Risk-limiting Audits and Evidence-based Elections in a Nutshell

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EVN Annual Conference
Atlanta, GA
14 March 2013
What do we want election audits to do?

Ensure that the electoral outcome is correct;
If outcome is wrong, correct it before it’s official.
How can an audit correct a wrong outcome?

If there’s an adequately accurate audit trail, the audit could in principle count all the votes by hand.

Don’t overturn outcome on statistics alone.
<table>
<thead>
<tr>
<th>Why not just count all votes by hand?</th>
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</thead>
<tbody>
<tr>
<td>- Unnecessarily expensive and time-consuming.</td>
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<td>- Instead, count by machine, and check a random sample by hand.</td>
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<tr>
<td>- Keep checking until there’s convincing evidence that the outcome is right—or until all ballots have been examined and the right outcome is known.</td>
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</table>
Controlling the chance of error

- Since the sample is drawn at random, there’s a chance a wrong outcome will escape correction—but we can make that chance as small as we want. Statistics says how.
- **Risk** is the largest possible chance that the audit does not correct the outcome, if the outcome is wrong.
- **Risk-limiting audit** ensures that the largest possible chance is still a small chance, like 10%, 5%, 1%.
- Generally, have to check more to make chance smaller.
“Stirring” is key to reducing work

- Don’t have to climb into the bathtub to tell if it’s hot: can just stick your toe in—if the water is stirred well.
- Don’t have to walk all over town to tell if it’s cold outside: the air is mixed well enough that you just have to step outside to get a pretty good idea.
- Don’t have to drink a whole pot of soup to tell if it’s too salty: a teaspoon is enough—if the pot has been stirred. ( Doesn’t matter whether the pot holds 1q or 50g.)
How do you stir ballots?

Random sampling is stirring

- Imagine numbering the ballots.
- Write the numbers on ping-pong balls; put in a lotto machine.
- Lotto machine stirs the balls and spits some out.
- The ballots with the numbers on the selected balls are a random sample of ballots.
- Easier to stir balls than ballots. Even easier to generate random numbers.
- Still amounts to putting ballots into a huge cement mixer to stir them, then taking a “teaspoon” of ballots.
Risk is *not*

- The chance that the certified outcome is wrong.
- The fraction of certified outcomes that are wrong.
Paper rules— if it is right

- Can’t correct wrong outcomes without counting the whole audit trail.
- Counting the whole audit trail won’t give right answer unless it’s adequately accurate and intact.
- Current procedures for protecting, tracking, and accounting for ballots are spotty. Should be top priority!

Risk limit *assumes* outcome is wrong in the hardest-to-find way. Biggest chance the outcome won’t be corrected.
Ballot-polling Audits and Comparison Audits

- Ballot polling audit: sample ballots until there is strong evidence that looking at all of them would show the same election outcome. Like an exit poll—but of ballots, not voters.
- Comparison audit:
  1. Commit to vote subtotals (or CVRs), e.g., precinct-level results
  2. Check that the subtotals add up exactly to contest results
  3. Check subtotals by hand until there is strong evidence the outcome is right
Tradeoffs

• Ballot polling audit
  • Virtually no set-up costs
  • Requires nothing of voting system
  • Need a ballot manifest to draw sample
  • Preserves voter anonymity except possibly for sampled ballots
  • Requires more counting than ballot-level comparison audit
  • Does not check tabulation: outcome could be right because errors cancel

• Comparison audit
  • Heavy demands on voting system for reporting and data export
  • Requires LEO to commit to subtotals
  • Requires ability to retrieve ballots that correspond to CVRs or subtotals
  • May compromise voter privacy
  • Most efficient (ballot-level) not possible w/ current systems: requires rescan
  • Checks tabulation (but not for transitive audits unless subtotals are cross checked as well)
  • Ballot-level comparison audits require least hand counting
Ballot-polling Audits are often Cheap for Big Contests

255 state-level presidential contests, 1992–2011, 10% risk limit

BPA expected to examine fewer than 308 ballots for half the contests.

Work expands as margins shrink, but we could get a lot of election integrity at low cost—with any paper-based system.
Workload estimate: Ballot-Polling Audit, 2 Candidates, 10% Risk Limit

<table>
<thead>
<tr>
<th>Winner’s True Share</th>
<th>Ballots drawn</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>median</td>
</tr>
<tr>
<td>70%</td>
<td>22</td>
</tr>
<tr>
<td>65%</td>
<td>38</td>
</tr>
<tr>
<td>60%</td>
<td>84</td>
</tr>
<tr>
<td>58%</td>
<td>131</td>
</tr>
<tr>
<td>55%</td>
<td>332</td>
</tr>
<tr>
<td>54%</td>
<td>518</td>
</tr>
<tr>
<td>53%</td>
<td>914</td>
</tr>
<tr>
<td>52%</td>
<td>2,051</td>
</tr>
<tr>
<td>51%</td>
<td>8,157</td>
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<tr>
<td>50.5%</td>
<td>32,547</td>
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</tbody>
</table>
Risk-Limiting Audits

• 17 pilot audits in CA, CO, and OH; another 13 planned.
• CO has law; CA has pilot law
• simple measures, super-majority, multi-candidate, vote-for-n
• 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
• several jurisdictions have audited on their own—no geeks needed
Evidence-based elections

Principle: Trust, but verify

LEOs should give convincing evidence that outcomes are right (or say they can’t).
“Trust me” is not convincing.

- Voters create complete, durable, accurate audit trail.
- LEO curates the audit trail adequately.
- Compliance audit to check whether the audit trail is trustworthy enough to determine who won.
  If not, how strong can the evidence be?
- Risk-limiting audit to correct the outcome if it is wrong.
  Presumes audit trail is OK.
  “Explaining” or “resolving” errors isn’t enough.