Colorado Risk-Limiting Audit: Conception to Application

Presented by...
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Featuring...
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and
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Agenda

• Provide an overview of what a risk-limiting audit (RLA) is
• Provide a brief history of RLAs in Colorado
• Current post-election audit vs. RLA
• Provide workload examples
• Describe the benefits and challenges of an RLA
• Describe the tools that will be used to conduct an RLA
• Describe the responsibilities of the county clerk, the county audit board, and the SOS
• Lessons learned
• Q&A
What is a risk-limiting audit?

A risk-limiting audit provides strong statistical evidence that the election outcome is right, and has a high probability of correcting a wrong outcome.¹

• Risk limit: the largest chance that a wrong outcome will not be corrected
• Wrong outcome: when the reported outcome does not match the actual outcome – this can happen due to various reasons like adjudication or equipment errors.

If the risk limit is 5% and the outcome is wrong, there is at most a 5% chance that the audit will not correct the outcome, and at least a 95% chance that the audit will correct the outcome.²

The number of ballots required to conduct an RLA will vary based on the smallest margin of the contest selected by the SOS and the risk limit. The smaller the margin, the more ballots to audit. The smaller the risk limit, the more ballots to audit.
RLA History in Colorado

- **2009**: HB 09-1335 introduced RLA pilots to commence with the 2014 General Election
- **2010**: Conducted RLA Study with CSU and Douglas County
- **2011**: Received EAC grant to conduct RLA research
- **2012**: Conducted the first pilot RLA at Arapahoe County for the 2013 Coordinated Election using Clear Ballot; HB Bill 13-1303 revised the RLA date from 2014 General Election to the 2017 Coordinated Election
- **2013**: A Gentle Introduction to Risk-Limiting Audits" was published by Drs. Stark and Lindeman
- **2014**: Additional RLA pilot at Arapahoe County using COTS scanners and OpenCount software
- **2015**: RLA pilots at Denver, Adams, Garfield, and Jefferson counties as part of the Pilot Election Review Committee review
- **2016**: RLA pilots at Pitkin and Arapahoe counties using the Dominion Democracy Suite voting system
- **2017**: Colorado is developing rules, procedures, and software to conduct an RLA for the 2017 Coordinated Election
Random

3 days after

500 or 20%

Ballots on randomly selected devices

Canvass early

Starts at soon as SOS sends post-election audit form to counties

RLA

9 days after

0 or more

Randomly selected ballots

Canvass on statewide date

Starts after all counties submit all tabulation info to SOS
Random Audit

Pre-Audit:
- County sends voting equipment inventory to the SOS and appoints an audit board
- SOS randomly selects equipment within 2 days after election night

Scanners: Randomly select ballots – 500 or 20%, whichever is less;
DREs: 100% of VVPAT records

Compare rescanned ballots and VVPAT records to tabulation report

Do they match?

- Yes: Audit board completes the SOS audit form
- No: Confirm manual count; Look at each audited ballot for overvotes, stray marks, damage, etc.; Take any other action; Submit detailed report to SOS

County submits the form and applicable reports to the SOS

No later than 5 pm on the last day of canvass
Risk-Limiting Audit

Pre-Audit:
- County appoints audit board, downloads the ballot manifest form, and defines the batch size
- SOS selects the contest to audit and sets the risk limit

9 Days after the Election
Counties send ballot manifests and CVR to SOS

SOS randomly selects ballots using RLA software after ballot manifests and CVRs are received from all of the counties
SOS notifies counties of what ballots to audit
Audit board retrieves ballots selected by SOS and compares them to the CVR

SOS: risk limit met?
Yes
County submits results to SOS

No
SOS selects additional ballots to audit

SOS notifies county that audit is complete
Audit board completes the SOS RLA form
County submits the form to the SOS

Day before Thanksgiving
SOS notifies county that audit is complete
## 2016 Presidential Contest

<table>
<thead>
<tr>
<th>Total Ballots Cast</th>
<th>2,859,216; Risk Limit = 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinton</strong></td>
<td>1,338,870</td>
</tr>
<tr>
<td><strong>Trump</strong></td>
<td>1,202,484</td>
</tr>
</tbody>
</table>

Smallest Margin = 136,386  
Diluted Margin = smallest margin/total ballots cast = 4.77%

Using Dr. Stark's comparison RLA algorithm, the number of ballots to audit is **142** for the whole state.  
(In our current audit, all counties are probably required to audit at least **32,000** ballots)
**City and County of Denver Referred Question 2A**

<table>
<thead>
<tr>
<th>Total Ballots Cast = 341,987; Risk Limit = 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes/For</td>
</tr>
<tr>
<td>Yes/For</td>
</tr>
<tr>
<td>No/Against</td>
</tr>
<tr>
<td>No/Against</td>
</tr>
</tbody>
</table>

Smallest Margin = 159,997
Diluted Margin = smallest margin/total ballots cast = 46.8%

Using Dr. Stark’s comparison RLA algorithm, the number of ballots to audit is **15** for the county.

