

Risk-Limiting Audits: Soup to Nuts, and Beyond

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EVT/WOTE
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Things to keep in mind

The purpose of elections is to convince the losers that they lost.
(D. Wallach)

The purpose of election audits is to convince everybody who isn't nuts that the losers lost. (Y. T.)

OK, nuts to soup.

- What's a nut?
- Somebody whose biggest fear is different enough from yours.
- Somebody who *shares* your biggest fear is sane (and smart!).
- Somebody whose biggest fear is close to yours has an interesting perspective.
- Eccentric → preoccupied → irrationally fixated → nuts.
- The “Wayne’s World” test.

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What good is a Risk-Limiting Audit?

- Helps convince the non-nuts that the losers lost.
- But it's only one piece of the puzzle.
- Will try to explain why.
- Please interrupt.

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Big Ideas

Strongly Software-Independent Voting System

A voting system is strongly software-independent if an undetectable error or change to its software cannot produce an undetected 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.

New (Big?) Idea

Resilient Canvass Framework

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

Combine a strongly software-independent voting system with a compliance audit and a risk-limiting audit.

Ingredients for resilient canvass framework

- **Voters create complete, durable, accurate audit trail.**
Strongly software independent voting system.
- **LEO curates the audit trail properly.**
Proper use of seals, surveillance, secure chain of custody, . . .
- **Compliance audit** to ensure that the audit trail is adequately intact before the risk-limiting audit starts. **If not, need a re-vote.**
“No smoking gun” is not affirmative evidence.
- **Timely reporting of all-but-final results for auditable batches.**
Smaller batches are better.
- **Count votes by hand until there’s strong evidence that counting the rest won’t change the outcome—risk-limiting audit**
“Explaining” or “resolving” errors isn’t enough.
Might need to count all votes by hand if margin is small or audit finds enough error.

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Status quo ante

- Does any state regulate how the audit trail is curated and checked prior to audit?
- States with audit laws generally have “audit theater”: the audits do little if anything to ensure that outcomes are correct.
- Lots of hubbub over flat percentages versus sampling percentages that depend on the margin: sideways to verifying outcomes.

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California Elections Code §15360

[T]he official conducting the election shall conduct a public manual tally of the ballots tabulated by those devices, including absent voters' ballots, cast in 1 percent of the precincts chosen at random by the elections official . . .

The official conducting the election shall include a report on the results of the 1 percent manual tally in the certification of the official canvass of the vote. This report shall identify any discrepancies between the machine count and the manual tally and a description of how each of these discrepancies was resolved . . .

Shrug.

What should audits do?

Pro forma audits

Most vote tabulation audit laws have no clear goal: “count and stop,” or “count and explain discrepancies.”

Checking integrity of the audit trail is not formalized or regulated.

Compliance vs. materiality audits

Compliance: Were proper procedures followed? (e.g., secure chain of custody?)

Materiality: Did any errors that occurred despite compliance matter?

Compliance and Materiality Audits

Effective compliance audit

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

Might require a re-vote.

Effective materiality audit

Correct the outcome if it is wrong.

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, 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, need a re-vote.

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Materiality audit: check reported outcome against audit trail

- Did the vote tabulation system count the votes accurately enough to determine who won?
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- If materiality audit generates convincing affirmative evidence that a full hand count of the audit trail would show the same outcome that the VTS reported, stop.
- If not, need a full hand count.

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Soup

- To know whether the soup is too salty, don't need to eat all of it.
- Enough to taste a teaspoon, if soup is stirred well.
- Doesn't matter how big the pot is: a teaspoon is enough.

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Election Soup

- Salt is like vote tabulation error.
- To tell whether there's enough error to have altered the apparent outcome, don't need to count all the votes.
- Amount you need to count depends on the size of the election, just the tolerable level of (signed) error—related to the margins, not the number of ballots.

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Auditing: standard approach

- Check the addition (more generally, the algorithm); check what was added (more generally, the vote data).
- Sum should be perfect (or call the feds!).
- Summands need to be accurate enough to determine correct winner. (If DRE results aren't perfect, call the feds!)
- Requires vote tabulation system to reveal what it's adding at the same level of granularity at which you do the checks.
- Have to match parts of the audit trail to the summands in order to check. Nontrivial.

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Auditing: blind ballot polling

- Draw a random sample of ballots to extrapolate who won.
- Can do it with a quill, ink, dice, and paper: steam punk.
- Sample size require to extrapolate confidently grows inversely like the square of the margin.
- Much less efficient than standard approach, but no demands on the voting system other than that it produces an audit trail—no data export.
- Tried in Monterey County in 2011.

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Definitions

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- *Outcome* of a contest: set of winners, not the exact vote counts.
- *Apparent outcome*: winner or winners according to the voting system.
- *Correct outcome*: winner or winners that a full hand count of the audit trail would find.
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Risk-limiting audits

- *Risk-limiting audit*: pre-specified minimum chance of correcting apparent outcome if apparent outcome is wrong.
- *Risk*: largest possible chance an apparent outcome that's wrong won't be caught and corrected—no matter why it's wrong.
- *Simultaneous risk-limiting audit*: pre-specified minimum chance of correcting all incorrect apparent outcomes in the election.
- *Simultaneous risk*: largest possible chance that one or more wrong outcomes won't be caught and corrected—no matter why they are wrong.

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Role of statistics

Limiting the risk is easy

No statistics needed: just count all the ballots by hand.

Statistics lets you do less counting when the outcome is right, but still ensure a big chance of a full hand count when outcome is wrong.

