Electronic Voting: Problems & Solutions

Daniel P. Lopresti

http://www.cse.lehigh.edu/~lopresti

Department of Computer Science & Engineering
Lehigh University, Bethlehem, PA

E-Voting in the news

Security Analysis of the Diebold AccuVote-TS Voting Machine

Electronic Voting Systems:
the Good, the Bad, and the Stupid

SECURITY ALERT: July 4, 2005
Critical Security Issues with Diebold Optical Scan Design

Security Assessment of the Diebold Optical Scan Voting Terminal

Pennsylvania voters: trust but verify
Poll finds most want ballot verification

Electronic Voting System Usability Issues

HE MACHINERY OF DEMOCRACY:
ROTECTING ELECTIONS
N AN ELECTRONIC WORLD

Hack-a-Vote: Security Issues with Electronic Voting Systems

Analysis of an Electronic Voting System

Privacy Issues in an Electronic Voting Machine

SECURITY ALERT: May 11, 2006
Critical Security Issues with Diebold TSx

Trusted Agent Report
Diebold AccuVote-TS Voting System

Main take-away points

- E-voting systems are general-purpose computers running specialized voting software.
- Same concerns arise as in any complex software/hardware system.
- Current certification process provides little or no assurance: it is incapable of identifying many critical vulnerabilities.
- Independent computer security experts left largely on the sidelines.
- Situation in Pennsylvania is troubling because we do not require Voter Verified Paper Records (VVPR), unlike many states.

Why are we interested?

Motivation:

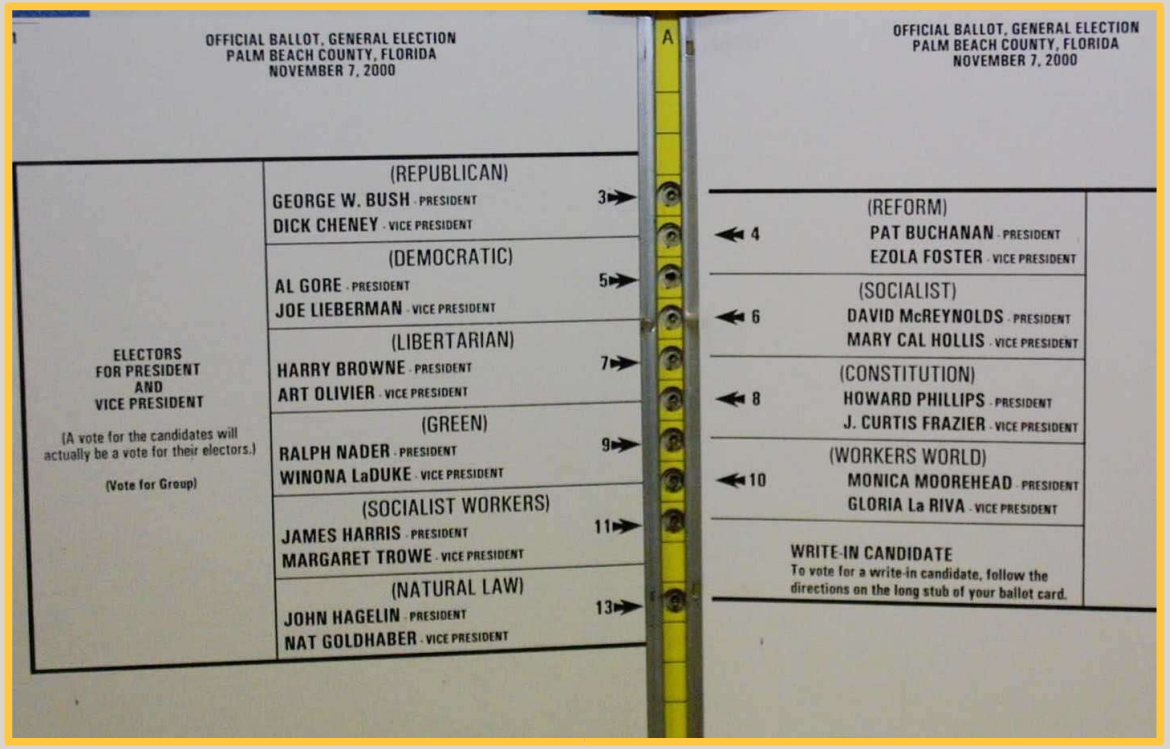
- Fair and accurate elections are vital for a healthy democracy.
- Any voting system carries with it some risk. Past experience with paper ballots, lever machines, etc., has let us understand that risk.
- Electronic voting systems introduce whole new classes of risks.

