



VoTeR Center

UConn Voting Technology Research Center

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Pre-Election Audit of Memory Cards for the August 2008 Connecticut Primary Elections

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Summary

The UConn VoTeR Center performed a pre-election audit of the memory cards for the Accu-Vote Optical Scan tabulators that were used in the August 2008 Connecticut Primary Elections. The cards were programmed by LHS Associates of Methuen, Massachusetts. The districts covered by this pre-election audit included all 185 districts participating in the elections. The VoTeR Center received in total 185 memory cards before the elections to be audited. The memory cards were shipped by LHS directly to the VoTeR Center. This document reports on the findings obtained as the result of the audit. Among the 185 cards received and tested by the VoTeR Center, 175 cards (94.6%) were found to have been properly programmed for election. These cards contained valid ballot data and the executable code on these cards was the expected code, with no extraneous data or code on the cards. The remaining 10 cards, or 5.4%, were found to contain “junk” data, that is, they did not contain usable data. Such cards are detected by the tabulators to be unusable, thus they could not have been used in the election.

The audit was performed on request of the Office of the Secretary of the State.

1 Preface

The Voting Technology Research (VoTeR) Center at the University of Connecticut conducted a pre-election audit of the memory cards used in the AccuVote Optical Scan (AV-OS) tabulators in the primary elections of August 2008. The audit was performed on request of the Office of the Secretary of the State of the State of Connecticut.

The memory cards are programmed for the August 2008 election by LHS Associates of Methuen, Massachusetts. The cards for this audit were shipped to the VoTeR Center from LHS.

The memory cards were subject to several integrity tests (an earlier report presents a comprehensive overview of the procedures followed by the VoTeR Center personnel in conducting such audits). In this report, we present the objectives of the pre-election audit, the audit process, and the audit results. The audit process included testing, comparison, and analysis of the data collected during the audit. The procedures followed in this audit include a strict chain of custody policy with regard to handling the cards, maintaining a log of all transactions and activities, and safekeeping (both physical and electro-magnetic) of the memory cards.

We conclude the report with several observations based on what was learned during the pre-election audit process. We believe that technological audits are crucial in providing valuable feedback and maintaining the integrity of the electoral process.

This report is a high-level, non-technical presentation of the audit results and it omits all technical details. We also note that we had no access to, and we did not use any vendor documentation regarding the design and the internals of the AV-OS terminal.

About the UConn VoTeR Center

Following our participation in the Connecticut Voting Technology Standards Board in 2005, the Voting Technology Research (VoTeR) Center was established in 2006 to advise state government in the use of voting technologies, to research, investigate and evaluate voting technology and voting equipment, and to develop and recommend safe use procedures for the computerized voting technology in elections. The personnel of the Center includes several faculty members, graduate students, and staff of the Computer Science and Engineering Department at the University Of Connecticut.

The work of VoTeR Center in the State of Connecticut is funded by the Office of the Connecticut Secretary of the State (SOTS), and we function in close contact with the SOTS Office personnel. We offer the State an independent, objective analysis of the voting technologies offered by several vendors, we advise the State on selecting and administering the voting equipment for its election needs, and we are not associated with any of the voting technology vendors. The evaluations of the voting technology are performed at the VoTeR Center Lab at the University of Connecticut. These include hands-on evaluations, exploration of possible attack vectors, physical integrity checks of the terminals and memory cards, and mitigation strategies. The VoTeR Center is not involved in establishing State's policies for procuring the voting technology, but limited to providing technical expertise on, and evaluating these technologies before deployment and during the use by the State. In this sense the VoTeR Center is a third party independent technical consulting resource for the State of Connecticut.

VoTeR Center personnel assisted the State in developing safe use procedures for the Optical Scan terminals. The procedures in place for the election include strict physical custody policy, tamper-resistant protection of the equipment, and audits.

2 Introduction

We start by overviewing the AV-OS based election system used in Connecticut, the goals of the pre-election memory card audit, and a preview of the audit results.

