



Making Sure Every Vote Counts in the Digital Era: The Need for Standards Mandating Voter-Verified Paper Ballots

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Abstract

Americans vote using a variety of different technologies. At present, paper ballots, lever machines, and punchcards are being replaced by optically-scanned ballots and direct recording electronic (DRE) voting systems. While many communities have been eager to embrace computerized voting, important security and reliability concerns exist. Some experts in the field of computer science have recognized these vulnerabilities and advocate for the use of voter-verified paper ballots as a means to ensure election integrity.

Few standards exist to regulate electronic voting. While Congress passed the Help America Vote Act of 2002, several states have independently taken measures to improve the election process. Guidelines mandating the use of voter-verified paper ballots need to be developed and enacted in an effort to increase voter confidence.

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“If you think technology can solve our voting problems, then you don’t understand the problems and you don’t understand the technology.” –An observer of voting technology

“After the 2000 election, the voting technology itself became the focus of large-scale public attention. The issue of electronic voting machines, particularly those that generate no paper receipts or other record that can be used in a recount, spawned a huge grassroots activist movement.” –Avi Rubin, Johns Hopkins University computer scientist and electronic voting expert

1.0 Introduction

The means by which Americans vote have evolved greatly over the past 200 years. From paper ballots to mechanical lever machines to punchcards, optical scanners, and direct electronic recording (DRE) machines, Americans have cast their vote using - and placed their faith in - various voting technologies. Changes in how Americans vote have been typically incited by a specific problem, technological advances, or efforts to improve the voting process. However, while innovative solutions solve old problems, new problems inevitably emerge. Frederick Allen wrote in 2001 that “no vote-counting method can ever be perfect, because no technology can ever be perfect - and that’s because technology is but the continuation of human activity by other means.”¹ Six years later, his words remain true.

In the United States, elections are not administered by the federal government but by states and local jurisdictions. Rebecca Mercuri, an expert on electronic voting, remarks that “the establishment of election standards is a matter of states’ rights. In the absence of congressionally enacted laws or a Constitutional amendment creating minimal requirements for Federal elections, the equipment used for voting (which typically is the same as that provided for local or state-wide races) can differ from state to state, and further may even differ between and within counties in each state.”² Counties,

¹ Manning, Jason, and Jessica Moore. *History of Voting Technology*. 15 December 2003. The Online NewsHour. 5 July 2007. <http://www.pbs.org/newshour/vote2004/primaries/sr_technology_history.html>.

² Mercuri, Rebecca. *The FEC Proposed Voting Systems Standard Update*. 10 September 2001. 13 July 2007. <<http://www.notablessoftware.com/Papers/FECRM.html>>.

sometimes even individual municipalities, are given the responsibility of choosing the voting system that best matches the needs and budget of their particular community.

2.0 Background

2.1 Paper Ballots

Paper ballots have been employed since the mid-19th century, when the desire to cast votes in secret gained prominence. (The confidentiality of individual ballots was not a priority during the infancy of the United States; votes were verbally cast in public.) At first, American voters created their own ballot by simply writing down their choices on a piece of paper. Concern over accurate vote counting along with voter privacy and vote fraud, however, led to the establishment of government-printed standardized ballots. Originally adopted by the Australian state of Victoria in 1856, the Australian ballot was a major innovation in voting technology. New York became the first American state to use the ballot in 1889.

While the Australian ballot continues to be used around the world, vote-counting scandals and a desire to make elections more efficient have led to a general move away from paper ballots. Jason Manning and Jessica Moore write that “reformers who sought to change the system argued that corrupt officials could manipulate the counting procedure by stuffing ballot boxes or throwing out legitimately cast paper ballots.”³ According to legend, often times “vote counters elected officials, not voters.”⁴

Another issue with hand-marked paper ballots is the subjective interpretation of each and every mark on the ballot. Douglas W. Jones of the University of Iowa writes that “this weakness was the focus of the Supreme Court decision that followed the 2000 general election...if corrupt officials cannot control the ballots that land in the ballot box, they may still try to control how they are counted.”⁵

Regardless, problems with the Australian paper ballot can be overcome by strict accounting requirements, specifically the requirement that the official election canvass include not only the count of acceptable votes for one or another candidate, but also

³ Manning, Jason, and Jessica Moore. *History of Voting Technology*. 15 December 2003. The Online NewsHour. 5 July 2007. <http://www.pbs.org/newshour/vote2004/primaries/sr_technology_history.html>.

⁴ Ibid.

⁵ Jones, Douglas W. *A Brief Illustrated History of Voting*. 5 July 2007. <<http://www.cs.uiowa.edu/~jones/voting/pictures/>>.

counts of the numbers of undervotes (a race in which a voter did not select a candidate) and votes not counted due to improper marking. Jones concludes by stating that “a properly administered Australian paper ballot sets an extremely high standard that any competing election technology must match, but in a general election such as those in the United States, where a single ballot may include over 50 individual candidates and questions on the ballot, hand counting can be a very expensive proposition.”⁶

2.2 Lever

The Meyers Automatic Booth was first introduced in Lockport, New York in 1892. This mechanical lever machine employed a complicated network of gears and levers to “protect mechanically the voter from rascaldom, and make the process of casting the ballot perfectly plain, simple, and secret.”⁷ Lever machines also sped up the voting process, providing instantaneous results by combining the casting, recording, and counting of votes. The machines grew in popularity, and by the 1930s, the majority of the nation’s urban centers had adopted lever voting machines.

While lever voting machines completely eliminate questions related to ballot interpretation, they too are not perfect. Johns Hopkins computer scientist Avi Rubin writes that “the machines were intricate and delicate, with hundreds of tiny moving parts that were subject to breakdown and malfunction.”⁸ Another downside is the lack of a record of each voter’s individual ballot. In addition, election policy and technology consultant Roy G. Saltman has noted that the number 99 shows up in lever machine vote totals significantly more than expected than if the vote totals were randomly distributed. For an unknown mechanical reason, the gears did not turn over to 100 and a large number of votes were lost.

2.3 Punchcards

Invented by Herman Hollerith in the late 19th century, punched cards were first used to tabulate vital statistics by the Baltimore Board of Health. Much later, IBM developed

⁶ Jones, Douglas W. *A Brief Illustrated History of Voting*. 5 July 2007. <<http://www.cs.uiowa.edu/~jones/voting/pictures/>>.

⁷ Ibid.

⁸ Rubin, Aviel. *Brave New Ballot: The Battle to Safeguard Democracy in the Age of Electronic Voting*. New York: Broadway, 2006. Page 12.

pre-scored punched cards and the *Port-A-Punch* card punch; this technology was adapted for voting by two University of California at Berkeley professors in the 1960s. The system became known as the Votomatic machine and ballot.

The Votomatic ballot was “printed on a standardized punch card that a computer could read, which sped up the process and purportedly decreased the possibility that human vote counters could tamper with results. The punch card voting system also left a record of individual voter intent, making a recount possible.”⁹ In addition, ten punch card devices could be purchased for the cost of two lever machines.

