To: Congressman Rush Holt

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Date:**   1 February 2007

Re: Thoughts on Mandatory Audits

We write to support your decision to adopt a "tiered" approach to auditing of voter
verified paper records in the Voter Confidence and Increased Accessibility Act of 2007.
Our understanding is that the language in the bill is as set forth in Appendix A.

This replaces earlier language that would have required all states to audit 2% of all
precincts under all circumstances. We believe the new language will give jurisdictions
more confidence that they will catch programming errors, software bugs or attacks
against voting systems. This audit scheme also seems to allow jurisdictions to develop
other, innovative audit procedures on their own and still receive federal funding for such
audits, as long as they are at least as effective as what is otherwise required. Finally, this
scheme minimizes potential burdens on election officials by requiring increased levels of
audits *only when races are exceptionally close*. Below we explain the reasons behind our
consensus.

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* The authors' affiliations are provided for identification purposes only. The views expressed in this
memorandum are the authors' personal views. The authors do not purport to represent the views of their
respective institutions.
** Updated on March 19, 2007

Discovery of Systemic Error vs. Confidence Level and the Development of the Tiered Auditing Approach

Some of your colleagues may want to know what percentage of precincts must be audited in order to ensure that there is not an "unacceptable" level of error.

In truth, it may be that attempting to prevent an "unacceptable" level of error on electronic voting machines through audits is too administratively burdensome. This is particularly true if we assume that a certain number of votes (e.g., 10 % or 20%) can be miscounted in a single polling place without giving rise to an independent investigation, and that some errors will be "clumped" into a relatively small number of precincts, rather than spread evenly among them.

Thus, we might say that the miscounting of 1% of all votes in a federal race is "unacceptable." In an imagined typical congressional district, with 400 precincts of roughly equal size, we would need to audit more than 10% of all precincts to have at least 90% confidence that an audit would discover an error causing a miscounting of 1% or more of the votes.

Mandating a 10% audit for all races would be a high burden on many States. And in the vast majority of races, a shift of 1% of the votes would not alter the outcome of the race. For that reason, we might say that while less than ideal, we are willing to live with the risk that audits will not catch the 1% counting error in races where such an error is not going to change the outcome of the race.

But in races decided by less than 1% (in recent history, this has represented less than one percent of all federal elections), we might say we are *unwilling* to accept this risk.

Typical Congressional District

It is therefore worth considering how well the tiered approach will perform if we ask how likely audits in this scheme are to detect errors that would change the outcome of a specific race. The table below gives the probabilities of detecting discrepancies in 2, 3, 5 and 10% post-election audits in a typical congressional district with 400 precincts for races with margins ranging from 0.5% to 5.0% (Note: the highlighted numbers give confidence levels for audits conforming to the tiered approach of the Voter Confidence and Increased Accessibility Act of 2007.)[1]

No. of precincts	Margin of victory	Probability in a 2% audit	Probability in a 3% audit	Probability in a 5% audit	Probability in a 10% audit
400	0.50%	10%	14%	22%	41%
400	0.75%	15%	22%	34%	57%
400	1.00%	18%	27%	40%	66%
400	1.75%	31%	43%	61%	86%
400	2.00%	33%	46%	65%	89%
400	5.00%	66%	80%	94%	99.6%

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[1] These calculations assume that a vote shift of 20% or more within a single precinct will be detected.

As you can see from this chart, in cases of narrow margins, adopting the tiered approach could give the public and jurisdictions considerably greater confidence that result-changing errors were caught than would a fixed-percentage audit, without putting an unreasonable burden on the vast majority of districts.[2]

Minimizing the Burden on Election Officials

This tiered audit approach has the benefit of providing increased security in close elections without placing an undue burden on election officials. We can see this in the chart below, which shows the number of Congressional races in recent history with margins that would have triggered the tiered audits set forth in the Act. If your audit scheme were required in the last three federal elections, the number of expanded audits would have been exceedingly small.

Year	Federal Races Requiring 3% Audit (decided by more than 2% margin)	Federal Races Requiring 5% audit (decided by between 1% and 2% margin)	Federal Races Requiring 10% audit (decided by between 0% and 1%).
2002	461	3	4
2004	510	5	5
2006	451	7	10

Thus, we see that in 2002, 2004, and 2006, having a tiered audit procedure as proposed in the Holt bill would have a cost that is negligibly increased compared to a flat audit of 3%, since almost all of the races would be audited at the 3% level anyway (the first tier). The extra cost of performing some audits in the second and third tier contributes about 1/30th of the total audit cost.[3] Although having a tiered approach adds some complexity to the process, it does not add significantly to the cost of doing the audits; yet it greatly increases one's confidence that election results are correctly reported for all races—even close races.

The tiered audit scheme adopted by the Holt Bill reasonably balances a number of interests: confidence in election results, deterrence of electoral fraud, audit cost, innovation in new audit designs, and the burdens of administrability and frequency of increased percentage audits.

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[2] As some commentators have noted, where Congressional Districts have less than 400 precincts, or precincts that vary substantially in size, the confidence levels listed in this chart will fall. Nevertheless, the basic concept remains the same: by increasing the audit percentage in close races, we gain greater confidence that result-changing errors will be caught. *See e.g.* Ronald Rivest, *On Auditing Elections When Precincts Have Different Sizes,* Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology (March 18, 2007), *available at* http://theory.csail.mit.edu/~rivest/Rivest-OnAuditingElectionsWhenPrecinctsHave-DifferentSizes.pdf, and Howard Stanislevic, *Random Auditing of E-Voting Systems: How Much is Enough*, *available at* http://www.votetrustusa.org/pdfs/VTTF /EVEPAuditing.pdf.

[3] This calculation assumes that costs of increased audits increased linearly with audit percentage.

The text of the tiered audit used by the Voter Confidence and Increased Accessibility Act of 2007:

(a) IN GENERAL.—Except as provided in subsection (b), the number of voter-verified paper ballots which will be subject to a hand count administered by the Election Audit Board of a State under this subtitle with respect to an election shall be determined as follows:

(1) In the event that the unofficial count as described in section 323(a)(1) reveals that the margin of victory between the two candidates receiving the largest number of votes in the election is less than 1 percent of the total votes cast in that election, the hand counts of the voter-verified paper ballots shall occur in 10% of all precincts (or equivalent locations) in the Congressional district involved (in the case of an election for the House of Representatives) or the State (in the case of any other election for Federal office).

(2) In the event that the unofficial count as described in section 323(a)(1) reveals that the margin of victory between the two candidates receiving the largest number of votes in the election is greater than or equal to 1 percent but less than 2 percent of the total votes cast in that election, the hand counts of the voter-verified paper ballots shall occur in 5% of all precincts (or equivalent locations) in the Congressional district involved (in the case of an election for the House of Representatives) or the State (in the case of any other election for Federal office).

(3) In the event that the unofficial count as described in section 323(a)(1) reveals that the margin of victory between the two candidates receiving the largest number of votes in the election is equal to or greater than 2 percent of the total votes cast in that election, the hand counts of the voter-verified paper ballots shall occur in 3% of all precincts (or equivalent locations) in the Congressional district involved (in the case of an election for the House of Representatives) or the State (in the case of any other election for Federal office).

(b) USE OF ALTERNATIVE MECHANISM.—Notwithstanding subsection (a), a State may adopt and apply an alternative mechanism to determine the number of voter verified paper ballots which will be subject to the hand counts required under this subtitle with respect to an election, so long as the National Institute of Standards and Technology determines that the alternative mechanism will be at least as effective in ensuring the accuracy of the election results and as transparent as the procedure under subsection (a).