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TEST REPORT

HARDWARE QUALIFICATION TESTING OF THE SEQUOIA AVC ADVANTAGE D-10 DRE VOTING MACHINE (FIRMWARE VERSION 10.3.11)

for

Sequoia Voting Systems
 7677 Oakport Street, Suite 800
 Oakland, CA 94621

(sd)

STATE OF ALABAMA }
 COUNTY OF MADISON }

Robert D. Hardy, Department Manager, being duly sworn, deposes and says: The information contained in this report is the result of complete and carefully conducted testing and is to the best of his knowledge true and correct in all respects.

Robert Hardy

SUBSCRIBED and sworn to before me this 27 day of July 20 07

Sandra A. Daniel
 Notary Public in and for the State of Alabama at Large

SEAL

My Commission expires June 5, 2011

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1.0 INTRODUCTION

1.1 Scope

This report presents the test results for Hardware Qualification Testing of the Sequoia Advantage D-10 DRE Voting Machine with VVPAT.

1.2 Objective

The objective of this test program was to ensure that the Sequoia Voting Systems Advantage DRE Voting Machine, Firmware Version 10.3.11, met the intent of the guidelines set forth in the Federal Election Commission (FEC) Voting System Standards (VSS), April 2002, under which it was originally qualified as documented in Wyle Laboratories' Test Report No. T51884-11, "Hardware Qualification Testing of the AVC Advantage DRE Voting Machine (Firmware Release 10.3.5)", dated September 18, 2006.

1.3 Summary

The AVC Advantage D-10 (Serial Number 23713), configured with a Seiko VVPAT (identified as 'Engineering Sample 4') was subjected to qualification testing per the guidelines of the Federal Election Commission (FEC) Voting System Standards (VSS), April 2002.

The qualification testing (functional testing and source code review) was limited to the resident machine firmware and hardware used at the precinct level and did not include any election management software, which typically resides on a personal computer and is used for ballot definition, absentee, and report canvassing activities.

It was demonstrated that the system tested successfully met the qualification test requirements of the Federal Election Commission Voting System Standards, April 2002. Note: Certification testing requires a production-ready configuration and the VVPAT tested was labeled/represented as an "Engineering Sample".

Due to the varying requirements of individual jurisdictions, it is recommended by the Voting Systems Standards that local jurisdictions perform pre-election logic and accuracy tests on all systems prior to their use in an election within their jurisdiction.

2.0 REFERENCES

- Sequoia Voting Systems Purchase Order No. 10006806
- Sequoia Voting Sequoia Voting Systems Change Release Summary-Main Application, Version 10.3.7 from 10.3.5, Thursday, August 17, 2006
- Sequoia Voting Sequoia Voting Systems Change Release Summary-Main Application, Version 10.3.9 from 10.3.7, Thursday, October 12, 2006
- Sequoia Voting Sequoia Voting Systems Change Release Summary-Main Application, Version 10.3.11 from 10.3.9, Thursday, October 19, 2006

2.0 REFERENCES (continued)

- Sequoia Voting Systems AVC Advantage 10 System Overview, Version 1.02, Part Number 096050082, dated July 2006
- Sequoia Voting Systems AVC Advantage 10 Functional Spec, Version 1.04, Part Number 096050042, dated July 2006
- Sequoia Voting Systems AVC Advantage 10 Software Technical Spec, Version 1.02, Part Number 096050012, dated July 2006
- Sequoia Voting Systems AVC Advantage 10 Data Dictionary, Version 1.03, Part Number 096050032, dated August 2006
- Sequoia Voting Systems AVC Advantage 10 Validation Test Plan, Version 1.05, Part Number 096050092, dated October 2006
- Sequoia Voting Systems AVC Advantage 10 Operators Manual, Version 1.04, Part Number 096050062, dated July 2006
- Sequoia Voting Systems AVC Advantage 10 Maintenance Manual, Version 1.03, Part Number 096050052, dated July 2006
- Sequoia Voting Systems AVC Advantage 10 Change Specification, Version 1.00, Part Number 096050022, dated July 2006
- Sequoia Voting Systems AVC Advantage 10 VVPAT Operators Manual, Version 1.01, Part Number 096050121, dated October 2006
- FEC April 2002 Voting System Standards, Volume I, "Performance Standards", and Volume II, "Test Standards"
- Wyle Laboratories' Test Report No. T51884-11, "Hardware Qualification Testing of the AVC Advantage DRE Voting Machine (Firmware Release 10.3.5)", dated September 18, 2006
- Wyle Laboratories' Quality Assurance Program Manual, Revision 2
- MIL-STD-45662A, "Calibration System Requirements"
- ANSI/NCSL Z540-1, "Calibration Laboratories and Measuring and Test Equipment, General Requirements"
- ISO 10012-1, "Quality Assurance Requirements for Measuring Equipment"