Douglas W. Jones writes that “problems with Votomatic technology have been known since the late 1960s. It is common to notice a few pieces of chad [paper particles created when holes are punched in paper] accumulating in areas where Votomatic ballots are being processed, and each of these may represent a vote added to some candidates’ total by accident...[however] it was not until the general election of November 2000 that problems with Votomatic voting technology became the subject of widespread public discussion.”¹⁰

Another punchcard voting technology of note is the DataVote system. DataVote ballots are specially printed for each election and have candidate names printed by each punching position. While the punch system employed by the DataVote ballot eliminates the chad problems of the Votomatic, the capacity of a single DataVote ballot is smaller.

2.4 Optical Scan

The first optical mark-sense test scoring machines were invented in the mid-1950s by University of Iowa professor E.F. Lindquist. The technology was developed as an alternative to that used by IBM since the late 1930s, which sensed the electrical conductivity of graphite pencil marks on paper. Originally used to score large numbers of standardized educational tests, the optical mark-sense technology was first used for voting in 1962. While optical scanning systems create an individual paper record of each vote for auditing purposes, improperly filled-in ballots can lead to serious irregularities.

⁹ Manning, Jason, and Jessica Moore. *History of Voting Technology*. 15 December 2003. The Online NewsHour. 5 July 2007. <http://www.pbs.org/newshour/vote2004/primaries/sr_technology_history.html>.

¹⁰ Jones, Douglas W. *A Brief Illustrated History of Voting*. 5 July 2007. <<http://www.cs.uiowa.edu/~jones/voting/pictures/>>.

2.5 Electronic

The concept of electronic voting dates back to 1850, when Albert Henderson patented “an electrochemical vote recorder for legislative roll-call votes (U.S. Patent 7,521).”¹¹ Thomas Edison improved upon this idea in 1869 by adding electromechanical counters to count votes (U.S. Patent 90,646). A push-button paperless electrical voting machine for use in polling places (U.S. Patent 616,174) was proposed by Frank S. Wood in 1898 but not realized until nearly 70 years later.

McKay, Ziebold, Kirby, Hetzel, and Snyderaker were granted U.S. Patent 3,793,505: Electronic Voting Machine on February 19, 1974. This patent comprised an “electronic voting machine including a video screen containing the projected names of candidates or propositions being voted, utilizing a film strip containing individual frames having images projected onto the video screen by a light source, wherein photo-optical information transmittal circuits are actuated by the light source projecting the voting image and, by means of controlled light sensitive areas on the film strip, energizing phototransistor units in the system to activate voting buttons, check film alignment, operate vote counters and identify the vote, whether it be cumulative, a proposition or an ordinary vote, with the information furnished by the phototransistor units being read by photosensitive logic units which transmit information to the projector and counter units.”¹²

Between 1976 and 1980, voters in several Illinois counties used the “Video Voter” machine, the first direct-recording electronic voting system employed in a real election. Not until 2000, however, did the disputed presidential election lead to a nationwide move toward voting technology that would eliminate punch card machines. The most common electronic voting systems today are the AccuVote-TS by Diebold Election Systems, the AVC Advantage by Sequoia Voting Systems, the Microvote DRE and MV-464 by Microvote Corp., the Votronic and iVotronic by ES&S, and the Shouptronic 1242 DRE.

¹¹ Jones, Douglas W. *A Brief Illustrated History of Voting*. 5 July 2007. <<http://www.cs.uiowa.edu/~jones/voting/pictures/>>.

¹² McKay, et. al. *United States Patent: 3793505*. USPTO Patent Full-Text and Image Database. 13 July 2007. <<http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=3,793,505.PN.&OS=PN/3,793,505&RS=PN/3,793,505>>.

2.6 Comparison

While paper ballots were the norm during the first half of the 20th century, by the 1960s more than half of the Nation's votes were cast on lever machines. Kimball Brace, president of Election Data Services Inc., writes that "precincts then tended to be smaller in size because the high cost of lever machines prevented election officials from placing large numbers of these devices in each precinct."¹³ However, many women (who traditionally staffed the polls) were moving into the workforce, and due to the resulting loss in manpower, election officials proposed cutting the number of precincts and increasing the size of the remaining polling places.

Following development, the low cost of punch card voting apparatus enabled election officials to create larger precincts. Brace continues to write that "while bigger counties began to adopt punch cards, smaller counties needed a solution that would allow them to continue to use paper ballots, but tally election results more quickly. This led to the development of optical scan devices for voting in the 1970s."¹⁴ Since then, trends show that counties using paper ballots tend to switch to optically scanned ballots, while counties using punch cards tend to switch to DRE machines.

The following graphs show the percentage of counties and registered voters, respectively, using various voting technologies over the time period 1980 – 2006:

¹³ Brace, Kimball W. *Overview of Voting Equipment Usage in United States, Direct Recording Electronic (DRE) Voting*. 5 May 2004. Election Data Services. 5 July 2007.

¹⁴ Ibid.

