

# The Future: Fears, Predictions, Hopes, & Plans

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## Smart phones, . . .

I predict:

If technological progress continues at the current rate, within a decade, in many U.S. jurisdictions we will be able to use iPhones to reliably . . .

## ... less-than-smart ideas

~~vote~~ make phone calls.

## Four Horsemen of the Votocalypse

- Internet voting, phone voting, widespread remote voting (including VBM)
- failure to create accurate, complete, voter-verified audit trail
- failure to curate audit trail and check curation
- failure to use audit trail appropriately to check/correct outcomes

I think we, as a community, can avert the Votocalypse.

IRV/RCV is the Shetland-pony jockey of the Votocalypse, because it greatly exacerbates the difficulty of confirming outcomes and auditing.

# Foundations

## Strongly Software-Independent Voting System (Rivest & Wack)

A voting system is strongly software-independent if an undetected error or change to its software cannot produce an undetectable change in the outcome, and we can find the correct outcome without re-running the election.

## Risk-limiting Audit

Large, known chance of a full hand count if the outcome is wrong, thereby correcting the outcome.

Risk is maximum chance of failing to correct an apparent outcome that is wrong, no matter what caused the outcome to be wrong.

## Organizing idea for (my) future work

### Resilient Canvass Framework

Known minimum chance that the overall system (human, hardware, software, procedures) gives the correct election outcome—when it gives an outcome.

- Use voting system that creates a voter-verified audit trail.
- Conduct a compliance audit to ensure that—as actually used in this election—the system is strongly software-independent.
- If so, conduct a risk-limiting audit. If not, do not declare an outcome.

Ideally, the overall election and canvass process should correct its own errors before announcing results, or report that it can't guarantee that it corrected its errors (for instance, because the audit trail can't be shown to be intact).

## Ingredients for resilient canvass framework

- Voters create complete, durable, accurate audit trail.
- LEO curates the audit trail adequately.
- Compliance audit to ensure that the audit trail is adequately intact.  
Was the system, as used, strongly software independent?  
If not, don't declare an outcome.
- Timely reporting of all-but-final results for auditable batches.  
Smaller batches are better; individual ballots are best.  
Biggest bottleneck: need changes in voting systems.
- Risk-limiting audit: Count votes by hand until there's strong evidence that counting the rest won't change the outcome.  
"Explaining" or "resolving" errors isn't enough.

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## Evidence-Based Elections

- Law should require LEOs to give convincing evidence outcomes are right.
- Does not necessarily require radical transparency—but requires a good audit trail.
- Certifying equipment isn't enough: How was the equipment used?
- Election should generate hard evidence, checked for integrity.
- Audit trail needs to be scrutinized to confirm or correct the outcome.
- “I’m good at my job” is widely true, but is not convincing evidence: stuff happens. Often.
- Why certify equipment but not procedures, especially curation of the audit trail?

# Compliance Audits and Materiality Audits

## Effective compliance audit

Determine whether the audit trail is trustworthy enough to determine who won.

If not, do not declare an outcome (nb: danger of DOS attacks).

## Effective materiality audit

Correct the outcome if it is wrong.

Requires intact audit trail—need to pass compliance audit first.

Might require counting the entire audit trail by hand.

## Compliance audit: check creation & curation of audit trail

- Did election use equipment that should create an accurate audit trail and adhere to procedures that should keep the audit trail sufficiently accurate to reflect the outcome according to how voters actually voted?
- Should include ballot accounting, checks of seals, chain of custody, surveillance tapes, forensic dismantling of voting machines, etc.
- If compliance audit generates convincing affirmative evidence that a full hand count of the audit trail would show the outcome according to how votes were cast, proceed to risk-limiting audit.
- If not, lack evidence that the outcome is right: don't declare election outcome.

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## Materiality audit: check outcome against audit trail

- Did the vote tabulation system count the votes accurately enough to determine who won?
- Relies on the audit trail, which the compliance audit has checked for integrity.
- If hand-to-eye check of sample of ballots generates convincing evidence that a full hand count of the audit trail would show the same outcome that the VTS reported, stop.
- If not, expand the sample and count more votes by hand. Keep expanding until there's convincing evidence or until there has been a full hand count.

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## Risk-Limiting Audits

- 10 pilot audits in CA and CO; another 20 planned.
- EAC funding for CA and CO
- CO has law; CA has pilot law
- simple measures
- measures requiring super-majority
- multi-candidate contests
- vote-for- $n$  contests,
- multiple contests audited simultaneously with one sample
- contest sizes: 200 ballots to 121,000 ballots
- counting burden: 16 ballots to 7,000 ballots
- cost per audited ballot: nil to about \$0.55.

## Regulate evidentiary standards?

- Have: regulations for voting technology instead of outcome accuracy.
- Need: certify procedures for creating, curating, and auditing the audit trail, Use of seals and surveillance, ensuring proper chain of custody, ballot accounting, audits.
- Need: standards for data exchange formats.
- Need: latest, cheapest, most accurate technology for counting and auditing.
- Need: evidence-driven rules that require a re-vote (or court adjudication?) if can't show that the audit trail is sufficiently accurate to show right outcome.
- Need: evidence-driven rules that require counting the entire audit trail if the machine count is not accurate enough.

## Hopes and plans

The difference between theory and practice is smaller in theory than it is in practice.

- Move to evidence-based requirements instead of equipment-based requirements.
- Work with elections officials at the state and local level, integrity advocates, vendors, computer scientists, political scientists, statisticians, financial auditors, attorneys, to draft model legislation for election auditing.
- Clarify in tradeoff of risks and costs. What kinds of errors are we (as a society) willing to tolerate? With what frequency? What are we willing to pay? How long are we willing to make the canvass?
- Do the work required to put theory into practice, to have resilient canvass frameworks.



## What would brighten future?

- **Laws and regulations that put incentives in the right place, and focus on evidence rather than equipment.**
- Voting systems that “commit” to the interpretation of each ballot. (CVRs linked to individual ballots)
- Compliance audits of every election.
- Willingness to re-vote (or do something sensible) if the compliance audit does not give strong evidence that the audit trail reflects how people voted.
- Risk-limiting audits: willingness to have a full hand count if there is not enough evidence that the apparent outcome is what a full hand count would show.

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