power supply (UPS) in Electrical Fast Transient (EFT) / Burst testing (IEC 61000-4-4 Levels 2-4), during standard certification tests with SLI Compliance and Element in Longmont, Colorado. EFT testing simulates how the system would respond to rapid switching electrical signals sometimes associated with connecting or disconnecting the system from mains power. These tests then are important for increasing confidence that the system will function smoothly during unusual or adverse supply in electrical power. For these tests, the EFT signals are applied to mains powering the UPS, which in turn powers the VxScan unit. The failure is described, as well as a mitigation of replacing the Anker UPS with another commercial off-the-shelf UPS rated for similar use: the Goldenmate 1000VA/600W UPS.

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> March 14, 2025	<u>Time of Anomaly:</u> 2 PM (Mountain Time)
<u>Place of Anomaly:</u> Element, Longmont, CO	<u>Person identifying Anomaly:</u> Don Chu, VotingWorks
<u>Expected Results of actions leading up to anomaly:</u> <ul style="list-style-type: none">Fast Transient (EFT) / Burst testing (IEC 61000-4-4 Levels 2-4) was to be performed on the test system during standard electromagnetic compliance tests at Element with SLI Compliance. The system consisted of the VxScan unit and the Anker Solix C300 UPS. The software installed on VxScan was the Hardware Test Utility software that allows constant stress-testing of the system more than the production software.VxScan and the Anker UPS were expected to pass EFT tests. The Anker UPS was expected to maintain smooth power output during EFT inputs. The VxScan unit was expected to function normally following the EFT inputs. This was based on testing with NOVO Engineering in July 2024 where VxScan did not fail with preliminary tests of different electrical disturbances. Those past tests did not use a UPS with VxScan. Given that the Anker UPS was a widely used commercial off-the-shelf (COTS) component, it was not expected to fail and was expected to supply consistent power as it is marketed to do.	

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Detailed description of the event / anomaly:

- Instead of passing EFT tests, the system lost power (failed) at 2kV applied to mains. The Anker UPS lost power, so it did not output any power, which then resulted in VxScan losing power.
- The UPS was able to be power cycled manually, and it continued functioning after that, but it did not maintain an uninterruptible power supply to the VxScan unit.

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

- Image VxScan with the Hardware Test Utility software that continuously runs its major components, including running the scanner in shoeshine mode.
- Set up the VxScan system to be powered from the Anker UPS, which in turn is powered by plugging directly into mains.
- Power on VxScan and run the test software utility. Insert a sheet of paper into the scanner to implement shoeshine mode.
- Conduct (EFT) / Burst testing according to IEC 61000-4-4 Levels 2-4. Monitor system function for any power loss or functional failures.

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	3/14/25, 2pm	VxScan + Anker UPS underwent EFT / Burst testing.	Don Chu, VotingWorks, with SLI	<p>EFT testing started, but the system failed, due to the Anker UPS failing and no longer supplying power during the 2kV electrical disturbance. That led to no power being supplied to the VxScan unit anymore.</p> <p>The Anker UPS was pulled out of the system, power cycled, and then showed normal function again.</p> <p>An alternate UPS, the APC BN1500M2, was swapped into the test system, connected to VxScan, to test for comparison.</p>
2	3/14/25, 2:45pm	VxScan + alternate UPS underwent EFT / Burst testing.	Don Chu, VotingWorks, with SLI	The system passed the EFT test with the APC UPS swapped in. The APC UPS showed no issues in this test. VxScan maintained normal function.

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3	3/17/25, 10am	VxScan + new Anker UPS underwent Voltage Dip and Interruption testing, separate from EFT testing.	Don Chu, Arsalan Sufi, Brian Donovan, Jesse DeWald, VotingWorks, with SLI	<p>The system with the Anker UPS failed another electrical test: Voltage Dip. The logs from the software test utility were recovered and analyzed, showing that the faulty behavior was likely not permanent damage. However this was more evidence that the Anker unit would provide unreliable backup power.</p> <p>Plans were made to investigate swapping the Anker UPS with a different UPS more formally, and to investigate this with NOVO Engineering in San Diego, California, to see if the Anker failures could be reproduced and mitigated.</p>
4	3/31/25	NOVO Engineering finished conducting EFT on another VxScan unit, along with a new Anker UPS, the APC UPS model tested previously at Element, and the Goldenmate 1000VA/600W UPS for comparison. They summarized their findings in a report shared with VotingWorks.	Al Walters, Jeff Johnson, NOVO Engineering, with Pius Wong VotingWorks	<p>EFT tests were conducted under IEC 61000-4-4 using a pre-compliance test set applied to the AC input of each UPS (Anker, APC, GoldenMate) while connected to VxScan. The Compact NX5 was used to apply the EFT, with a standard burst test module with preset test parameters to carry out IEC 61000-4-4 under levels 1-4. After test completion, emissions testing around the UPS and VxScan was also observed for any increase in spectral amplitude in the 30M - 1GHz range compared to before EFTs. In addition, the VxScan unit was rebooted to ensure normal operation. Also, the UPS backup unit itself was plugged and unplugged from the wall AC outlet to also ensure normal operation.</p> <p>EFT results for the Anker and APC UPS models were similar and passed, maintaining power after EFT signals. However, they both resulted in some pausing of the test software for several seconds. The Goldenmate UPS showed the best results, with no apparent pauses in the test software throughout the EFT test. The “complete shutdown” Anker failure seen at Element/SLI was not reproduced. For more detail, with the Anker UPS, once the burst transients were issued to the UPS mains, the VxScan touchscreen display would flicker a bit until the burst transients were finished. All during the time of the burst transients, beeping from the hardware test utility paused as well. Once the NX5 burst transients finished, the test utility continued to run again as if nothing happened, although paused. VxScan did not lose power.</p>

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				Emissions scans done immediately after the EFT test found nothing out of the ordinary looking around all UPS devices and the VxScan unit.
5	7/17/25	VotingWorks officially changes the VxScan UPS to the Goldenmate model, based on internal testing.	Matt Roe, VotingWorks	Previous pre-certification tests with NOVO Engineering verified that the Goldenmate UPS met EMC test requirements. In order to gain an even longer backup battery life than the APC model, the COTS UPS product was changed to the Goldenmate model.