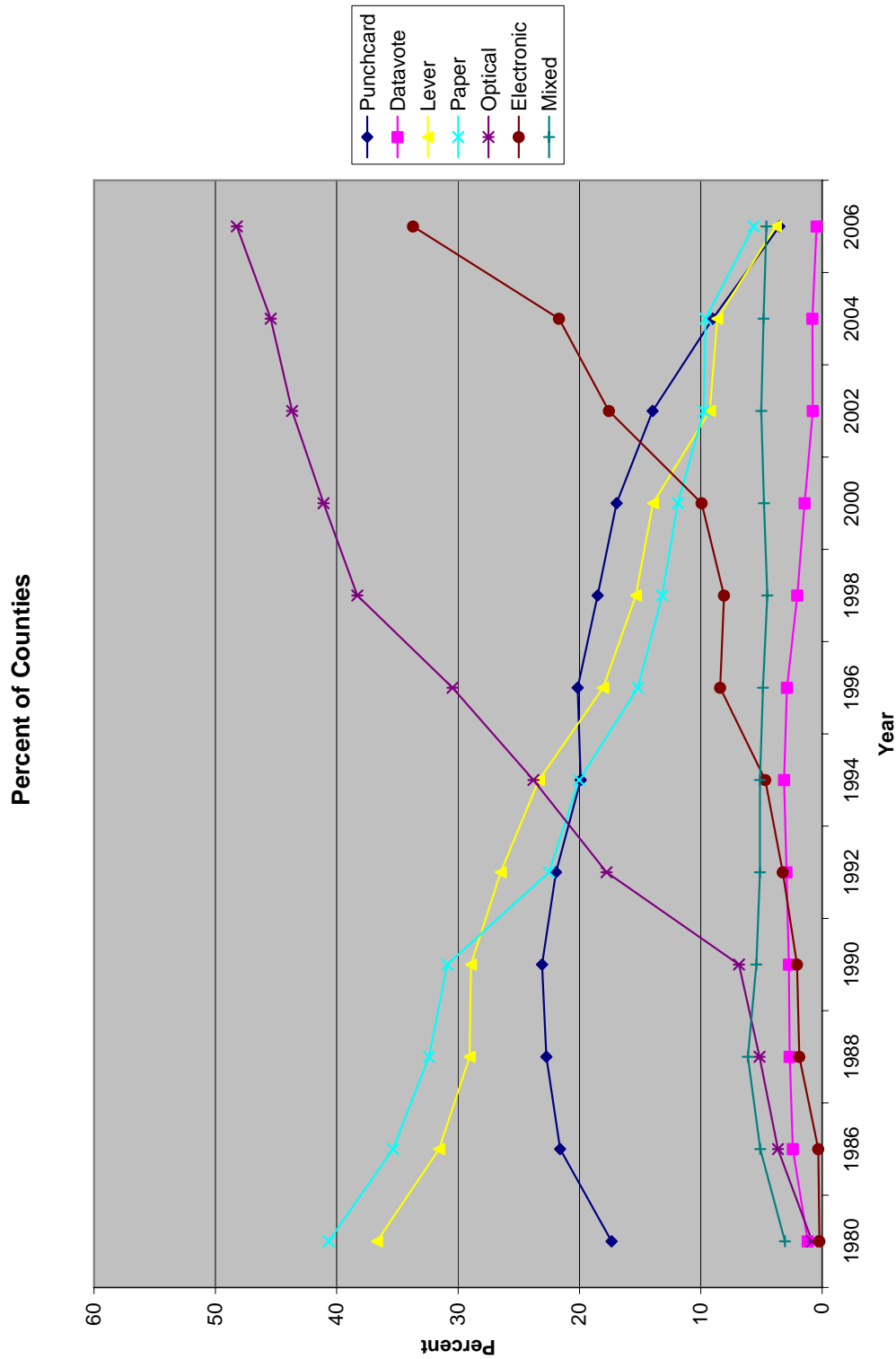


Figure 1. Voting Technologies Used by Percent of Counties.¹⁵

¹⁵ All data from *Voting Equipment Studies* released by Election Data Services.
 <<http://www.edssurvey.com/index.php?content=votequip>>.

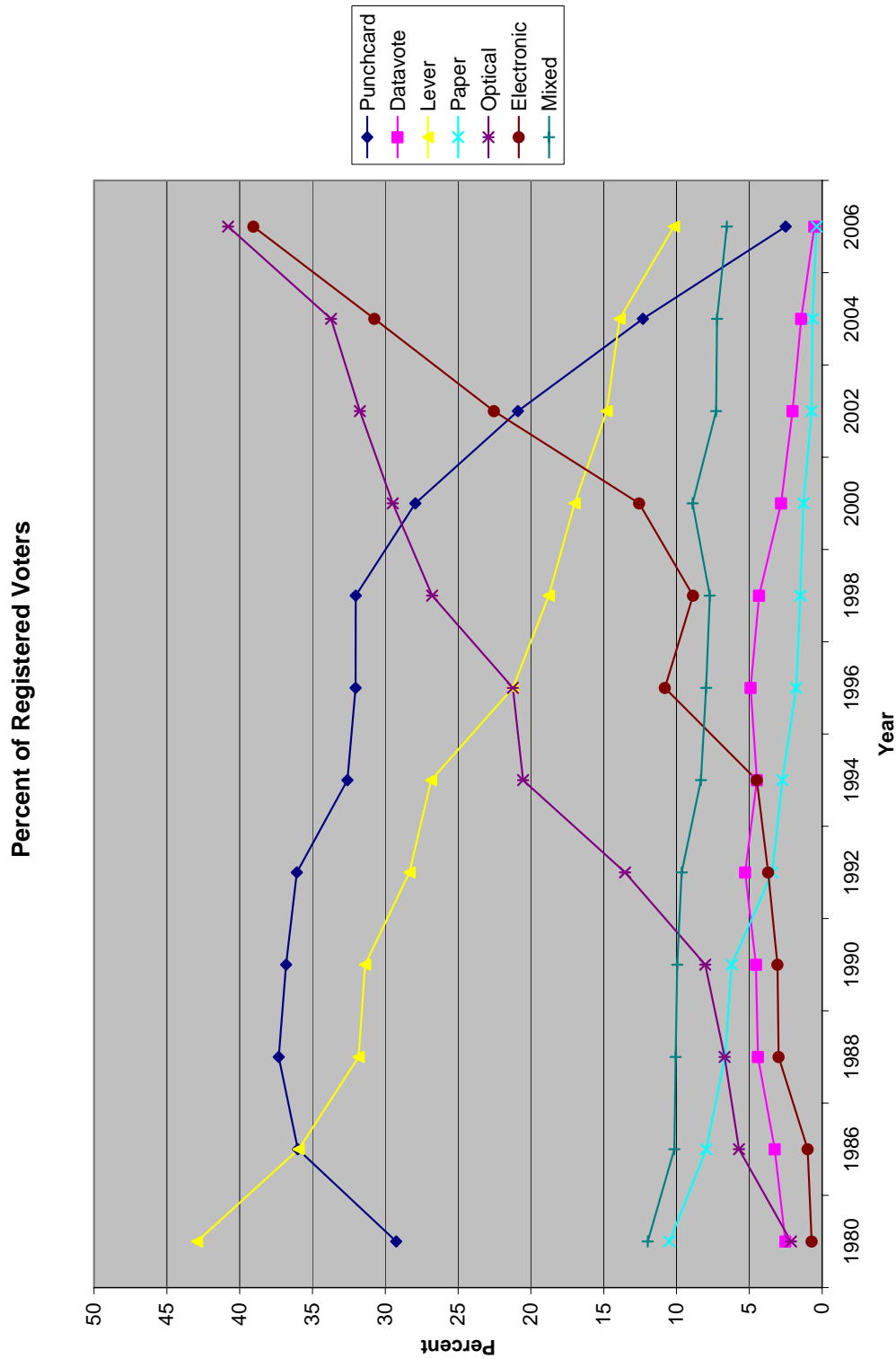


Figure 2. Voting Technologies Used by Percent of Registered Voters.¹⁶

¹⁶ All data from *Voting Equipment Studies* released by Election Data Services.
 <<http://www.edssurvey.com/index.php?content=votequip>>.

3.0 Problem

David A. Powner and Randolph C. Hite of the U.S. Government Accountability Office (GAO) advocate that “while electronic voting systems hold promise for a more accurate and efficient election process, numerous entities have raised concerns about their security and reliability, citing instances of weak security controls, system design flaws, inadequate system version control, inadequate security testing, incorrect system configuration, poor security management, and vague or incomplete voting system standards, among other issues.”¹⁷

Even with the use of randomization and encryption schemes to protect ballot images, voting systems manufacturers cannot ensure that the ballots cast are identical to the ones being recorded, transmitted, and counted. Roy Saltman stated in 1988 that “the voter is given some reason to believe that the desired choices have been entered correctly into the temporary storage, but no independent proof can be provided to the voter that the choices have, in fact, been entered correctly for the purpose of summarizing these choices with all others to produce vote totals.”¹⁸ Nearly twenty years later, the implementation of an independently auditable electronic process in an anonymous election has yet to occur.