2.1 Brief Description of the AV-OS

The AV-OS election system consists of two components: the AccuVote Optical Scan voting terminal (AV-OS terminal) and the ballot design and central tabulation system, GEMS, for Global Election Management System. See our reports at URL <http://voter.engr.uconn.edu/voter/> for details on this election system, our audit methodology, and prior audit results. We point out the following characteristics of these components:

- The AV-OS systems currently in use in the State of Connecticut contains the firmware version 1.96.6. It is equipped with an optical scanner, a paper-tape dot-matrix printer, a LCD display, a serial communication port, and telephone jacks leading to a built-in modem.
- The GEMS software is installed on a conventional PC (or a laptop). It includes a ballot design system and a tabulation system.
- Once the election data is entered into the GEMS system, the specifications of the election are downloaded into a memory card via an AV-OS system connected to GEMS by a serial line cable. In the State of Connecticut, GEMS is not used for central tabulation of election results.
- The memory cards are the 40-pin 128KB Epson cards. The memory card is installed into the 40-pin card slot (J40 connector) of the AV-OS. It is worth mentioning that Epson has discontinued this memory card some time ago, and reader/writers for this memory card are not readily available.

For election deployment the system is secured within a ballot box so that no sensitive controls or connectors are exposed to the voter. Each memory card contains executable code that is used for printing the reports. The code is written in a proprietary symbolic language. Such executable files are identified as *.abo (AccuBasic Object) bytecode. The installation of the GEMS software on the PC contains several databases that include the data and ballot layout corresponding to the districts of the State of Connecticut, as well as the bytecode for AV-OS.

2.2 Goals of the Pre-Election Memory Card Audit

The VoTeR Center prepared for and implemented the memory card audit on request of the CT SOTS Office. The primary goal of the pre-election audit was to perform an integrity check of the contents of the memory cards. The 185 cards used in this audit were programmed by LHS and shipped directly to the VoTeR Center. Thus it was expected that no cards will show the results of any pre-election testing and preparation that is normally done at individual districts prior to elections.

The memory cards contain the data and the ballot layout for the elections. The memory cards used in the AV-OS terminals also store the tally of the ballots cast and report the results of the election. In this sense the memory cards are the electronic summary of a physical ballot box. The data, layout and the functionality on the memory cards are loaded on to the memory card using the AV-OS terminal from the GEMS database. The GEMS database to be used as the baseline for the election data was provided by LHS Associates prior to the election. The contents of each of the 185 cards were then extracted and compared with the intended contents using the GEMS database as the reference. The audit process was automated to the extent possible. Any discrepancies or deviations

from the baseline were then logged and analyzed. Specifically, the memory cards were audited for any deviations in the ballot data/layout, bytecode, the state of the counters, and to some extent the audit logs on the memory card.

2.3 Preview of the Audit Results

A total of 185 cards, one card for each participating district, were received and tested by the VoTeR Center. Among the 185 cards, 175 cards (94.6%) were found to have been properly programmed for election. These cards contained valid ballot data and the executable code on these cards was the expected code, with no extraneous data or code on the cards. Moreover these 175 cards were in the state “Not Set for Election” and had non-zero counters. All the cards indicated that one test election was run. In 155 cards 1 ballot was cast and in the remaining 20 cards 2 ballots were cast.

Among the 185 cards, 10 cards, or 5.4% were found to contain “junk” data, that is, they were unreadable by the tabulators, and could not have been used in the election. This is a high percentage of faulty cards.

3 Audit Results

We now present the results of the pre-election audit in detail. For the August 2008 Primary elections we received and examined 185 cards.

3.1 Memory Card Data Audit Results

Table 1 shows the frequency of various states observed on the audited memory cards for the 185 cards examined. Our reported results are divided into three parts:

(a) **Card Format:** About 94.6% of the cards were properly formatted and contained good data.