(In our current audit, Denver is probably required to audit at least **500** ballots)
<table>
<thead>
<tr>
<th>Benefits</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Should examine significantly fewer ballots than are required in the current audit</td>
<td>Potentially audit more ballots than are currently required, and if the outcome is incorrect, could evolve into a full hand count</td>
</tr>
<tr>
<td>Statistically based - the county manually inspects a number of ballots based on a statistical algorithm</td>
<td>Retrieving specific ballots can be more difficult than simply selecting ballots haphazardly</td>
</tr>
<tr>
<td>Check how the voting system interpreted each ballot</td>
<td>Requires maintaining counted ballots in the exact order they are scanned, or imprinting numbers on the ballots, in order to accurately compare a CVR to the ballot it represents</td>
</tr>
<tr>
<td>Should require fewer resources to conduct the audit</td>
<td>Will not be able to canvass early</td>
</tr>
</tbody>
</table>
RLA Tool Kit – what is required to conduct an RLA

• Ballot manifest – a document that describes how ballots are organized and stored
• CVR – an export of data from the voting system showing how the voting system interpreted markings on every ballot
• Hash utility – will create a hash value (digital fingerprint) for a county’s CVR export
• RLA software\(^3\) – used to calculate the number of ballots to audit, randomly select the ballots, provide a ballot lookup table, and notify the user when the audit can stop.
Sample Ballot Manifest

- Batch size – the smaller the batch size, the easier to retrieve ballots
- Label all ballot storage bins for easy location and retrieval
- Maintain documented chain-of-custody for all ballot storage bins

<table>
<thead>
<tr>
<th>County</th>
<th>Scanner ID</th>
<th>Batch #</th>
<th># of Ballots Scanned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fremont</td>
<td>Scanner1</td>
<td>4</td>
<td>49</td>
</tr>
<tr>
<td>Fremont</td>
<td>Scanner2</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Fremont</td>
<td>Scanner3</td>
<td>3</td>
<td>51</td>
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### Sample Cast Vote Record

<table>
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<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
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<th>N</th>
<th>O</th>
<th>P</th>
<th>Q</th>
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<tbody>
<tr>
<td>1</td>
<td>2017 Colorado Demonstration Project</td>
<td>5.2.13.24</td>
<td>Presidential Election</td>
<td>Presidential Election</td>
<td>President</td>
<td>President</td>
<td>President</td>
<td>President</td>
<td>President</td>
<td>President</td>
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<td>3</td>
<td>2017 Colorado Demonstration Project</td>
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<tr>
<td>4</td>
<td>CvrNumber</td>
<td>TabulatorNum</td>
<td>BatchId</td>
<td>RecordId</td>
<td>ImprintedId</td>
<td>CountingGroup</td>
<td>PrecinctPortion</td>
<td>BallotType</td>
<td>DEM</td>
<td>REP</td>
<td>ACN</td>
<td>LBR</td>
<td>GRN</td>
<td>AVP</td>
<td>ADE</td>
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<tr>
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<td>3</td>
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<td>1</td>
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<td>0</td>
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</table>
Conducting the RLA

1. County creates ballot manifest describing in detail how ballots are stored (County ID, scanner ID, batch ID, # of ballots in each batch)
2. County keeps ballots in the same order in which they are scanned or imprints ballots with identifying numbers
3. County secures and stores ballots
4. County exports CVR by 11:59 PM on the 9th day after the election and creates a hash of the CVR file
5. County sends ballot manifest and CVR to SOS by 11:59 PM on the 9th day after the election.
Conducting the RLA continued

6. SOS uses RLA software to randomly select ballots to audit and sends information to counties after ballot manifests and CVRs are received from all of the counties.

7. County audit board retrieves the selected ballots and compares them to the CVR.

8. County reports results of RLA to the SOS.

9. SOS determines whether additional auditing is needed. If so, SOS sends county a list of additional ballots to retrieve and inspect.

10. County reports audit results and other pertinent data to SOS at the end of the audit.
RLA Timeline

November 16th
11:59 PM
Submit CVR and Ballot Manifests

November 17th
11:59 PM
SOS Sends Ballots to Audit

November 18th
Conduct the Audit

November 20th
5:00 PM
Submit Initial Audit Results

November 21st
SOS Provides Audit Feedback

November 22nd
Submit Final Audit Report
Lessons Learned

• Embrace the wide spectrum of opinions

• Don't get so caught up in how or why you are doing this and forget who will be doing this

• Don't lose sight of the big picture. Come to terms with the fact that there will be mistakes, but those stumbling blocks are simply opportunities to make it better.

• Be on the same page with your team – opposing philosophies can hinder progress

• Expect resistance – monumental change naturally brings resistance

• Plan, plan, plan, test, test, test, train, train, train…and then do it all over again
References

3. http://www.stat.berkeley.edu/~stark/Vote/auditTools.htm#
Colorado SOS Contact Information

- Jerome Lovato: jerome.Lovato@sos.state.co.us
- Danny Casias: danny.casias@sos.state.co.us
- Jessi Romero: jessi.romero@sos.state.co.us