To further this claim, Rebecca Mercuri writes that “encryption provides no assurance of privacy or accuracy of ballots cast. Cryptographic systems, even strong ones, can be cracked or hacked, thus leaving the ballot contents along with the identity of the voter open to perusal.”¹⁹ In addition, ballot definition files can be altered so that votes for one candidate are recorded for another. Stanford University computer science professor David Dill states that “if you look at the consequences [possible with DRE systems] for democracy, it’s terrifying.”²⁰

¹⁷ *Elections: Federal Efforts to Improve Security and Reliability of Electronic Voting Systems are Under Way, but Key Activities Need to be Completed*. 21 September 2005. U.S. Government Accountability Office. 6 June 2007. <<http://www.gao.gov/new.items/d05956.pdf>>.

¹⁸ Saltman, Roy G. *Accuracy, Integrity, and Security in Computerized Vote-Tallying*. August 1988. U.S. Department of Commerce, National Bureau of Standards Special Publication 500-158.

¹⁹ Mercuri. *Rebecca Mercuri’s Statement on Electronic Voting*. 12 July 2007. <<http://www.notablessoftware.com/RMstatement.html>>.

²⁰ Manning, Jason, and Jessica Moore. *History of Voting Technology*. 15 December 2003. The Online NewsHour. 5 July 2007. <http://www.pbs.org/newshour/vote2004/primaries/sr_technology_history.html>.

Examples of lost votes and other issues involving electronic voting machines abound throughout the United States. Myriad problems occurred in Florida, where the “election code was extensively revised, punchcard systems were outlawed, and over \$125 million was spent on new voting equipment and training for voters and election administrators.”²¹

Palm Beach County experienced problems with Sequoia voting machines in two March 2002 city council elections. A runoff election in the city of Wellington involved one race with two candidates. While the winning candidate triumphed by a margin of four votes (1,263 to 1,259), 78 ballots were not recorded by the DREs. Meanwhile in Boca Raton, former mayor Emil Danciu finished third in his race with an 8% undervote. Suspiciously enough, low numbers were reported in his home precinct, where he was projected to do well. Rebecca Mercuri continues to write that “Florida 2000 woke us up to what many already knew – our voting systems and laws were flawed. Florida 2002 lets us know that expensive computers can not and will not provide the answer to our election troubles.”²²

Building Confidence in U.S. Elections writes that “a malfunction of DREs in Carteret County, North Carolina, in the November 2004 elections caused the loss of more than 4,400 votes. There was no backup record of the votes that were cast. As a result, Carteret County had no choice but to rerun the election, after which it abandoned its DREs. Other jurisdictions have lost votes because election officials did not properly set up voting machines.”²³

More recently in the 2006 midterm election, Republican Vern Buchanan beat Democratic candidate Christine Jennings in the Florida 13th District Congressional race by just 368 votes, excepting the 18,000 voters who didn't manage to vote in the race. The majority of these voters were using ES&S's iVotronic touchscreen DRE. In addition, *The New York Times* reported that “an audit of last November's general election in the

²¹ Mercuri, Rebecca. *Florida 2002: Sluggish Systems, Vanishing Votes*. Communications of the ACM. November 2002. Volume 45, Number 11. 9 July 2007.
<<http://www.notablessoftware.com/Papers/Florida2002.pdf>>.

²² Mercuri, Rebecca. *Florida Primary 2002: Back to the Future*. The Risks Digest: ACM Committee on Computers and Public Policy. 11 September 2002. Volume 22, Issue 24. 24 July 2007.
<<http://catless.ncl.ac.uk/Risks/22.17.html>>.

²³ *Building Confidence in U.S. Elections: Report of the Commission on Federal Election Reform*. September 2005. Center for Democracy and Election Management, American University. Pages 25-26.

Cleveland [Ohio] area has found that hundreds of votes were lost, that others were recorded twice and that software used to count the ballots was vulnerable to data problems.”²⁴ The problems occurred on optical scan and touch-screen machines manufactured by Diebold Election Systems Inc.; Microsoft’s JET file-sharing database system, used by Diebold, was previously known to have problems potentially resulting in database corruption.

4.0 Solution

Avi Rubin writes that his dream voting machine “would have a user interface much like a DRE, but in reality it wouldn’t be a voting machine at all. I call it a ‘ballot-marking machine.’ Voters would navigate through touch screens, just as with a DRE, and make their choices for candidates and for ballot resolutions. However, instead of clicking on Cast Vote at the end, they would select a Print Ballot option, and the machine would produce a filled-in paper ballot that the voter would be able to check for accuracy.”²⁵

Similarly, Rebecca Mercuri writes that “one solution to the disappearing elections problem is to require that all fully-electronic balloting systems provide a physical audit trail that is human-readable. The simplest such mechanism involves the production of a printed ballot...this would be perused by the voter and then deposited...into a ballot box.”²⁶ Most importantly, the printed ballots would serve as the actual record of the election. These could be recounted through the use of optical scan recognition technologies or by hand, both methods under bipartisan watch.

The solution to this problem, as stated by VerifiedVoting.org is to “advocate for the use of voter-verified paper ballots (VVPBs) for all elections in the United States, so voters can inspect individual permanent records of their ballots before they are cast and so meaningful recounts may be conducted...also [to] insist that electronic voting equipment and software be open to public scrutiny and that random, surprise recounts be

²⁴ Driehaus, Bob. *Audit Finds Many Faults in Cleveland’s ’06 Voting*. The New York Times. 20 April 2007. 11 June 2007.

<<http://select.nytimes.com/search/restricted/article?res=F00E17F6345B0C738EDDAD0894DF404482>>.

²⁵ Rubin, Aviel. *Brave New Ballot: The Battle to Safeguard Democracy in the Age of Electronic Voting*. New York: Broadway, 2006. Page 208.

²⁶ Mercuri, Rebecca. *The FEC Proposed Voting Systems Standard Update*. 10 September 2001. 13 July 2007. <<http://www.notablessoftware.com/Papers/FECRM.html>>.

conducted on a regular basis to audit election equipment.”²⁷ Most importantly, each and every voter would affirm that his or her choices have been cast as intended, and the paper ballot would be used for official election results, not only in the case of audit or recount.

