# Testimony on voter verification
## To be presented to Senate Committee on Rules and Administration
## 301 Russell, Building 10:00 AM June 21st 2005
Trent Lott, Chairman

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In the past five years, following the 2000 Florida election fiasco, the voting technologies used in the United States have undergone a significant change. The use of direct recording electronic (DRE) voting machines has increased and provided great opportunities for advances in accessibility and voting user interface design. Auditing steps of elections is important. Demonstrating that a computer program in a optical scan or DRE system is collecting them correctly must be done by testing and might be improved by redundant media created by separate means (electronic, or physical). One audit trail proposal is for the Voter Verified Paper Audit Trail (VVPAT). The VVPAT system adds a printer to a machine and adds an extra step to the end of the voting process when the voter prints out and approves a paper receipt of their vote. We have introduced the idea of a voter verified audio audit transcript trail (VVAATT). A VVAATT system adds audio feedback to the voting process. The audio feedback is recorded and the recording serves as an audit for the election.

We designed a study to understand the ability of people to verify that what they voted on a ballot coincides with what they receive as verification. This study assesses some of the most important factors to voting and audit systems, general usability of the system, the time needed for voters to use the system, and the number of errors voters were able to catch in each audit trail.

In all the verification systems VVPAT is quite simple: The voter uses the DRE to record their choices. When they are finished recording their choices, they press a button on the DRE and a printout appears behind a glass panel. The voter must read over the printout to verify that their selections have been properly recorded on the paper. If the voter accepts the printout then the paper is deposited in a secured ballot box. Otherwise, if the voter rejects the printout, they will have to begin voting again. Rejected paper ballots are not deposited in the ballot box.

The procedure a for voter using the VVAATT system is even simpler: each time the voter makes a selection, the cassette tape visibly revolves, the record level light fluctuates and the headphones confirm it. For example, when the voter selects candidate A, the DRE will say “selected candidate A”. As the voter is listening to the audio feedback, it is recorded on a physical medium such as an audio cassette. At the end of the session the voter submits their ballot and leaves the voting booth.

One important difference is the timing of the verification process. When using a VVPAT, all verification is delayed till the end of the voting process, however, with a VVAATT verification is done throughout the voting process. Eliminating this time delay means that the voter does not have to rely on their memory, often of dozens of race selection choices, to properly verify their votes. In addition, accidental mistakes such as pressing the wrong candidate are immediately identified with the audio feedback. The other main difference between the two systems is that VVAATT is provided though a separate modality in an attempt to make comparison simpler and to reduce cognitive load of verification while VVPAT does not. The VVAATT audio verification complements the visual verification that the voter receives from the DRE. Instead of competing for the voter’s attention, the two forms of feedback actually combine to heighten the voter’s attention and create a more engaging voting process.

To uncover the value of electronic selection verification we conducted a user study involving 36 paid subjects. When comparing the two systems, we focused our study on determining how easy it was for voters, how long it took voters, and how many errors users were able to find with each system.

This study used the Low Error Voter Interface (LEVI) shown to reduced voters errors as compared to some of the current commercial DRE interface styles. This should have improved voters ability to be aware of their votes and help verification. The VVPAT system was implemented with a commercial receipt printer similar to VVPAT receipt printers available on today’s DREs. The VVAATT system used a standard Sony voice operated cassette tape recorder, and headphones like those supplied for sightless voters.

Each subject voted on both the VVPAT and the VVAATT systems. They completed 4 elections on each system. Each election consisted of 11 races with a mixture of single selection races and multiple selection races. For each election, we gave the subjects directions on how they should vote.

Each subject voted three elections which contained an error and one election which had no error. The three kinds of errors that we inserted in the audit trail were replacing the candidate the voter voted for with a different candidate, removing a vote for any candidate, and removing a whole race from the audit trail. In all cases, the visual feedback that appeared on the screen and in the final review screen of the DRE was accurate, only the audit trail, either the paper receipt or the audio feedback was inaccurate.

The most startling results from our study concerned the number of errors that voters were able to identify. We noted the number of errors that voters reported to us as they were voting. . The numbers at each level are quite startling. Out of 108 elections that contained errors, 14 errors were reported to us in the VVAATT audit while no errors were reported in the VVPAT audit. In our post-survey data 85 percent of participants agreed with the statement that there were errors in the audio verification while only 8 percent agreed with this statement for the paper trail. Almost a third of participants actually disagreed with the statement about errors in the paper trail.