Some questions my colleagues and I seek to answer:

- What are the risks associated with e-voting technologies?
- How can these risks best be mitigated?
- Can the current certification process identify bad e-voting systems?
- If not, what would be an effective certification procedure?

Background leading to HAVA

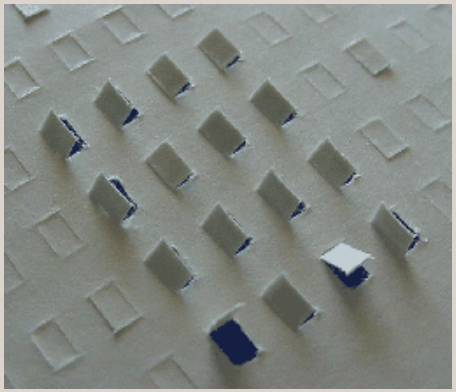
The infamous butterfly ballot from the 2000 Presidential election:

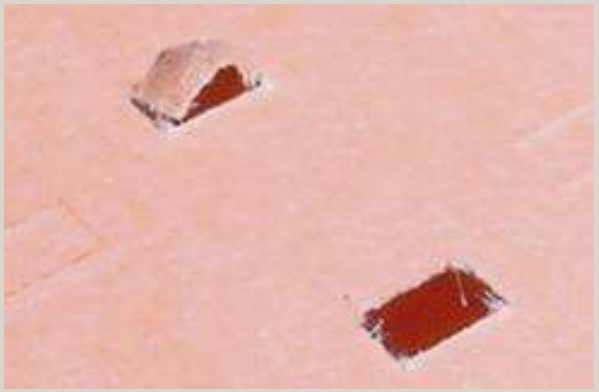


The Florida ballot is a classic example of bad user interface design. Computer software can suffer from such problems just as easily.

http://www2.indystar.com/library/factfiles/gov/politics/election2000/img/prezrace/butterfly_large.jpg

Hanging chads & voter intent





Votomatic technology used in Florida was prone to paper jams. This led to hanging and dimpled chads, making it hard to determine voter intent.

http://www.cs.uiowa.edu/~jones/cards/chad.html
http://www.pushback.com/justice/votefraud/DimpledChadPictures.html

Election technology & HAVA

The Help America Vote Act (HAVA) provides funds for states to replace punched card and lever voting systems. It does not mandate the use of direct recording electronic (DRE) systems.

Some general goals to keep in mind as we weigh alternatives:

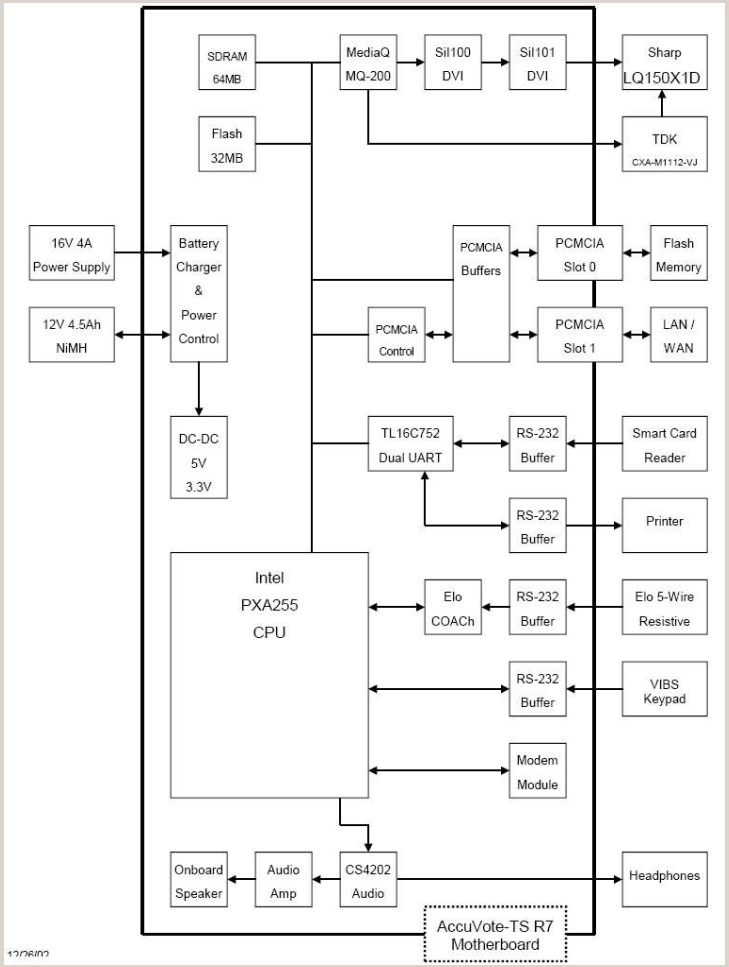
- secure and transparent elections,
- accurate determination of voter intent,
- voter anonymity,
- accessibility for disabled voters and non-native English voters,
- if possible, prevent overvoting (invalidates voter's ballot),
- if possible, prevent unintentional undervoting (voter confusion?).