3.0 CUSTOMER

Sequoia Voting Systems
7677 Oakport Street, Suite 800
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4.0 TEST HARDWARE/FIRMWARE DESCRIPTION

The following paragraphs address, in greater detail, the design methodology and product description of the AVC Advantage D-10 DRE Voting Machine, of which the Sequoia Voting Systems' Technical Data Package was the source for much of this information.

4.0 TEST HARDWARE/FIRMWARE DESCRIPTION (continued)

4.1 Hardware

The AVC Advantage D-10 is a Direct-Record Electronic voting machine. It performs the following functions:

- Validate and load ballot definitions.
- Perform pre-election testing and verifications.
- Perform Election Day voting.
- Perform post-election testing and verifications.
- Print Zero Proof and Results Reports.
- Perform maintenance diagnostic tests and functions such as Audit Trail Transfer, Set Time/Date, and print the Event Log report.

The AVC Advantage D-10 provides a full-face ballot presentation for the voter, with up to 504 voting positions. The voting positions are represented by an array of pushbutton switches and LEDs. A printed overlay is used to indicate each contest and candidate, and to provide instructions as desired by the jurisdiction. A Mylar sheet is secured on top of the printed overlay to protect it. Privacy panels, a privacy curtain and an integral booth light are standard.

The AVC Advantage D-10 hardware consists of the following major components:

- **Main CPU:** This is an embedded AMD Elan SC400 based system, running ROM-DOS. It contains 8 Mb of DRAM, 2 Mb of Flash ROM (used for application program storage, ballot definition, and vote data storage), a PCMCIA slot (used for the results cartridge), a battery backed real time clock, and a serial port for communication with the I/O Board.
- **I/O Board CPU:** This is the original Z80 CPU. With firmware version 10, it manages I/O devices and communicates via a dedicated serial port with the Main CPU. It contains program ROM, system ROM, configuration ROM, time and date clock, backup batteries, timers and counters, speaker (beeper), and additional circuits for self-monitoring, connecting the other assemblies, and controlling AVC power consumption.
- **Voter Panel:** The Voter Panel contains all the selection and display devices for the voter. This includes an array of switch modules to select candidates and answer questions, write-in modules to enter write-in selections, cast vote switches to finalize all the voter's selections, and a booth light to light up the front of the ballot.
- **Write-in Keyboard:** The write-in keyboard and display is located below the Voter Panel. The keyboard is used for entering write-in names; the display provides prompts and confirmations to the voter. The write-in keys consist of the letters A-Z, enter (\n), comma (,), hyphen (-), period (.) and apostrophe ('), plus 4 arrow keys: up, down, left, right.

4.0 TEST HARDWARE/FIRMWARE DESCRIPTION (continued)

4.1 Hardware (continued)

- **Operator Panel:** The tethered Operator Panel is mounted on the side of the AVC Advantage D-10 and contains all the selection and display devices for the maintenance technician or poll worker including: switches and LEDs to select and display 12 options, activate or test; an LCD message display; and indicators for ac on and low battery.
- **Report Printer:** An integral thermal printer is used for printing reports.
- **Power Supply:** The power supply includes a 32 amp-hour backup battery that can power the AVC Advantage for up to 16 hours.
- **VVPAT:** The AVC Advantage D-10 supports an optional "cut & drop" VVPAT (Voter Verified Paper Audit Trail) printer. This printer connects to the main CPU printer port and is powered by a Power Splitter board attached to the I/O Board power input.
- **Audio Voting Interface:** The AVC Advantage D-10 includes an optional audio voting interface that is enabled by the poll worker. This interface uses Sequoia's standard Rev D Audio Box. The audio voting interface allows the voter to navigate through the ballot using Next, Back, and Select buttons and to control the volume and playback speed. Ballots cast with the audio interface are not distinguished in any way from those cast using visual voting.

