Remarks by Rebecca Mercuri, Ph.D.
P.O. Box 1166, Philadelphia, PA 19105
215/327-7105 609/587-1886
http://www.notablesoftware.com/evote.html
mercuri@acm.org

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Senator Kinnaird, Senator Allran, Ms. Adams, Representative Insko, and members of the Joint Select Committee on Electronic Voting Systems of the North Carolina General Assembly, I would like to thank you for the opportunity to comment today on the important subject of auditability and standards for electronic voting and tabulation equipment. I apologize for my absence at last month's meeting due to inclement weather and appreciate your interest in rescheduling this presentation.

For those of you who are unfamiliar with my background, I am considered one of the foremost international experts on electronic election systems, and have been researching, writing and testifying on this subject for 15 years. Currently, I hold the position of Fellow at the Radcliffe Institute for Advanced Study at Harvard University where I am investigating the general question of transparency and trust in electronic systems, for which voting is an illustrative example. I hold 5 academic degrees, including a Master of Science in Computer Science from Drexel University, and a Master of Science in Engineering and Ph.D. from the University of Pennsylvania's School of Engineering and Applied Science. Coincidentally, I happened to defend my Doctoral Dissertation, "Electronic Vote Tabulation: Checks & Balances," 11 days before the controversial 2000 U.S. Presidential election. My expertise was immediately put to use when opinions were sought in Bush v. Gore – my requested testimony was submitted to the 11th Circuit Court of Appeals and footnoted in one of the briefs to the U.S. Supreme Court. Since that time, I have been consulted on a nearly continual basis to assist county boards of election, state and local legislatures, Secretaries of States, and national government members and Commissions both here in the United States and in world Democracies (such as the United Kingdom, Singapore, Brazil, and Ireland). I am also constantly barraged with press requests for commentary and analysis on election matters. Nearly all of this work, including today's appearance before your Committee, I provide pro bono, although occasionally (like today) I am remunerated for some travel expenses.

This hearing in North Carolina comes on the day following the historic debates in the U.S. House and Senate regarding the legitimacy of Ohio's electoral votes and the election process that decided them. This marks only the second time when such dispute has occurred, the prior one being the 1876 Tilden/Hayes Presidential race where 3 states' electoral votes were involved. Although yesterday's discussions and others on voting matters that I have witnessed in the past few years on Capitol Hill fell, unfortunately, along party lines, it is my strong belief that accuracy and integrity in elections should not be a partisan matter – indeed, I have provided expert opinion in court cases involving both Democrats and Republicans who had strong evidence to support their claims that

election returns were incorrect. I am glad to see that your legislature, as are many throughout the United States, is engaged in a bipartisan effort to ensure election reforms.

When vote totals are deemed questionable, whether they be manually prepared (such as in 1876, or the more recent 2004 election in the Ukraine) or generated by electronic computers, public confidence in the resulting Democracy is invariably at risk. Such issues should not be marginalized by characterization as conspiracy theories or "sore loser" reactions – these concerns are based in fact, as North Carolina has witnessed.

In 2004, electronic computers were used in unprecedented numbers to tally nearly 80% of the votes in the United States, and 100% of the votes in India, Brazil, and Venezuela. But unlike in Venezuela, where each of their 17 million voters was provided with a paper ballot printout that they could examine for correctness and deposit into a secured ballot box for later review, some 30% of U.S. votes are cast directly into computers that provide nothing but an ephemeral display of the selections. As experienced in North Carolina's Carteret County, such a computerized display provides absolutely no guarantee that the ballot is being recorded and totaled as the voter intended. Computers can, and do, fail – and when this occurs, electronic votes have been irretrievably lost.

Such failures occur, in part, because of the current inadequacies in election system design and standards. An example can be found in the 163 hour Mean Time Between Failures (MTBF) specification for electronic voting units. A MTBF of 163 hours does not mean that voting machines must be capable of running for 163 consecutive hours without failure, but instead, as my colleague Stan Kline has explained, "the resulting failure probability is 1/163 per hour of machine operation. For a 15 hour election day, the probability of a machine failing is 9.2% (reliability of 90.8%). To illustrate, if fewer than 1472 of Maryland's 16,000 voting machines fail on election day, observably or unobservably, the system satisfies the reliability requirement." Similar strong statements can be made about the security and reliability (or lack thereof) of software used in voting systems. Whether connected to the Internet or not, there is no way to prove that exploitable flaws and backdoors do not exist in voting software – vendors and "experts" who testify otherwise are either lying or are unaware of fundamental, underlying laws of computer science.