http://www.fec.gov/hava/law_ext.txt

Diebold AccuVote System

Demo in Allentown:

Diebold AccuVote-TSx block diagram:



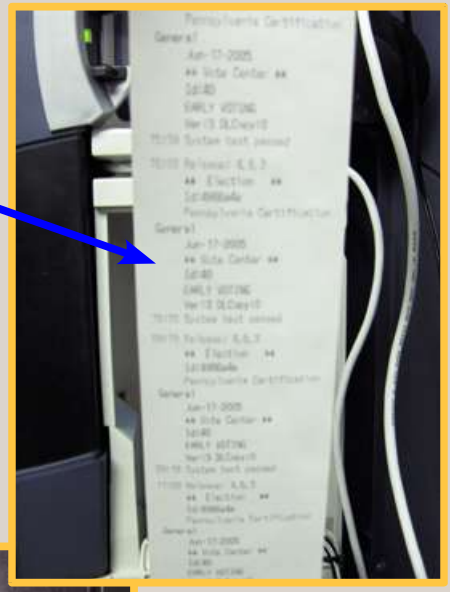
DRE systems are nothing more than specialized computers.

http://www.wfmz.com/cgi-bin/tt.cgi?action=viewstory&storyid=13711
http://www.bbvforums.org/forums/messages/1954/AccuVote-TSx_2_02_System_Overview-23267.pdf

More photos from Diebold demo

Built-in printer

Paper tape (used for end-of-day tally)



PCMCIA slot

PCMCIA card

E-voting risks

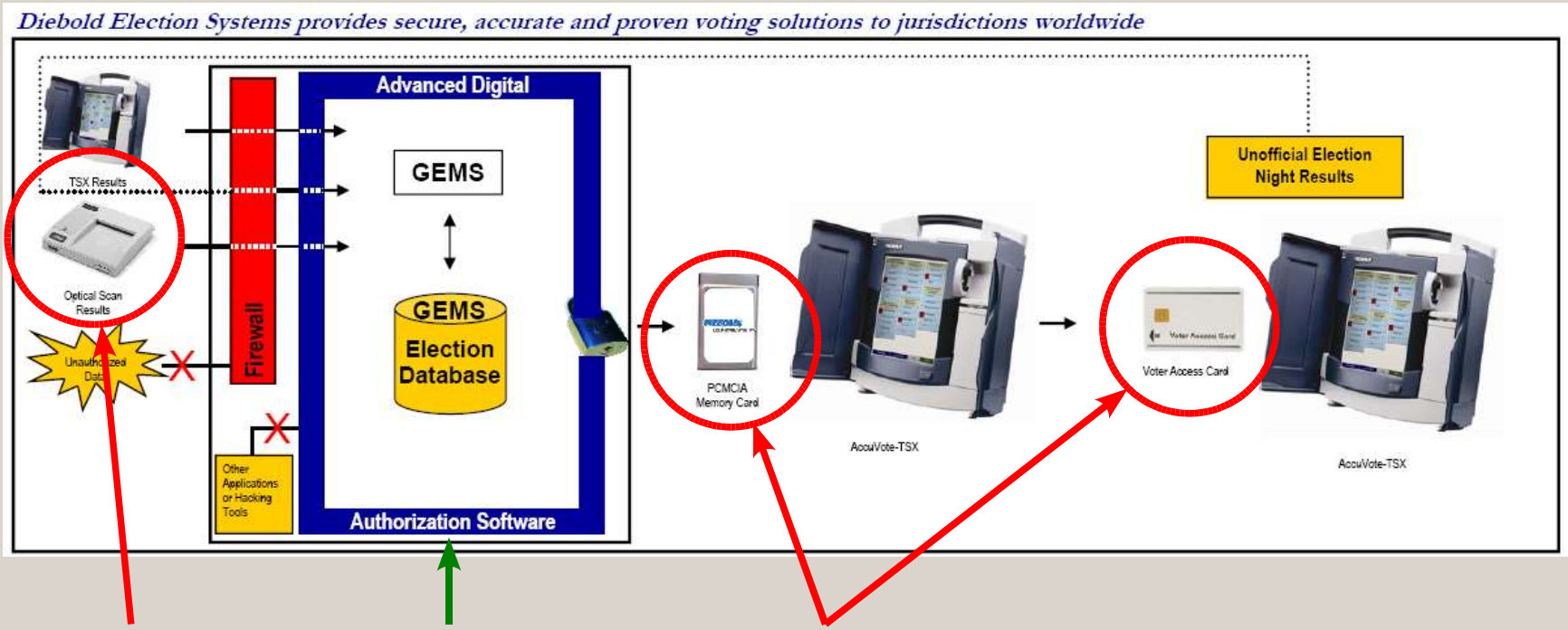
While there are several DRE vendors, one truth holds: all computer hardware/software systems of this complexity have bugs.