The AVC Advantage D-10 weighs approximately 265 lbs. When opened into the voting position, the AVC Advantage D-10 overall dimensions are: Height: 78", Width: 49", and Depth: 46". The AVC Advantage is designed to operate with a standard 120 VAC, 60 Hz power source.

4.2 Firmware

The Advantage D-10 firmware is partitioned so that the application code resides on the audio subsystem CPU (Application CPU) and the Z80 CPU board (I/O Processor) serves the role of front-end I/O processor. Communications between the I/O Processor and Application CPU is through the serial port.

In depth discussion of the software design concepts are documented in the Sequoia Voting Systems AVC Advantage 10, Software Technical Specification, Document Version 1.02, Part Number 096050012, July 2006.

5.0 MATERIALS REQUIRED FOR TESTING

5.1 Equipment

Sequoia provided a sufficient number of AVC Advantage D-10 machines configured for use with a VVPAT (hereinafter collectively referred to as the EUT); to ensure that parallel testing where feasible could be performed. The machines tested were configured for Manual and Audio Ballot processing. The following identification information was taken from the machines used for testing:

- AVC Advantage D-10: Serial Number 23713
- VVPAT Printer: Seiko Engineering Sample 4

5.0 MATERIALS REQUIRED FOR TESTING

5.2 Test Materials

Sequoia provided all ancillary support material required during the course of the Hardware Qualification Testing.

5.3 Deliverable Materials

Sequoia provided the latest versions of all hardware and software specifications and poll-worker hardware and software user/maintenance manuals. All user manuals have an identifiable Version Number or Document Control Number or Release Date.

The following documents constitute the deliverable materials to the end user:

- Sequoia Voting Systems AVC Advantage 10 Operators Manual, Version 1.04, Part Number 096050062, dated July 2006
- Sequoia Voting Systems AVC Advantage 10 Maintenance Manual, Version 1.03, Part Number 096050052, dated July 2006
- Sequoia Voting Systems AVC Advantage 10 VVPAT Operators Manual, Version 1.01, Part Number 096050121, dated October 2006

6.0 TEST SPECIFICATIONS

6.1 Functional Qualification Tests

The EUT was subjected to a series of tests to simulate Election Day activities at the precinct level. These tests were performed to ensure compatibility of voting machine functions at the precinct level using the revised firmware.

These included activities to simulate:

- a) verification of hardware status via diagnostic reports prior to election
- b) performing procedures required to prepare hardware for election operations
- c) obtaining 'zero' machine report printouts on all contest fields
- d) performing procedures to open the polling place and enable ballot counting
- e) casting of ballots to demonstrate proper processing, error handling, and generation of audit data
- f) performing hardware operations required to disable ballot counting and closing the polls
- g) obtaining machine reports and verifying correctness
- h) obtaining machine generated audit logs and verifying correctness

6.0 TEST SPECIFICATIONS (continued)

6.1 Functional Qualification Tests (continued)

Functional tests were performed to verify source specific changes associated with Change Release 10.3.11. The associated changes added functional enhancements, improvements in the overall structure, maintainability, and readability of the code as well as addressing any bugs identified during actual use or as a result of introduction through a previous step release while still in development. Additionally, some changes were imbedded in overall system operation and not specific to a singular functional attribute.

The following synopsis list major revisions associated with the revised release 10.3.11:

- New Main CPU board that includes:
 - Compact Flash designated as the internal ballot & vote storage device. This provides improved performance over the previous CPU's Flash ROM.
 - Parallel printer port for VVPAT use.
- Firmware changes to support the new Main CPU board.
- Support for an optional cut & drop VVPAT.
- Several bug fixes related to the I/O Board – Main Board communication stability.