This unacceptable situation involving problems with electronic balloting and vote tabulation in the United States has evolved from the procurements that occurred in the wake of the 2000 Presidential election, as stimulated by the Congressional Help America Vote Act (HAVA). This bill was the direct result of the failure of Florida's newly purchased election equipment in its first statewide use in their 2002 Gubernatorial Primary. Despite the expenditure of nearly $25M in each of Broward and Miami/Dade counties, equipment that had been certified by the State failed to perform properly, resulting in long lines at the polls, the declaration of a State of Emergency by Governor Jeb Bush, and the subsequent dismissal of a county election official. Janet Reno herself called me to inquire as to the reason why thousands of votes appeared to be missing from various precinct totals, and whether or not these votes might be retrievable from internal computer memory units without corruption. Prior to this event, the HAVA bill (and

others that had been introduced regarding election reform) had been indefinitely stalled in Congress, but Florida's experiences caused the legislation to come to the floor and it was passed with bipartisan support.

Earlier, in 2001, I had been requested to testify to the U.S. House Science Committee regarding the need for improved standards for election equipment and systems. The Federal Election Commission's 1990 guidelines (which had only been adopted by 2/3 of the States) had been deemed obsolete in the late 1990's, but the FEC had not received the modest funding they had requested in order to revise them. It is not widely known that the new election equipment purchased between 2000 and 2002 was constructed and certified to the obsolete 1990 FEC specifications. (This is not unlike buying a 2002 car with 1990 emission controls.) In fact, despite the known problems with the new election equipment, it was not until the early part of 2004 when devices began to emerge that had been certified to the FEC's revised 2002 guidelines. Even these newer guidelines had been deemed seriously flawed, especially in the areas of security and auditability, and it was the intention of the Help America Vote Act to stimulate the construction of a new national set of standards.

Unfortunately, procurements under HAVA were never tied to the existence of the new HAVA standards, and in a "cart before the horse" fashion, States have been required to commit to equipment purchases before these standards can be constructed and applied. In fact, because of delays in the appointment of HAVA's four Election Assistance Commissioners (EAC) and the members of the Technical Guidelines Development Committee (TGDC), the HAVA standards will not be available until the Summer of 2005 (at the earliest), and equipment will not likely begin to be compliant with these guidelines until late in 2006 or 2007, long after all of the HAVA monies have been spent. It is for this reason that I have repeatedly called for a moratorium on the HAVA equipment spending, but, as yet, to no avail. I urge your state, as I have others, to investigate the possibility of a further HAVA extension by the EAC, until such time as equipment conforming to HAVA standards can be obtained.

This is only one part of the numerous problems with the HAVA bill. States are grappling with the need to be compliant with HAVA's disability components, also without guidance from the EAC. Certainly it is crucial that disabled voters have access to election equipment that they can use privately and effectively in order to cast ballots, but the current crop of products being offered by the vendors falls far short in this regard. Blind voters in California, for example, were instructed by the computer to "press the yellow button" – provoking one visually impaired citizen to remark that "yellow means nothing to me." Of the 300 accessible voting systems that Mercer County New Jersey purchased from Sequoia in 2004, at a cost of an additional $2000 apiece, only a few have ever worked and the County had to instruct its poll workers to not allow voters to use the disability feature. HAVA's disability requirements have been misinterpreted (with the encouragement of certain disabled activists, some of whom were later revealed by the New York Times to have received funding from voting system vendors, including $1M from the Diebold company) to erroneously assert that only Direct Recording Electronic (DRE) balloting devices may be used. In fact, the tactile ballot system, as used by the

State of Rhode Island and supported by the United Nations' ACE project, can be inexpensively implemented in order to allow private voting by visually impaired and illiterate citizens. Nor does HAVA preclude the use of paper ballots, as some have insisted. The U.S. Department of Justice has produced a memorandum opinion explaining that as long as the prepared ballot's contents can be confirmed (such as via a scanner with voice readback), paper is acceptable for disabled use. Certainly, those person with physical disabilities that do not involve reading, should be allowed access to paper systems, such as via the new products that use computers to prepare optically scanned ballots.