Bugs can manifest themselves in different ways:

- cause system to be unreliable (crash, lose votes),
- create openings that allow an outsider to compromise election,
- create openings that allow an inside to compromise election.

Such attacks can be impossible to detect after-the-fact.

Diebold security



What we mostly worry about

May or may not be safe

What we mostly worry about

(But insider attacks can arise anywhere.)

http://www.diebold.com/dieboldes/pdf/industrysecurity.pdf

Risk analysis of e-voting software

- Avi Rubin and colleagues at Johns Hopkins obtained copy of Diebold e-voting software which appeared on the Internet.*
- Studied it carefully – made results public in 2003.
- Findings include:
  - "... far below even the most minimal security standards ..."
  - "... unauthorized privilege escalation, incorrect use of cryptography, vulnerabilities to network threats, ..."
  - "... voters ... can cast unlimited votes without being detected ..."

* E-voting vendors often assert they must be allowed to keep their software secret to protect it. This proves the futility of that idea.

"Analysis of an Electronic Voting System," Tadayoshi Kohno, Adam Stubblefield, Aviel D. Rubin, and Dan S. Wallach, *IEEE Symposium on Security and Privacy*, 2004.

Risk analysis of e-voting software

Summary of potential vulnerabilities identified by Rubin, et al.

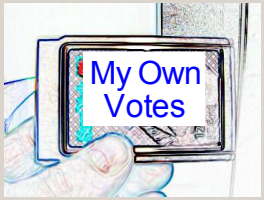
	Voter (with forged smartcard)	Poll Worker (with access to storage media)	Poll Worker (with access to network traffic)	Internet Provider (with access to network traffic)	OS Developer	Voting Device Developer	Section
Vote multiple times using forged smartcard	•	•	•				3.2
Access administrative functions or close polling station	•	•			•	•	3.3
Modify system configuration		•			•	•	4.1
Modify ballot definition (e.g., party affiliation)		•	•	•	•	•	4.2
Cause votes to be miscounted by tampering with configuration		•	•	•	•	•	4.2
Impersonate legitimate voting machine to tallying authority		•	•	•	•	•	4.3
Create, delete, and modify votes		•	•	•	•	•	4.3, 4.5
Link voters with their votes		•	•	•	•	•	4.5
Tamper with audit logs		•			•	•	4.6
Delay the start of an election		•	•	•	•	•	4.7
Insert backdoors into code					•	•	5.3

"Analysis of an Electronic Voting System," Tadayoshi Kohno, Adam Stubblefield, Aviel D. Rubin, and Dan S. Wallach, *IEEE Symposium on Security and Privacy*, 2004.

One potential exploit

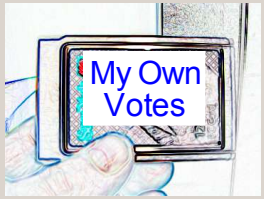
Attempt is made to protect integrity of voting records by encrypting them before storage on PCMCIA memory card ...

Okay!



No way!

... unfortunately, the key is hardwired in the code and now widely known across Internet (it's "F2654hD4").



Okay!

"Analysis of an Electronic Voting System," Tadayoshi Kohno, Adam Stubblefield, Aviel D. Rubin, and Dan S. Wallach, *IEEE Symposium on Security and Privacy*, 2004.