The EUT was also subjected to a volume/accuracy test. During the volume and accuracy testing, the Advantage was subjected to the casting of a large number of ballots to verify vote recording accuracy, i.e., at least 1,549,703 ballot positions correctly read and recorded. Testing was performed using an automated Logic & Accuracy test routine. During testing, ballots were cast and printed on the VVPAT. The Barcodes on each receipt were then scanned, totaled, and compared with the machine's total report at the close of testing.

6.2 Electrical Qualification Tests

The EUT was subjected to various Electromagnetic Compatibility tests to ensure continued system operation and reliability in the presence of abnormal electrical events. The EUT was powered and actively processing ballots during all electrical tests.

6.2.1 Power disturbance

Electrical Power Disturbance testing was performed in accordance with Paragraph 4.8.1 of the 2002 Voting Systems Standards. This testing was performed to ensure that the EUT will be able to withstand electrical power line disturbances (dips/surges) without disruption of normal operation or loss of data.

The EUT was configured to run in an automated ballot count test mode, whereas continual ballot processing would occur during the testing. The EUT was then subjected to the voltage dips and surges over periods ranging from 20 ms to four hours.

There was no loss of normal operation and or loss of data as a result of the applied electrical disturbances.

An Electrical Power Disturbance Data Sheet is contained in Attachment A. The Instrumentation Equipment Sheet for the test is presented in Attachment H.

6.0 TEST SPECIFICATIONS (continued)**6.2 Electrical Qualification Tests (continued)****6.2.2 Electromagnetic Radiation**

Electromagnetic Radiation (FCC Part 15 Emissions) measurements were performed in accordance with Paragraph 4.8.2 of the 2002 Voting Systems Standards. This testing was performed to ensure that emissions emanating from the EUT do not exceed the limits of FCC Part 15, Class B emissions.

The EUT was configured to run in an automated ballot count test mode, whereas continual ballot processing would occur during the testing.

The EUT was found to comply with the required emissions limits. The Electromagnetic Radiation data sheets are contained in Attachment B. The Instrumentation Equipment Sheet for the test is presented in Attachment H.

6.2.3 Electrostatic Disruption

Electrostatic Disruption Testing was performed in accordance with Paragraph 4.8.3 of the 2002 Voting Systems Standards to ensure that should an electrostatic discharge event occur during equipment setup and/or ballot counting, that the EUT would continue to operate normally. A momentary interruption is allowed so long as normal operation is resumed without human intervention or loss of data.

The EUT was configured to run in an automated ballot count test mode, whereas continual ballot processing would occur during the testing without operator intervention. The EUT was then subjected to electrostatic discharges of +/- 8 kV contact and +/- 15 kV air. Discharges were performed at areas typical of those, which might be touched during normal operation, including the touch screen, user buttons, and other likely points of contact.

There was no loss of normal operation and or loss of data as a result of the applied discharges.

An Electrostatic Discharge Data Sheet is contained in Attachment C. The Instrumentation Equipment Sheet for the test is presented in Attachment H.

6.2.4 Electromagnetic Susceptibility

Electromagnetic Susceptibility testing was performed in accordance with Paragraph 4.8.4 of the 2002 Voting Systems Standards. This testing was performed to ensure that the EUT would be able to withstand a moderate level of ambient electromagnetic fields without disruption of normal operation or loss of data.

The EUT was configured to run in an automated ballot count test mode, whereas continual ballot processing would occur during the testing without operator intervention. The EUT was then subjected to ambient electromagnetic fields up to a maximum of 10 V/m over a range of 80 MHz to 1000 MHz.

There was no loss of normal operation and or loss of data as a result of the applied electromagnetic fields.

An Electromagnetic Susceptibility Data Sheet is contained in Attachment D. The Instrumentation Equipment Sheet for the test is presented in Attachment H.

6.0 TEST SPECIFICATIONS (continued)**6.2 Electrical Qualification Tests (continued)****6.2.5 Electrical Fast Transients**

Electrical Fast Transients (EFT) testing was performed in accordance with Paragraph 4.8.5 of the 2002 Voting Systems Standards to ensure that, should an electrical fast transient event occur on a power line, the EUT would continue to operate without disruption of normal operation or loss of data.

