Overview of the Journey

• Post-Election Audits are Important
• How Traditional Audits Work
• Why RLA is better
• Definitions
• How RLA Works in CO – The Basics
• Status of RLA Process in Colorado and Beyond
• Using RLA with Non-Plurality Voting Methods
Why Audits are Important

• Ensure that votes are counted accurately and securely, while protecting voter privacy. Want to **confirm** election outcomes and **correct** errors.

• Machine interpretation is recorded in a Cast Vote Record, but machines misinterpret ballots, and humans mismark ballots.

• Routine audit in Palm Beach County, FL in 2012 revealed two city council contests were certified with the wrong outcomes.
Kinds of Audits

• Fixed Percentage – Example: 2% of precincts
• Fixed Size – Example: 1,000 ballots
• Tiered Samples
  – depending on reported margin of victory
• Risk-Limiting Audits
• End-to-end open audits (STAR-Vote, Scantegrity)
Why Risk-Limiting Audits are Better

• We want vote counts to be at least accurate enough to correctly determine the outcome

• Traditional audits usually either
  – require more work than necessary to confirm an outcome
  – yield too little information to be conclusive.

• An RLA uses statistics to check enough voted ballots to get strong evidence that election outcome is correct.
Definitions: Types of Risk-Limiting Audits

- **Ballot comparison** – audit individual ballots
  - Verify that the Cast Vote Record (machine interpretation) is correct
- **Batch Comparison** – audit entire batches or precincts (less efficient but required if reporting is inadequate)
- **Ballot Polling** – random sample of ballots if auditable counts aren't available. Less efficient by factor of $1/\text{margin}$
Supplemental slides

- Challenges: Slide 3
- Ballots, imprinted IDs, random selection video: Medium post
- Data format standards: Slides 6, 7
- Public RLA Oversight Protocol: Slide 8
- Public engagement in verification: Slide 12
- Example of a misinterpretation: Slide 14
Definitions: Risk-Limiting Audit Theory

- **Risk Limit** – largest statistical probability that an incorrect reported tabulation outcome is not detected and corrected in a risk-limiting audit. Worst-case scenario! E.g. 5%, 20%
- **Diluted Margin** – the smallest margin (in any contest) as a fraction of all the ballots subject to the audit
- **Vote Overstatement** (narrows the margin) and **Vote Understatement** (increases the margin)
Definitions:

Logistics

• **Publicly Verifiable Random Seed** – a starting point for randomly selecting ballots to audit
  – A 20-digit number, e.g.
    84437724778708423271
  – 20 stakeholders each roll a 10-sided dice.
  – Put the 20-digit number into a public pseudo-random number generator to determine which ballots to audit
Definitions:

Logistics

• **Ballot Manifest** – a list detailing where each ballot is located
# Ballot Manifest (Excerpt)

## Boulder County

<table>
<thead>
<tr>
<th>County</th>
<th>Device ID</th>
<th>Batch</th>
<th># of Ballot</th>
<th>Carrotion</th>
</tr>
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<tbody>
<tr>
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<td>146</td>
<td>1</td>
</tr>
<tr>
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<td>1</td>
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<td>21</td>
</tr>
</tbody>
</table>
Definitions:

Logistics

• **Ballot Cards** – individual pieces of paper that together constitute a single ballot containing all of the contests an elector is eligible to vote
How RLA Works in CO – The Basics

• Breakdown in 2017:
  – 50 counties: Ballot Comparison
  – 6 counties: Ballot Polling (CO Risk Limit = 20%)
  – 2 counties: Hand Count Ballots
  – 6 counties: No Coordinated Election

• Targeted only 1 Contest per county. Others audited “opportunistically”.

CO Risk-Limiting Audits -- Feb 2018 -- N. McBurnett
Successes in CO

• Efficiently-auditable election system
• All contests subject to audit (but not reviewed)
• Open Source Software developed for ballot-level RLAs
• Publicly verifiable random selection
• Officials could check risk limits
Remaining work

• Share results for opportunistic audits, and allow Public RLA Oversight (publish CVRs, \texttt{rla\_export data})
  - Requires addressing anonymity issues better
• Develop support for multi-county and sub-county contests
• Handle non-voter-verifiable ballots properly (e.g. received by email)
• Support in-person scanners (most states which have them currently)

CO Risk-Limiting Audits -- Feb 2018 -- N. McBurnett
Status of RLA Process in Colorado and Beyond

• Upcoming hearing to review SoS-proposed changes to Rule 25 and public comments for other changes
  – Transparency concerns around ballots and audit reports
  – More auditing, e.g., simultaneous audits
  – Should Sec of State select the statewide and county contests to audit?

• In February CO Sec of State to brag about RLA at National Association of Secretaries of State (NASS)
Using RLA with Non-Plurality Voting Methods

• In instant-runoff voting or single transferable vote, even determining the margin (minimum number of changed ballots that could lead to different outcome) is very very hard.

• Bayes audits (Rivest & Shen) can estimate the risk for any voting method. No traditional frequentist approach is available for most.
RLA and Various Voting Methods

• Single-Winner
  – Plurality (easy)
  – Approval (easy)
  – Score (easy??)
  – Score Runoff (Bayes)
  – Instant-Runoff Voting (Bayes)
  – Cumulative Voting (easy?)

• Multi-Winner
  – At-Large Plurality (easy)
  – Sequential Proportional Approval Voting (Bayes)
  – Score (easy??)
Website Resources

• CO Risk-Limiting Audit Project (CORLA): http://bcn.boulder.co.us/~neal/elections/corla/
• CO Sec of State Audit Center: http://www.sos.state.co.us/pubs/elections/auditCenter.html