5.0 Standards

Mary Bellis writes that “during the 1970s, nearly anyone could cobble together a ‘voting machine,’ and sell it to local election officials. Few states had any guidelines for testing or evaluating these devices.”²⁸ Concerns surfaced regarding the integrity of the voting process, and in February 1975 the “General Accounting Office’s Office of Federal Elections (predecessor to the Federal Election Commission) signed an interagency agreement with the National Bureau of Standards to develop operational guidelines that election administrators could use to help ensure the accuracy and security of the computer-based vote-tallying process.”²⁹

Effective Use of Computing Technology in Vote-Tallying, released in March 1975, concluded that “one of the basic causes for computer-related election problems was the lack of appropriate technical skills at the state and local level for developing or implementing written standards, against which voting system hardware and software could be evaluated.”³⁰ Congress soon directed the Federal Election Commission (FEC), along with the National Bureau of Standards (now the National Institute of Standards and Technology, or NIST) to “conduct a study on the feasibility of developing voluntary engineering and procedural performance standards for voting systems used in the United States.”³¹

The joint effort resulted in 1984’s *Voting System Standards: A Report on the Feasibility of Developing Voluntary Standards for Voting Equipment*. While Congress immediately appropriated funds allowing the Commission to begin developing voluntary national standards for computer-based voting systems, the first performance and test

²⁷ Rubin, Aviel. *Brave New Ballot: The Battle to Safeguard Democracy in the Age of Electronic Voting*. New York: Broadway, 2006. Page 14.

²⁸ Bellis, Mary. *The History of Voting Machines*. 5 July 2007. <<http://inventors.about.com/library/weekly/aa111300b.htm>>.

²⁹ Ibid.

³⁰ Ibid.

³¹ Ibid.

standards for punchcard, marksense, and direct recording electronic voting systems were not approved until January 1990.

Since then, two more sets of voting standards have been released (in 2002 and 2005) and “federal organizations and nongovernmental groups have issued recommended practices and guidance for improving the election process, including electronic voting systems, as well as general practices for the security and reliability of information systems.”³² In addition, the Help America Vote Act was passed by Congress in 2002 and other pieces of voting legislation are presently active in the House and in the Senate.

To this day, no “electronic voting system has been certified to even the lowest level of the U.S. government or international computer security standards (such as the ISO Common Criteria or its predecessor, TCSEC/ITSEC)...hence, no current electronic voting system has been properly validated as being secure.”³³

5.1 FEC 1990 Voting Systems Standards

The FEC 1990 Voting Systems Standards proposes performance and test standards for punchcard, marksense, and direct recording electronic voting systems. Sections covering functional requirements, hardware and software standards, security, quality assurance, qualifications, and acceptance tests are followed by lengthy appendices containing design recommendations and criterion.

The standard requires DRE systems to “incorporate multiple memories, both in the voting machine itself and in programmable memory device(s), where there is no paper ballot that can serve as a redundant means of verifying or auditing election results.”³⁴ DRE systems must also maintain an electronic image of each voter’s ballot via an independent processing path. While not mandating voter-verified paper ballots, the 1990 Voting Systems Standards does refer to a standard for paper verification, stating that “voter confirmation capability may be implemented using the same data processing path that provides for the capture and retention of ballot images. After a voter has made all

³² *Elections: Federal Efforts to Improve Security and Reliability of Electronic Voting Systems are Under Way, but Key Activities Need to be Completed*. 21 September 2005. U.S. Government Accountability Office. 6 June 2007. <<http://www.gao.gov/new.items/d05956.pdf>>.

³³ Mercuri. *Rebecca Mercuri’s Statement on Electronic Voting*. 12 July 2007. <<http://www.notablessoftware.com/RMstatement.html>>.

³⁴ *FEC 1990 Voting Systems Standards*. 23 July 2007. <http://www.cs.duke.edu/~justin/voting/docs/FEC_1990_Voting_System_Standards.pdf>. Page 6.

voting selections, the DRE machine should display or print on a paper ballot a summary of the voter's selections. If the voter is not satisfied with the confirmation, election workers must have a method of voiding the ballot."³⁵

The "Voter Confirmation in DRE Systems" section continues to state that "some jurisdictions may find the incorporation of a voter confirmation capability in DRE systems is advantageous. Voter confirmation provides voters with further indication that the voting device recognizes their choices. If the confirmation is produced as a physical record, that record may also be used in recounts...Voter confirmation does not, however, guarantee that the voter choices are correctly recorded and updated in memory registers. Instead, DRE system accuracy and integrity is best safeguarded by adequately testing the implementation of the requirements for multiple memories and a separate processing path for retention of ballot images."³⁶

5.2 FEC 2002 Voting Systems Standards

The Federal Election Commission released an updated set of standards following the disputed 2000 Presidential election. The FEC 2002 Voting Systems Standards "provide a common set of requirements across all voting technologies, using technology-specific requirements only where essential to address the specified technology's impact on voting accuracy, integrity, and reliability."³⁷

Unlike its predecessor, no reference to a paper verification standard for electronic voting machines exists in this document. (This was found to be the "result of simple oversight."³⁸) The 2002 Voting Systems Standards states that "as an additional means of ensuring accuracy in DRE systems, voting devices shall record and retain redundant copies of the original ballot image."³⁹ The backup record of each ballot cast would be

³⁵ *FEC 1990 Voting Systems Standards*. 23 July 2007.

<http://www.cs.duke.edu/~justin/voting/docs/FEC_1990_Voting_System_Standards.pdf>. Page E-10.

³⁶ *FEC 1990 Voting Systems Standards*. 23 July 2007.

<http://www.cs.duke.edu/~justin/voting/docs/FEC_1990_Voting_System_Standards.pdf>. Page E-9.

³⁷ *FEC 2002 Voting Systems Standards*. 25 July 2007.

<http://josephhall.org/fec_vss_2002_pdf/pdf/overview.pdf>. Page 2.

³⁸ Rubin, Aviel. *Brave New Ballot: The Battle to Safeguard Democracy in the Age of Electronic Voting*. New York: Broadway, 2006. Page 193.

³⁹ *FEC 2002 Voting Systems Standards*. 25 July 2007.

<http://josephhall.org/fec_vss_2002_pdf/pdf/v1s2.pdf>. Page 2-4.

maintained using a process and storage location different from the main vote detection, interpretation, processing, and reporting path.

Due to hardware or software defects, improperly programmed ballot configurations, or malicious actions, systems using electronic means to retain ballot images have failed in actual elections. Even more alarming is the fact that vendors have not been able to recover the original ballots cast. The 2002 Voting Systems Standards do not effectively address the need for physical verification of ballots cast in order to ensure election integrity.