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:
Don Chu - Lead Design Engineer
Jesse DeWald - Head of Hardware
Arsalan Sufi - Head of Software
Brian Donovan - Software Engineer
Al Walters - Engineer; Jeff Johnson - Engineer; NOVO Engineering
Pius Wong - Quality Assurance Lead
Matt Roe - Head of Product

Describe the data gathering process:

Don Chu led the investigation as the person on-site with Element and SLI Compliance during the initial EFT test. He applied his expertise and experience in the design of VxScan to analyze the test and potential mitigations. Don directly received the data from SLI, handled the devices under test when needed, and coordinated the response with other VotingWorks staff offsite.

When EFT tests failed, Don observed the behaviors of the system and chose to swap the Anker UPS out with an alternative UPS on-hand to narrow down sources of the failure. Jesse DeWald, Arsalan Sufi, and Brian Donovan advised the process at various points to evaluate the data being shared. Jesse focused on hardware solutions, and Arsalan and Brian analyzed software logs in the Voltage Dips and Interruptions tests.

Following the failed EFT test (and failed Voltage Dip test) with the Anker UPS, and following the passing EFT test with the APC UPS, the outside engineering agency NOVO Engineering was recruited to perform more testing on the VxScan system, including using three different UPS devices: Anker (original) and APC (used in VxMark) and GoldenMate (third option with better battery life). NOVO previously analyzed VxScan without a UPS in July 2024 in preliminary prescan electrical tests. This time they would also use the same Hardware Test Utility software used at Element/SLI and conduct the failing tests from Element/SLI. Pius Wong coordinated getting results from NOVO to VotingWorks. Data collection focused on analyzing the system in conditions as close as possible to the original observed EFT failure, and narrowing down the components responsible.

Matt Roe confirmed later that the UPS would switch to the Goldenmate model, due to superior backup battery runtime compared to the APC, given that it also passed other EMC pre-certification tests.

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

The investigative team used the 5 Why's strategy to discuss the causes of failures in EFT tests. This line of questioning was relatively straightforward initially, as it pointed to Anker UPS failures in general, since EFT failures were coupled with failures in radiated emissions and voltage drops/interruptions:

- Why did the system fail the EFT test?
 - The Anker UPS lost power, in contrast to its intended purpose. That led to VxScan not being powered.
- Why did the UPS lose power?
 - Internal UPS electronics and/or software were faulty in response to EFTs.

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Going deeper meant investigating the UPS more closely, which NOVO Engineering helped to do. More complexity arose when this additional testing did not reproduce the same failures as at SLI for EFT testing, as of April 10, 2025. EFT tests were conducted similarly to those at Element/SLI Compliance following strict test standards, but the Anker UPS did not lose power in response. NOVO had tested a different UPS and VxScan unit from the ones at Element/SLI. Therefore another continuing question was:

- Why were internal electronics or software faulty in the Anker UPS?
 - The Anker UPS could differ in behavior unit by unit due to product quality inconsistency, or it has additional sensitivities to the test environment and test procedures that were not able to be captured by the NOVO tests.

This questioning strategy could have gone further, but given the combined data about the questionable Anker UPS performance in other electrical tests, the choice was made to apply a mitigation that could resolve multiple electrical issues: replace the Anker UPS.

Findings and Root Cause

Key findings:

The electronics in the Anker UPS are not sufficiently well-manufactured to meet the desired response to EFTs and maintain power consistently. There may be differences in emissions between units or environments, and it is not reliable enough to remain as the UPS for the VxScan system, particularly if more reliable options are available. Tests showed that two other UPS models could pass the EFT test: the APC Back-UPS Pro 10-Outlet UPS (model number BN1500M2) tested directly at Element, as well as the Goldenmate 1000VA/600W model tested with NOVO Engineering.

The key supporting evidence was the power shutdown of the Anker UPS during standard EFT tests with Element/SLI. Even though NOVO did not exactly reproduce this result later in a different Anker UPS, the failure in the first case is still important to note, especially because neither the APC UPS nor the Goldenmate failed in other testing. This inconsistency, along with the other questionable electrical behavior for Voltage Dip tests and emissions tests, was enough evidence to change out the Anker UPS.

Corrective Action(s)

Two main corrective actions will be taken:

1. Testing will continue with Element/SLI on the VxScan system with the Goldenmate UPS. Based on data supplied by NOVO Engineering as of March 31, 2025, it passes EFT and other EMC tests.
2. Testing continued with NOVO Engineering on the VxScan system with the GoldenMate UPS. This clarified the electrical behavior of the UPS in the VxScan system.

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.

Plans to manage the solution following this RCA are as follows:

Testing and verification:

- Continue hardware certification tests at Element/SLI for VxScan using the Goldenmate UPS. This will help confirm normal function with this UPS in the system.
- Continued EMC testing at NOVO Engineering with VxScan and the Goldenmate UPS. This helped identify other ways to reduce the chance of system failure, in addition to using the better Goldenmate UPS.

Design:

- The Goldenmate UPS replaces the Anker UPS in the VxScan bill of materials.

Production:

- Modified plans for sourcing, shipping, and distribution, to account for the Goldenmate UPS.