A more recent risk analysis

- Report of the California Secretary of State's Voting Systems Technology Assessment Advisory Board (VSTAAB).
- Examined parts of both Diebold touchscreen system (AV-TX) and optical scan system (AV-OS) – published February 14, 2006.
- Findings include:
  - "Memory card attacks are a real threat ..."
  - "... anyone who has access to a memory card of the AV-OS ... and can have the modified card used ... can indeed modify the election results ..."
  - "The fact that the the [sic] results are incorrect cannot be detected except by a recount of the original paper ballots."

"Security Analysis of the Diebold AccuBasic Interpreter" by David Wagner, David Jefferson, Matt Bishop, Chris Karlof, and Naveen Sastry, February 14, 2006.

Some lessons never learned

"There is a serious flaw in the key management of the crypto code that otherwise should protect the AV-TSx from memory card attacks. Unless election officials avail themselves of the option to create new cryptographic keys, the AV-TSx uses a default key. This key is hard coded into the source code for the AV-TSx, which is poor security practice because, among other things, it means the same key is used in every such machine in the U.S. Worse, the particular default key in question was openly published two and a half years ago in a famous research paper, and is now known by anyone who follows election security, and can be found through Google."

"Security Analysis of the Diebold AccuBasic Interpreter" by David Wagner, David Jefferson, Matt Bishop, Chris Karlof, and Naveen Sastry, February 14, 2006.

Even more recent risk analyses

- Last May, Finnish security expert Harri Hursti announced he found a serious flaw in the Diebold AccuVote TSx touchscreen system.
- This flaw allows system to be permanently reprogrammed in a matter of a few minutes. No special hardware is required.
- Last fall, a team of Princeton researchers announced they had implemented Hursti's attack and proved that it works. They used an older Diebold system given by an anonymous donor.
- The Princeton team also implemented a virus form of the attack that spreads from one infected machine to others via memory card.
- Case opened using several methods, including picking the lock.

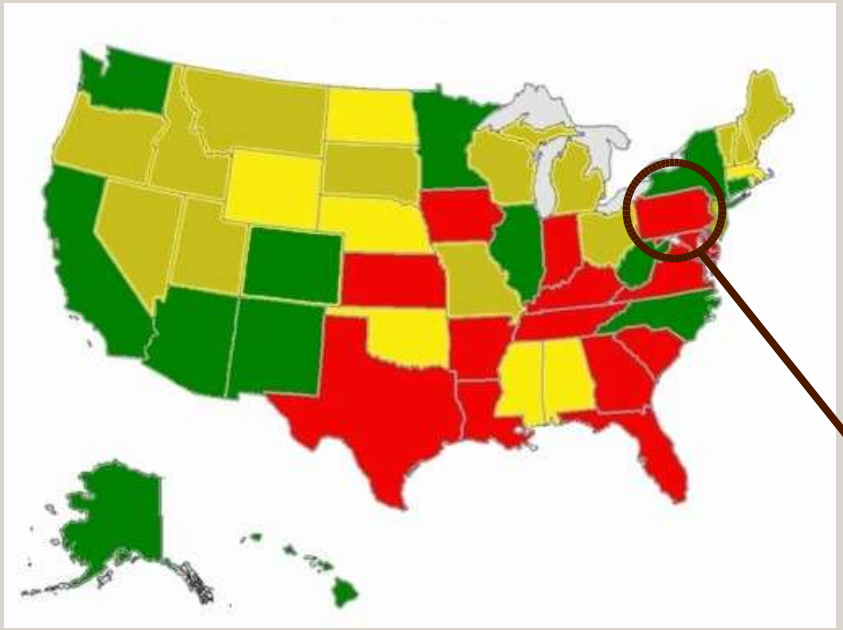
"Diebold TSx Evaluation: Critical Security Issues with Diebold TSx," by Harri Hursti, May 11, 2006.
"Security Analysis of the Diebold AccuVote-TS Voting Machine" by Ariel J. Feldman, J. Alex Halderman, and Edward W. Felten, September 13, 2006.

Short video clip

From the official video record of the Pennsylvania certification examination for Diebold AccuVote and OptiScan systems conducted by the Office of the Secretary of the Commonwealth in Harrisburg on November 22, 2005.

Voter-Verified Paper Records

- A key recommendation from many security experts is the establishment of Voter-Verified Paper Records (VVPR).
- As of today, this is only way to guarantee an independent recount.