5.3 Help America Vote Act of 2002

The Help America Vote Act of 2002 was passed by Congress to “establish a program to provide funds to States to replace punch card voting systems, to establish the Election Assistance Commission to assist in the administration of Federal elections and to otherwise provide assistance with the administration of certain Federal election standards for States and units of local government with responsibility for the administration of Federal elections, and for other purposes.”⁴⁰

Section 301 of the Bill mandates permitting “the voter to verify (in a private and independent manner) the votes selected by the voter on the ballot before the ballot is cast and counted” in addition to providing “the voter with the opportunity (in a private and independent manner) to change the ballot or correct any error before the ballot is cast and counted.”⁴¹ The Bill also states that the “voting system shall produce a permanent paper record with a manual audit capacity for such [voting] system[s]...the paper record produced...shall be available as an official record for any recount conducted with respect to any election in which the system is used.”⁴²

While making strides in the right direction, a bonafide voter-verified audit trail is not required by this legislation. Rebecca Mercuri writes that “it is essential...that voters be able to create a physical or paper ballot that is deposited at the polling place when their vote is cast. This ballot, which can be scanned in or hand-counted since it is human-

⁴⁰ *Help America Vote Act of 2002*. 29 October 2002. 25 July 2007.
<http://www.fec.gov/hava/law_ext.txt>.

⁴¹ *Ibid.*

⁴² *Ibid.*

readable, would be used to verify any machine-generated tallies produced from electronic (DRE) voting systems. Only in this way can the voters be assured that their ballot will be available for an independent recount.”⁴³

The Carter-Baker Commission shares Mercuri’s sentiments, stating that “the Help America Vote Act of 2002 authorized...federal funds to replace antiquated voting machines throughout the country. States are using these funds and their own resources to upgrade voting technology, generally to replace punch card and lever voting machines with new optical scan and electronic voting systems. As a result, voting technology is improving, but new concerns related to electronic voting systems have arisen. These concerns need to be addressed, because it is vital to the electoral process that citizens have confidence that voting technologies are registering and tabulating votes accurately.”⁴⁴

Also of note is the inherently flawed implementation of the legislation. The Help America Vote Act (HAVA) “authorized \$3.8B in federal spending, with a substantial portion of these funds allocated to US states and territories for the purpose of replacing their punch card and lever voting machines and making voting systems accessible to the disabled.”⁴⁵ To receive funds, states and territories were required to submit an implementation plan to the Election Assistance Commission by January 1, 2004.

The four members of the HAVA Election Assistance Commission, responsible for approving individual state plans, overseeing a 14-member Technical Guidelines Development Committee [TGDC] and a 110-member Standards Board, and making provisions for voting system hardware and software to be tested and certified by accredited laboratories, were appointed by the President nearly a year late. This in turn delayed the population of the TGDC and Standards Board, and technical guidelines were not ready before state implementation plans were due. This resulted in nine states requesting HAVA extensions, and several others contracting to purchase non-HAVA compliant voting systems.

⁴³ Mercuri, Rebecca. *Explanation of Voter-Verified Ballot Systems*. 24 July 2002. The Risks Digest: ACM Committee on Computers and Public Policy. Volume 22, Issue 17. 24 July 2007. <<http://www.notablessoftware.com/Papers/VoterVerify.html>>.

⁴⁴ *Building Confidence in U.S. Elections: Report of the Commission on Federal Election Reform*. September 2005. Center for Democracy and Election Management, American University. Page 25.

⁴⁵ Mercuri, Rebecca. *Electronic Voting*. 15 March 2007. 12 July 2007. <<http://www.notablessoftware.com/evote.html>>.

5.4 IEEE P1583

The Institute of Electrical and Electronics Engineers (IEEE) attempted to establish standards for voting equipment via IEEE Standards Coordinating Committee 38 (SCC 38) and its associated Voting Equipment Standard. IEEE Project P1583 was “charged with development of a standard of requirements and evaluation methods for election voting equipment. The standard will provide technical specifications for electronic, mechanical, and human factors that can be used by manufacturers of voting machines or by those purchasing such machines.”⁴⁶

Per the American National Standards Institute (ANSI), “consideration of and response to comments submitted by voting members of the relevant consensus body as well as by the public” is required.⁴⁷ The first circulation of this standard resulted in over one thousand comments. Work on P1583 continued, however, without investigating each and every comment as numerous areas of “contention and disagreement” continued to exist within the document.⁴⁸ The sheer volume of “comments became too difficult to untangle, and along with other disagreements, the working group voted to discontinue the effort.”⁴⁹ However, a “snapshot draft” of the proposal was provided to the Technical Guidelines Development Committee (TGDC) of the NIST Election Assistance Commission (EAC) as an input.⁵⁰

5.5 EAC 2005 Voluntary Voting System Guidelines

The 2005 Voluntary Voting System Guidelines “update and augment the 2002 VSS, as required by HAVA to address advancements in information and computer technologies.”⁵¹ The guidelines, presented in two volumes, “provide a set of specifications and requirements against which voting systems can be tested to determine if the systems provide all of the basic functionality, accessibility and security capabilities

⁴⁶ *IEEE P1583 – Voting Equipment Standard*. 23 July 2007. <<http://grouper.ieee.org/groups/scc38/1583/>>.

⁴⁷ *Overview of the U.S. Standardization System*. Introduction to ANSI. 23 July 2007. <http://www.ansi.org/about_ansi/introduction/introduction.aspx?menuid=1>.

⁴⁸ Interview with Stan Klein. 23 July 2007.

⁴⁹ *Ibid.*

⁵⁰ *Ibid.*

⁵¹ *EAC Adopts 2005 Voluntary Voting System Guidelines*. 13 December 2005. The United States Election Assistance Commission. 26 July 2007. <http://www.eac.gov/news_121305.asp>.

required of these systems. In addition, the guidelines establish evaluation criteria for the national certification of voting systems.”⁵²

Mark W. Skall, chief of the Software Diagnostics and Conformance Testing Division at NIST, testified before the House of Representatives that the “VVSG 2005 included the first Federal standard for Voter Verified Paper Audit Trails (VVPAT)...[the document] took no position regarding the implementation of VVPAT and neither required nor endorsed it. Thus, if states choose to implement VVPAT, the VVSG 2005’s requirements help to ensure that their VVPAT systems are usable, accessible, reliable, and secure. The VVSG 2005 also contained requirements to make the paper record useful to election officials for audits of voting equipment.”⁵³

5.6 Carter-Baker Commission Standards

Building Confidence in U.S. Elections: Report of the Commission on Federal Election Reform was released in September 2005. Co-chaired by Jimmy Carter and James A. Baker, III, the report proposes ways “to give confidence to voters using electronic voting machines that their votes will be counted accurately...[by calling for] an auditable backup on paper at this time.”⁵⁴

Formal recommendation 3.1.1 states that “Congress should pass a law requiring that all voting machines be equipped with a voter-verifiable paper audit trail and, consistent with HAVA, be fully accessible to voters with disabilities. This is especially important for direct recording electronic (DRE) machines for four reasons: (a) to increase citizens’ confidence that their vote will be counted accurately, (b) to allow for a recount, (c) to provide a backup in cases of loss of votes due to computer malfunction, and (d) to test – through a random selection of machines – whether the paper result is the same as the electronic result. Federal funds should be appropriated to the EAC to transfer to the states to implement this law. While paper trails and ballots currently provide the only

⁵² *EAC Adopts 2005 Voluntary Voting System Guidelines*. 13 December 2005. The United States Election Assistance Commission. 26 July 2007. <http://www.eac.gov/news_121305.asp>.