The full audio feedback audit record of the election, did add time to the process. Possibly because they falsely found no problems with paper people said that they would recommend the VVPAT system. Experiences watching peoples reactions to second chance voting and VVPAT verification systems has been revealing as well. Our VTP results in 2000 showed precinct counting improved optical scan ballots. My concerns for the value of voters viewing forensic paper trails came from watching the role out of the ESS PBC2100 in Cook county and Chicago in 2002. Dedicated poll workers were on hand to encourage voters to check for errors as paper trails pointed out errors on ballots, voters refused to fix mistakes. In Nevada I watched in surprise as 1 in 20 of the paper trail machines jammed during set up or on the day of election. After voting with a DRE that presented a paper record; a voter still spiritedly repeated the rhetoric “but how can I know how the machine counted my vote without a paper receipt”. I watched in dismay at a polling place where the one poll worker at trained with the technology called in about a jammed printer then took it over to a counter and without supervision, cut out the offending paper trail with who knows what ability to follow any process to keep it with the rest of the paper trail. The paper trails in Nevada are printed on thermal paper. It was very hot that day. A thermal printout might turn black if heated on a dashboard, or in a kitchen oven or microwave in a kitchen found in a rooms adjacent several of the polling locations. The paper trail printer has a power plug that goes into the voting machine without a way of securing it. In over 220 machines in Nevada I saw no printer ballot box with a seal on it.

Luckily I don’t believe any of the poll workers I met had any mal intent. I do wonder however about the fact that the printers are an extra device which might seem somehow ancillary and are not treated with the care and process of the voting machine. Added equipment and effort cause confusion.

To defraud a VVPAT machine a hacker might make the machine skip a race or appear to have a bad printer, perhaps by making the printer skip a race while printing, or simply by making an unreadable section on the receipt. This could be used to cover up software defrauding of the electronic vote or it could hide changes in the vote inside the computer.

In making the VVPAT and electronic ballot disagree, the defrauder could be calling into question the quality of technology to create a reason to call for a new election.

In a likely scenario, the defrauder will change the electronic ballot and depend on the statistics for reading and contesting bad receipts. If a person calls their receipt into question and asks for another receipt to be printed, the hacked VVPT machine can print the “duplicate” receipt correctly, fixing the “printer” mistake. By printing the correct receipt when a person asks for it a second time it could literally eliminate the changed ballot, thus eliminating the possibility of detection. If we generously considered that the people that didn’t mention a problem but noticed one did report it. The hacker could change one in 75 votes and still wouldn’t expect to have more than one complaint per day per polling place. When a voter complains and it comes to the attention of one of the several ballot workers that are running the election in a balloting area, it is likely to be caused by simple ergonomic problems. If it is because of the fraudulent VVPAT, it will likely be the first time the ballot worker encounters this problem, which will make it harder to handle correctly than if they encountered it often. They are likely to encourage the voter to reprint the receipt that would, allow the voting machine to fix the internal count and print the correct receipt to cover up the fraud. If the ballot worker does enter the balloting area where the voter is, in order to verify the legitimacy of a problem with a VVPAT, then they would have compromised the secrecy of that ballot. Even if they did enter the voters balloting booth to observe the strangely printed receipt, the natural reaction to an unreadable receipt would be to print a duplicate receipt. Exchanging printers would also reprint the ballot, thereby eliminating the evidence. Shutting down the machine is the only thing that would preserve the fraud to view later, but this would disenfranchise other voters.

Today's verification experiments do not show that we have produced a paper method that can be verified by voters. VVPAT can themselves be used as part of a hacking scheme. Further, counting paper is notoriously delivers 2 to 3 errors per thousand.

Evidence suggests that most votes are lost registration problems, machine user experience and polling place problems. While verification experiments might suggest more experiments to test other styles of paper trails, it is clear that these first tests with VVPAT do not bode well for there inclusion in imminent legislation to require this specific verification mechanism. We must require the solutions we propose to be improvements before we legislate them as improvements.

We know many ways to improvement to voting accuracy and reliability that can be implemented with testing training and process. Testing has found many problems with voting equipment. Forensic analysis of tallys has allowed people to correct counting errors as well. Let's look to creating voting approaches that increase end to end auditing and increase redundant records of the process in ways that don't complicate the voter experience or create a questionable forensic data as current paper trails seem to.

## *Biography for Ted Selker

Professor Ted Selker is co-director of the Caltech/MIT voting project (www.vote.caltech.edu/) and runs the Context-Aware Computing Lab (www.media.mit.edu/context) at the MIT Media and Arts Technology Laboratory.

Ted participates in observing elections, analyzing voting equipment, speaking, and writings and is part of the IEEE voting standards committee. A large part of his work in voting concerns inventing and testing new technology for voting. Examples include new approaches to user interface and ballot design; secure electronic architectures and approaches for improving registration.

Professor Selker's Context Aware Computing Lab strives to create a world in which peoples' desires and intentions guide computers to help them. This work creates environments that use sensors and artificial intelligence to create so-called "virtual sensors," adaptive models of users to create keyboard-less computer scenarios.

Prior to joining MIT faculty in November 1999, Ted was an IBM Fellow and directed the User Systems Ergonomics Research lab in IBM research. He has served as a consulting professor at Stanford University, taught at Hampshire, and Brown Universities and has worked at Xerox PARC and Atari Research Labs. Ted's research has contributed to products ranging from notebook computers to operating systems.

Ted is the author of numerous patents and papers. And was co recipient of computer science policy leader awarded for Scientific American 50 in 2004