The EUT was configured to run in an automated ballot count test mode, whereas continual ballot processing would occur during the testing without operator intervention. The EUT was then subjected to electrostatic fast transients of 2 kV applied to its AC power lines.

There was no loss of normal operation and or loss of data as a result of the applied transients.

An EFT Data Sheet is contained in Attachment E. The Instrumentation Equipment Sheet for the test is presented in Attachment H.

6.2.6 Lightning Surge

Lightning Surge Testing was performed in accordance with Paragraph 4.8.6 of the 2002 Voting Systems Standards to ensure that, should a surge event occur on a power line due to a lightning strike, the EUT will continue to operate without disruption of normal operation or loss of data.

The EUT was configured to run in an automated ballot count test mode, whereas continual ballot processing would occur during the testing. The EUT power input lines were then subjected to the following surges:

- +/- 2 kV AC line-to-earth
- +/- 2 kV AC line-to-line

There was no loss of normal operation and or loss of data as a result of the applied surges.

A Lightning Surge Test Data Sheet is contained in Attachment F. The Instrumentation Equipment Sheet for the test is presented in Attachment H.

6.2.7 Conducted RF Immunity

Conducted RF Immunity testing was performed in accordance with Paragraph 4.8.7 of the 2002 Voting Systems Standards. This testing was performed to ensure that the EUT will be able to withstand conducted RF energy onto its power lines without disruption of normal operation or loss of data.

The EUT was configured to run in an automated ballot count test mode, whereas continual ballot processing would occur during the testing without operator intervention. The EUT was then subjected to conducted RF energy of 10 VRML applied to its power lines over a frequency range of 150 kHz to 80 MHz.

There was no loss of normal operation and or loss of data as a result of the applied conducted RF energy.

6.0 TEST SPECIFICATIONS (continued)**6.2 Electrical Qualification Tests (continued)****6.2.7 Conducted RF Immunity (conducted)**

A Conducted RF Susceptibility Data Sheet is contained in Attachment G. The Instrumentation Equipment Sheet for the test is presented in Attachment H.

6.3 Temperature/Power Variation Test

To demonstrate a minimum acceptable Mean-Time-Between-Failure threshold, the EUT was placed inside an environmental walk-in test chamber and connected to a variable voltage power source. The temperature inside the chamber and the voltage supplied to the hardware varied from 50°F to 95°F and from 105 VAC to 129 VAC respectively. During test performance, the EUT was actively processing ballots using an automated test script. The ballots were then printed via the VVPAT. There were no hardware failures encountered during the 163-Hour Reliability Test. The Temperature Profile for the test is presented in Attachment I.

7.0 TEST EQUIPMENT AND INSTRUMENTATION

All instrumentation, measuring, and test equipment used in the performance of this test program were calibrated in accordance with Wyle Laboratories' Quality Assurance Program, which complies with the requirements of ANSI/NCSL 2540-1, ISO 10012-1, and Military Specification MIL-STD-45662A. Standards used in performing all calibrations are traceable to the National Institute of Standards and Technology (NIST) by report number and date. When no national standards exist, the standards are traceable to international standards, or the basis for calibration is otherwise documented.

8.0 WYLE QUALITY ASSURANCE

All work performed on this program was in accordance with Wyle Laboratories' Quality Assurance Program and Wyle Laboratories' Quality Program Manual, which conforms to the applicable portions of International Standard Organization (ISO) Guide 17025.

The Wyle Laboratories, Huntsville Facility, Quality Management System is registered in compliance with the ISO-9001 International Quality Standard. Registration has been completed by Quality Management Institute (QMI), a Division of Canadian Standards Association (CSA).

Wyle Laboratories is accredited (Certificate No. 845.01) by the American Association for Laboratory Accreditation (A2LA), and the results documented in this test report have been determined in accordance with Wyle's scope of accreditation unless otherwise stated in the report.

Pages A-1 through I-11 of the July 26, 2007 Wyle Report No. T51884-12 have been redacted because they contain trade secrets of Sequoia including proprietary source code and related materials.