VVPR + manual audits required (13)

VVPR required; No audit requirement (14)

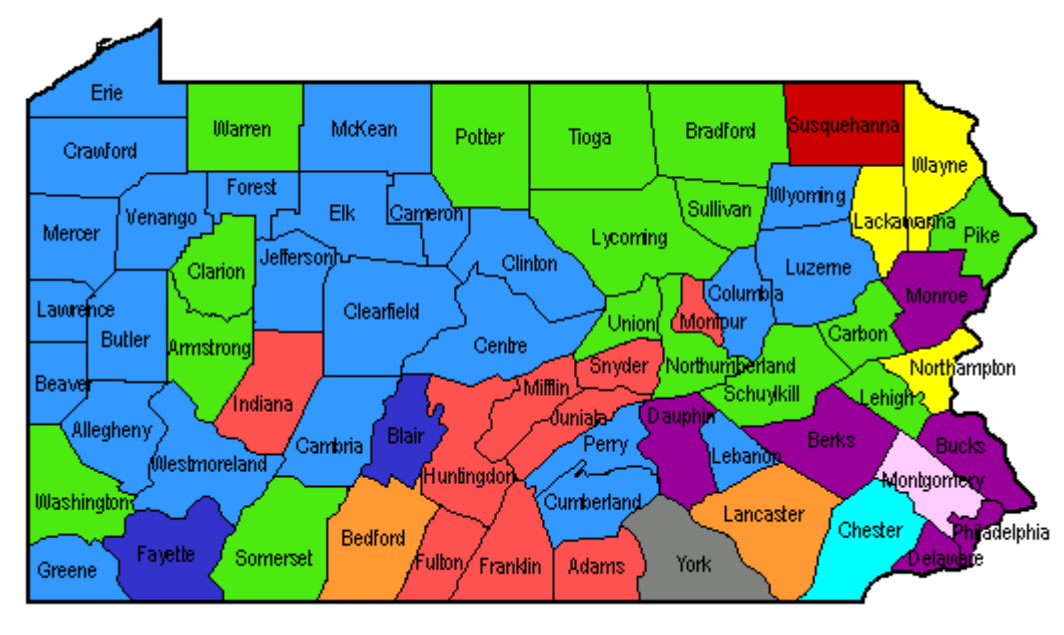
VVPR not required but in use statewide; No audit requirement (8)

No VVPR requirement; No audit requirement (15)

Pennsylvania

From CoalitionforVotingIntegrity.org,5/1/07

E-Voting in Pennsylvania



ES&S iVotronic

Advanced WINvote

Danaher 1242

Hart InterCivic eSlate2

ES&S Model 100/iVotronic

ES&S Model 650/AutoMark

Sequoia Edge

Sequoia Advantage

ES&S Model 100/AutoMark

Diebold TSX

Hart InterCivic eScan /
Hart InterCivic eSlate

http://www.dos.state.pa.us/voting/cwp/view.asp?a=1218&Q=446365

Common retorts

- "These attack scenarios are unlikely."
- "Our e-voting systems are certified, so they must be safe."
- "Poll workers are trained to recognize potential problems."
- "Multiple copies of the data are stored in the system, so we're okay."
- "Re-printing the end-of-day tally is just as good as a recount."
- "There's no evidence of anyone having success in an attack like this."

My assessment: = optimistic = wrong = plain silly

There is no doubt we need good policies and procedures in addition to good, safe technology. (I believe almost everyone involved would like to do the right thing.)

My recommendations

For secure and transparent elections, we should insist on:

- Giving independent experts unfettered access to e-voting software and hardware for verification purposes.
- Use of Voter Verified Paper Records (VVPR).
- Mandatory audits (hand-count a random sampling of all ballots).

And tell our lawmakers to pass pending legislation:

- H.R. 550 ("The Voter Confidence and Increased Accessibility Act").
- Pennsylvania H.B. 53.

Pennsylvania H.B. 53

(4.1) The voting system, pursuant to section 1112.1-A, shall produce or require the use of an individual voter-verified paper record of the voter's vote that shall be made available for inspection and verification by the voter before his vote is cast.

(b) A voter-verified paper record may include any of the following:

(1) A paper ballot prepared by the voter for the purpose of being read by an optical scanner.

(2) A paper ballot prepared by the voter to be mailed to an election official, whether from a domestic or overseas location.

(3) A paper ballot created through the use of a ballot marking device.

(4) A paper printout of the voter's vote produced by a touch screen or other electronic voting machine if, in each case, the record permits the voter to verify the record in accordance with this section.