Colorado's Risk-Limiting Audits (RLA)

Our Journey

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

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

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/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**

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

County	Device ID	Batch	# of Ballot Cards	Location
BOULDER	1	1	146	1
BOULDER	1	2	142	1
BOULDER	1	3	147	1
BOULDER	1	4	140	1
BOULDER	1	5	142	1
BOULDER	1	6	139	1
BOULDER	1	7	147	1
BOULDER	1	8	147	1
BOULDER	1	9	133	11
BOULDER	1	10	141	11
BOULDER	1	11	144	11
BOULDER	1	12	146	11
BOULDER	1	13	146	11
BOULDER	1	14	144	11
BOULDER	1	15	149	11
BOULDER	1	16	145	11
BOULDER	1	17	150	21
BOULDER	1	18	149	21
BOULDER	1	19	119	21

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

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How RLA Works in CO – The Basics
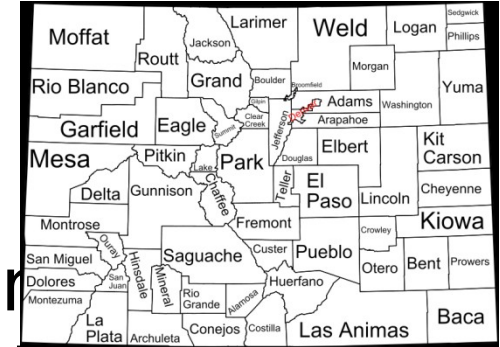
- Breakdown in 2017:
  - 50 counties: Ballot Comparison
  - 6 counties: Ballot Polling (CO Risk Limit = 20%)
  - 2 counties: Hand Count Ballots
  - 6 counties: No Coordinated Election
- Targeted only 1 Contest per county. Others audited "opportunistically".

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, `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

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/
- *Risk-Limiting Post-Election Audits: Why and How* https://www.stat.berkeley.edu/~stark/Preprints/RLAwhitepaper12.pdf
- CO Sec of State Audit Center: http://www.sos.state.co.us/pubs/elections/auditCenter.html
- *A Gentle Introduction to Risk-Limiting Audits* https://www.stat.berkeley.edu/~stark/Preprints/gentle12.pdf