⁵³ Skall, Mark W. “National Institute of Standards and Technology’s Role in Voluntary Voting System Guidelines and Testing.” *Testimony before the House of Representatives Committee on Oversight and Government Reform Subcommittee on Information Policy, Census, and National Archives*. 7 May 2007. 11 June 2007. <<http://vote.nist.gov/speeches/Skalltestimony.pdf>>.

⁵⁴ *Building Confidence in U.S. Elections: Report of the Commission on Federal Election Reform*. September 2005. Center for Democracy and Election Management, American University. Page v.

means to meet the Commission’s recommended standards for transparency, new technologies may do so more effectively in the future. The Commission therefore urges research and development of new technologies to enhance transparency, security, and auditability of voting systems.”⁵⁵

The report continues to recommend (3.1.2) that “States should adopt unambiguous procedures to reconcile any disparity between the electronic ballot tally and the paper ballot tally. The Commission strongly recommends that states determine well in advance of elections which will be the ballot of record.”⁵⁶

In June 2007, the Center for Democracy and Election Management at American University (the organizer of *Building Confidence in U.S. Elections*) released a progress report, *Carter-Baker Commission on Federal Election Reform: Status of the Recommendations*. The report discerned that “significant progress” had been made on both recommendations 3.1.1 and 3.1.2.⁵⁷ The report states that “the introduction of provisions for voter verified paper records...has been one of the areas of the most intense legislative activity.”⁵⁸

5.7 H.R. 811

The Carter-Baker Commission also cites H.R. 811 as being an important step toward mandating voter-verifiable paper audit trails. H.R. 811, or the “Voter Confidence and Increased Accessibility Act of 2007,” was introduced by Representative Rush Holt (D-NJ) and has 216 cosponsors.⁵⁹ The function of the Bill is “to amend the Help America Vote Act of 2002 to require a voter-verified permanent paper ballot under title III of such Act.”⁶⁰ Further, H.R. 811 “allows jurisdictions to continue to rely on the expediency, convenience, and accessibility of computer-assisted voting, while preserving the critical

⁵⁵ *Building Confidence in U.S. Elections: Report of the Commission on Federal Election Reform*. September 2005. Center for Democracy and Election Management, American University. Page 27.

⁵⁶ *Ibid.*

⁵⁷ *Progress Report*. June 2007. Center for Democracy and Election Management, American University. Page 14.

⁵⁸ *Ibid.*

⁵⁹ *H.R. 811: Voter Confidence and Increased Accessibility Act of 2007*.

<http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:h811rh.txt.pdf>.

⁶⁰ *Ibid.*

ability to independently confirm that the will of the voters is reflected in the final results.”⁶¹

Section 2 of the Bill amends the Help America Vote Act of 2002 to read “the voting system shall require the use of or produce an individual, durable, voter-verified paper ballot of the voter’s vote that shall be created or made available for inspection and verification by the voter before the voter’s vote is cast and counted...examples of such a ballot include a paper ballot marked by the voter for the purpose of being counted by hand or read by an optical scanner or similar device, a paper ballot prepared by the voter to be mailed to an election official (whether from a domestic or overseas location), a paper ballot created through the use of a ballot marking device or system, or a paper ballot produced by a touch screen or other electronic voting machine.”⁶²

The Bill additionally provides that “the voting system shall provide the voter with an opportunity to correct any error made by the system in the voter-verified paper ballot before the permanent voter-verified paper ballot is preserved” and that “the voting system shall not preserve the voter-verified paper ballots in any manner that makes it possible, at any time after the ballot has been cast, to associate a voter with the record of the voter’s vote.”⁶³ Finally, the Bill requires that “in the face of any inconsistencies or irregularities between any electronic vote tallies and the vote tallies determined by counting by hand the individual, durable voter-verified paper ballots produced...the individual, durable voter-verified paper ballots shall be the true and correct record of the votes cast.”⁶⁴

On July 20, 2007, *The New York Times* reported that “Democratic leaders in the House and Senate are slowing their drive to revamp the nation’s voting systems.”⁶⁵ While “overhauling voting systems before next year’s presidential election had once been a top Democratic priority,” Christopher Drew writes that “under pressure from state and

⁶¹ *H.R. 811: Voter Confidence and Increased Accessibility Act of 2007.*

<http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:h811rh.txt.pdf>.

⁶² *Ibid.*

⁶³ *Ibid.*

⁶⁴ *Ibid.*

⁶⁵ Drew, Christopher. *Overhaul Plan for Vote System will be Delayed.* 20 July 2007. *The New York Times.* 24 July 2007.

<<http://www.nytimes.com/2007/07/20/washington/20vote.html?ei=5070&en=f60e130e6cf934f1&ex=1186027200&adxnnl=1&adxnnlx=1185887476-xgkAJFotOGSV1CgegK3byQ>>.

local officials, as well as from lobbyists for the disabled, House leaders now advocate putting off the most sweeping changes until 2012, four years later than planned.”⁶⁶

The article continues to state that “House Democratic officials say that they are now working on compromise legislation that could allow hundreds of counties in 20 states to simply add tiny, cash-register-style printers to their touch-screen machines for the 2008 and 2010 elections, while waiting for manufacturers to develop better technology by 2012. House officials said the compromise would ensure that all voting machines nationwide would have some kind of paper trail in 2008 through which voters could verify that their ballots were properly recorded and that could be used in recounts.”⁶⁷

House leadership is negotiating with Representative Holt “over details of the [H.R. 811] compromise. Those talks, however, have hit a snag over how to guarantee easy access to voting machines by the handicapped without limiting the technology available to everyone else. Mr. Holt has long expressed a preference for optically scanned ballots marked by voters, but so far House leaders are siding with advocates for the handicapped, who fear that they cannot use optical ballots without help...if a deal [on the compromise] is reached soon, the House could vote on the bill within two weeks. House leaders also need to hold onto Mr. Holt’s support. Mr. Holt, a former Princeton University physicist, is the leading expert on voting technology in Congress, and any deal could fall apart if he withdrew his support.”⁶⁸

5.8 S. 559

S. 559, or the “Vote Integrity and Verification Act of 2007” is the companion bill to H. R. 811.⁶⁹ Since a bill cannot become law unless identical legislation passes both chambers of Congress, the existence of S. 559 is crucial to the success of H.R. 811. Sponsored by Senator Bill Nelson (D-FL), the bill aspires to “amend the Help America Vote Act of 2002 to require a voter-verified permanent paper ballot under title III of such

⁶⁶ Drew, Christopher. *Overhaul Plan for Vote System will be Delayed*. 20 July 2007. The New York Times. 24 July 2007.
<<http://www.nytimes.com/2007/07/20/washington/20vote.html?ei=5070&en=f60e130e6cf934f1&ex=1186027200&adxnml=1&adxnmlx=1185887476-xgkAJFotOGSV1CgegK3byQ>>.