The rest 5.4% of cards contained “junk” data, that is the card format is unrecognizable and appears to contain arbitrary noise. Such cards are not readable by AV-OS and they are readily detected through pre-election testing by poll workers, thus they could not have been used in the election.

In the rest of the analysis the percentages are computed for the 175 cards (94.6%) that were properly formatted and contained good data, i.e., the cards that did not contain junk data.

(b) **Card Status:** This refers to the current state of the memory card, such as loaded with an election, set for election, running an election, or closed election, and others.

All 175 cards were in Not Set for Election state. This is the intended state for cards that are programmed using GEMS (by LHS).

(c) **Card & Counter Status:** All 175 cards had non-Zero counters. This suggests that a test election was run on each card (presumably at LHS). This is confirmed by the fact the all 175 cards had election count one, indicating that one test election was run on them. This is the expected counter status for cards provided for Connecticut elections.

3.2 Bytecode Analysis Result

We have analyzed the Accu-Basic bytecode that is loaded into each programmed memory card. Based on the analysis we conclude that the bytecode provided by LHS Associates for the elections is safe to use. The bytecode performs the expected reporting functions. Note that it is not possible to overwrite the contents of the card with the Accu-Basic bytecode.

	All Cards	
	Number	% Total
(a) Card Format		
Good Data, Clean Card	175	94.6%
Good Data, Some "Specks"	0	0.0%
Unusable Cards, "Junk Data"	10	5.4%
Totals:	185	100%
(b) Card Status		
Not Programmed (Blank)	0	0.0%
Not Set for Election	175	100%
Set for Election	0	0.0%
Results Print Aborted	0	0.0%
Election Closed	0	0.0%
Results Sent/Uploaded	0	0.0%
Audit Report Printed	0	0.0%
Totals:	175	100%
(c) Card & Counter Status		
Not Set for Election, Non-Zero Counters	175	100%
Not Set for Election, Zero Counters	0	0.0%
Set for Election, Zero Counters	0	0.0%
Results Print aborted, Non-Zero Counters	0	0.0%
Election Closed, Non-Zero Counters	0	0.0%
Election Closed, Zero Counters	0	0.0%
Totals:	175	100%

Table 1: Memory card analysis summary for all cards: (a) card format, (b) card status, (c) card & counter status.

4 Discussion and Recommendations

Memory card audits are crucial in providing valuable and timely information necessary to ensure the integrity of our electoral system. This section contains the conclusions we draw from the pre-election audit process.

1. Larger than acceptable number of cards contained what we describe as “junk” data. By saying that we understand that the card does not contain proper programming, and instead contains what appears to be random noise. When one puts the card containing the “junk” data into the AV-OS terminal it issues a prompt requesting to format the card. Thus such cards are easily detectable and cannot possibly be used in an election. It seems unlikely that these cards were (electromagnetically) damaged in shipping. Consequently, it appears that these cards were either not adequately tested by LHS Associates, or they experienced some kind of hardware/software failure at some point. Among the audited cards 5.4% of the cards contained junk data. This percentage is high and this issue has to be resolved in the future.

2. No detected ballot data or bytecode corruption.

During the data analysis we have not detected any corruption of the ballot data or the bytecode. The ballot layout of the audited cards were identical to the ballot layout of the corresponding baseline data.

3. August 2008 pre-election audit vs. post-election audit.

We performed pre-election audit of cards for *all* districts, and in this sense it is a complete audit. However the cards do not contain the results of pre-election testing done by the districts, and they were not randomly selected by the districts for the purpose of the audit. Instead the cards were provided to us directly by LHS. The results of the audit would be strengthened if it covered also the pre-election testing done by the districts. Our previous memory card audits in fact included this. However, our forthcoming companion report (to be available at <http://voter.engr.uconn.edu/voter/Reports.html>) will document the results of the post-election audit, covering most of the districts, and containing the observations about the card usage in pre-election testing at districts and in the election itself.

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