Most importantly, all voters must be provided with a balloting mechanism whereby they can incontrovertibly verify that their choices have been registered properly, on a medium that is available for independent recount. Recounts are a necessary part of the election process and, whether or not a contest has occurred, they should take place on a mandatory basis as a check against the electronic totals. When such checks are routinely performed, anomalies have been detected and can be corrected, such as in California when certain optical scanners were discovered to not be recording votes marked with gel ink pens. The revelation of the overflow anomaly with the ES&S vote tallying software, was also a result of close scrutiny of the ballot totals. The fact that ES&S knew about this problem but was not required to disclose it to all of its customers, is but one of many examples of inadequate controls of the election system vendors. In 2004, both ES&S (in Indiana) and Diebold (in California and possibly also Georgia, Florida, and Maryland) were discovered to have substituted uncertified software in the voting systems, without appropriate alert to authorities, in direct violation of State election laws. Due to the current lax voting system guidelines, such substitution is nearly impossible to detect, and because of proprietary trade secrecy claims by the vendors on their products, investigation may be prevented to determine whether or not the substituted software subsequently affected vote totals and election outcomes.

As my doctoral dissertation proved, only paper can provide the appropriate checks and balances necessary for election systems while maintaining full anonymity for the voters. Optically scanned paper ballot systems meet the criteria of anonymity, voter verification of contents, and independent recount. Direct Recording Electronic voting systems can be outfitted with printers, as they were in Venezuela, or as they are in automatic teller and lottery machines, to efficiently print out paper ballots that can be perused by the voters and then dropped into ballot boxes. These are ballots, not receipts, since they may not be taken away by the voter. Unfortunately, as with the disabled access features, here again, vendors are offering devices that pretend to provide audit capabilities, but the equipment has been inappropriately constructed. Some vendors are producing paper ballots on a continuous roll of paper, which could be used to violate voter anonymity, if the order in which the voters entered the polling booth is transcribed (as required in some States). HAVA was compromised in its 11th hour negotiations by reducing the requirement for a "voter verified paper audit trail" to just a paper audit trail, which vendors gleefully implemented as only an after-the-fact reprint of data stored within the computer system. We refer to this in computer science as "Garbage In, Garbage Out." Most recently, the word "verified" has been permuted into "verifiable" (as I notice it is in the documents

authorizing the organization of your Committee), in order to accommodate the unsubstantiated claims by some members of the cryptographic community who assert that sufficient assurances can be provided to secure ballots through mathematical logic, thus precluding the necessity for paper. These systems, even if theoretically sound, are not transparent and turn the election process over to an intellectual elite. Caution is thus advised.

In short, what I have to say today may not be what you want to hear. There are no quick-fixes to the election process either in North Carolina, the United States, or the world's Democratic nations. Democracy, and elections, requires vigilance – and this can not be provided by technology alone. The best voting systems appear to be those that provide a minimum of intervention when voters are preparing ballots. Optically scanned systems continue to be used successfully – now by over 50% of US counties – and they are a cost-effective and reliable voting solution. Optically scanned ballots can be prepared by disabled voters, they are available for use in independent recounts and as a check against electronic vote totals, they eliminate the need for a dual system to accommodate precinct and absentee voters, and their lost (residual) vote rates have been shown to meet or better that of fully electronic voting products. I have encouraged the vendor community to institute additional controls in their optical scanning systems, such as bar coding, which could reduce or eliminate the problem of multiple scanning, ballot substitution, and expedite the process of manual recounting – some of these suggestions are being implemented in the new products.

I hope that my insights today have been helpful to you in your investigation process. I am certain that you have numerous questions about the material I have presented today, and other topics that I have not addressed, and I am willing to stay to answer as many questions as your time may permit. I have provided your Committee with the written set of these remarks and some background materials. I urge you to refer to the material on my website, and please feel free to communicate with me directly, if you should need additional information. Thank you for your time, and my best wishes to you and your State with your election plans.