⁶⁷ Ibid.

⁶⁸ Ibid.

⁶⁹ S. 559: *Vote Integrity and Verification Act of 2007*. <http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:s559is.txt.pdf>.

Act.”⁷⁰ The bill does not have any cosponsors, and no action has occurred since the bill was read twice and referred to the Committee on Rules and Administration.

5.9 S. 1487

S. 1487, or the “Ballot Integrity Act of 2007” is sponsored by Senator Dianne Feinstein (D-CA).⁷¹ The bill mirrors that of Holt’s regarding verifiable audits and would require states to employ machines that produce voter-verified paper receipts by 2010. Hearings were held on the bill, which has eleven cosponsors, on July 25, 2007.

6.0 Recommendation

A majority of the progress being made in the quest to require voter-verified paper ballots has occurred on the state level. *Status of the Recommendations* remarks that “In August 2005, 25 states required voter-verifiable permanent paper ballots, and another 14 states had proposed legislation with such a requirement. By March 2007, 28 states had regulations that require voter verified paper records. In addition, by June 2007, state legislatures were considering more than 50 bills pertaining to paper trails. Most bills call for paper trails or mandate standards for the use of voting machines with paper trails.”⁷² The report continues to cite specific states, including Maryland, where in April of 2007 the State Senate “unanimously approved a bill requiring the state to scrap its \$65 million electronic-voting system and switch to new machines.”⁷³ Manning and Moore likewise write that “some state officials, like [former] California Secretary of State Kevin Shelley, have already moved to require a paper record function for all voting machines...[and] other states are considering similar requirements.”⁷⁴

In the absence of Federal laws and all-encompassing standards, state legislatures and respective secretaries of state need to continue to play a leading role in election reform.

⁷⁰ S. 559: *Vote Integrity and Verification Act of 2007*. <http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:s559is.txt.pdf>.

⁷¹ S. 1487: *Ballot Integrity Act of 2007*. <http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_bills&docid=f:s1487is.txt.pdf>.

⁷² *Progress Report*. June 2007. Center for Democracy and Election Management, American University. Page 15.

⁷³ *Ibid*.

⁷⁴ Manning, Jason, and Jessica Moore. *History of Voting Technology*. 15 December 2003. The Online NewsHour. 5 July 2007. <http://www.pbs.org/newshour/vote2004/primaries/sr_technology_history.html>.

Current California Secretary of State Debra Bowen caused quite a stir on August 3, 2007 with the release of her “Top-To-Bottom Review of California’s Voting Systems.” Two months after commissioning local computer experts to rigorously analyze California’s voting systems and related security procedures, Bowen decertified Diebold, ES&S, Hart InterCivic, and Sequoia voting systems used by the state. She then recertified the systems (excepting the ES&S InkaVote Plus Precinct Ballot Counter Voting System, version 2.1) on a conditional basis.

Bowen’s conditions require, in brief, that counties must adopt security procedures detailed in the recertification documents, that counties using Sequoia and Diebold DREs use only one such machine per polling location and conduct a full manual count of the voter-verified paper audit trail for votes cast on the machines, and that all electronic systems undergo post-election audits. These measures will be in place for California’s February 2008 primary election. Other secretaries of state, including Jennifer Brunner and Mary Herrera, have followed Bowen’s lead and commissioned similar tests on voting machines in Ohio and New Mexico, respectively.

Meanwhile, Mark W. Skall testified that “immediately after completing its work on the VVSG 2005, NIST and the TGDC began working on the next iteration [of voluntary voting system guidelines]...this new VVSG builds upon the VVSG 2005 but takes a fresh look at many of the requirements. The new VVSG will be a larger, more comprehensive standard, with more thorough treatments of security areas and requirements for equipment integrity and reliability. The new VVSG will include updated requirements for accessibility and requirements for usability based on performance benchmarks. It will include updated requirements for data and documentation for testing laboratories. It will include a number of updated requirements dealing with voting equipment reliability, and will include many new requirements for improved security. As noted, it will prohibit radio frequency wireless communications, which includes the use of wireless local area networks. The requirements will be structured so as to improve their clarity to vendors and their testability by testing labs.”⁷⁵

⁷⁵ Skall, Mark W. “National Institute of Standards and Technology’s Role in Voluntary Voting System Guidelines and Testing.” *Testimony before the House of Representatives Committee on Oversight and Government Reform Subcommittee on Information Policy, Census, and National Archives*. 7 May 2007. 11 June 2007. <<http://vote.nist.gov/speeches/Skalltestimony.pdf>>.

The Holt Bill similarly is “the second effort by Congress to fix the nation’s voting system since the bitter fights over hanging punch-card chads in Florida. Under the Help America Vote Act, passed in 2002, the federal government has spent more than \$3 billion to help states and counties modernize their voting systems, installing thousands of touch-screen and other machines. But since then, growing concerns about the reliability and the security of some of the machines had led to widespread calls for another overhaul.”⁷⁶

While new voting legislation, standards, and technology continue to be developed, voter-verified paper ballots are at present the only way to ensure election integrity. Federal, local, and especially state governments must continue to implement this measure so vital to voter confidence along with confronting the needs and privacy of the disabled. Debra Bowen remarks in her Top-To-Bottom Review that “the systems we use to cast and tally votes...are the most fundamental tools of our democracy.”⁷⁷ Americans today have the challenge and privilege of sharpening these tools and ensuring, in the digital era, that every vote counts.

⁷⁶ Drew, Christopher. *Overhaul Plan for Vote System will be Delayed*. 20 July 2007. The New York Times. 24 July 2007.

⁷⁷ *California Secretary of State Debra Bowen Decertifies Diebold, Hart InterCivic and Sequoia Systems*. 4 August 2007. California Progress Report. 16 August 2007. <http://www.californiaprogressreport.com/2007/08/california_secr_1.html>.

About the Author

Sarah Rovito graduated from Case Western Reserve University in Cleveland, Ohio with a Bachelor's degree in systems and control engineering in May 2007. At Case, she was awarded the 2007 Undergraduate Alumni Capital Award in systems and control engineering along with the 2006 Philips Prize for best senior project in computer engineering. Sarah was a four-year member of the Case Women's Varsity Swim Team and served as a captain during the 2006-2007 season. In addition to being involved with the Case IEEE chapter, she was a founding member and chair of the Case School of Engineering Senior Class Gift Committee. Sarah completed a term as an embedded software engineering co-op at Rockwell Automation and will work as associate staff at a Washington, DC firm beginning in September 2007.

About WISE

Founded in 1980 through the collaborative efforts of several professional engineering societies, the Washington Internships for Students of Engineering has become one of the premier Washington internship programs. Its goal is to groom future leaders of the engineering profession who are aware of and can contribute to the important intersections of technology and public policy. Please see <<http://www.wise-intern.org>> for more information.

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