Risk-limiting audits: Endorsements

- American Statistical Association
- Brennan Center for Justice
- Citizens Alliance for Secure Elections - Ohio
- Citizens for Election Integrity Massachusetts
- Citizens for Election Integrity Minnesota
- Coloradoans for Voting Integrity
- Common Cause
- CTVotersCount.org
- E-Voter Education Project New York
- Florida Voters Coalition
- Georgians for Verified Voting
- Iowans for Voting Integrity
- League of Women Voters
- Michigan Election Reform Alliance
- SAVEourVotes-Maryland
- Verified Voting
- Voting Integrity Task Force - Coalition for Peace Action - New Jersey

California AB 2023 (Saldaña, sponsored by SoS Bowen)

(b)(3) “Risk-limiting audit” means a manual tally employing a statistical method that ensures a large, predetermined minimum chance of requiring a full manual tally whenever a full manual tally would show an electoral outcome that differs from the outcome reported by the vote tabulating device for the audited contest. A risk-limiting audit shall begin with a hand tally of the votes in one or more audit units and shall continue to hand tally votes in additional audit units until there is strong statistical evidence that the electoral outcome is correct. In the event that counting additional audit units does not provide strong statistical evidence that the electoral outcome is correct, the audit shall continue until there has been a full manual tally to determine the correct electoral outcome of the audited contest.

Unanimous bipartisan support in both houses.

20 counties committed to pilots.

Colorado Revised Statutes 1-7-515.

(1) (a) The general assembly hereby finds, determines, and declares that the auditing of election results is necessary to ensure effective election administration and public confidence in the election process. Further, risk-limiting audits provide a more effective manner of conducting audits than traditional audit methods in that risk-limiting audit methods typically require only limited resources for election races with wide margins of victory while investing greater resources in close races.

(b) By enacting this section, the general assembly intends that the state move toward an audit process that is developed with the assistance of statistical experts and that relies upon risk-limiting audits making use of best practices for conducting such audits.

(2) (a) Commencing with the 2014 general election and following each primary, general, coordinated, or congressional vacancy election held thereafter, each county shall make use of a risk-limiting audit in accordance with the requirements of this section. Races to be audited shall be selected in accordance with procedures established by the secretary of state, and all contested races shall be eligible for such selection. . . .

(5) As used in this section:

(a) “Incorrect outcome” means an outcome that is inconsistent with the election outcome that would be obtained by conducting a full recount.

(b) “Risk-limiting audit” means an audit protocol that makes use of statistical methods and is designed to limit to acceptable levels the risk of certifying a preliminary election outcome that constitutes an incorrect outcome.

Risk-Limiting Audits in California

Marin County (February 2008; November 2008, 2009)

Orange County (March 2011)

Yolo County (November 2008, 2009)

Santa Cruz County (November 2008)

Monterey County (May 2011)

Next: San Luis Obispo County, September 2011; 4 or 5 more in November 2011

Measures requiring super-majority, simple measures, multi-candidate contests, vote-for- n contests.

Contest sizes ranged from about 200 ballots to 121,000 ballots.

Counting burden ranged from 32 ballots to 7,000 ballots.

Cost per audited ballot ranged from nil to about \$0.55.

Risk-Limiting Audits in Colorado

Boulder County (November 2010)

3 or 4 of Boulder, Denver, Eagle, Jefferson, Pitkin Counties
(November 2011)

California and Colorado have EAC grants to implement risk-limiting audits.

Background
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Big Ideas
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Status quo ante
○○

What should audits do?
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Risk-limiting audits
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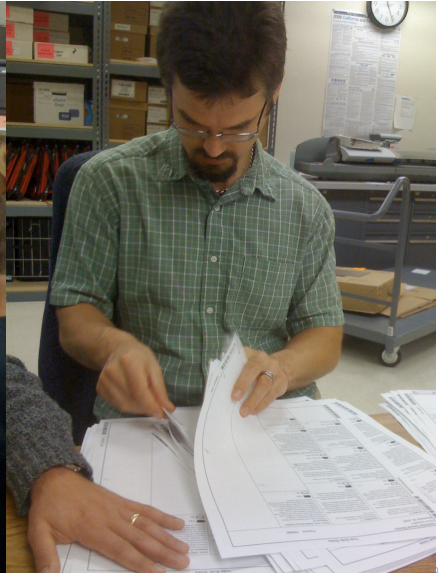
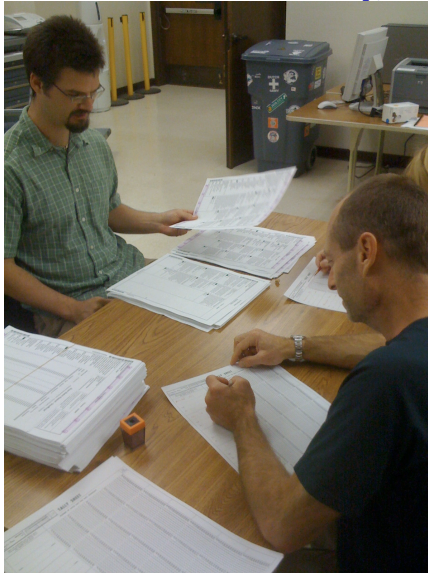
Pilot audits
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Batch size
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Evidence
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Nuts!
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2008 Yolo County, CA Measure W Audit



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TALLY SHEET

NUMBER OF VOTES CAST FOR EACH CANDIDATE

Ballot No.	1	2	3	4	5	6	7	8	9	0	TOTAL	DEF.	UND.	ABSEN.	BLANK	UNR.
1	1	1	1	1	1	1	1	1	1	1	10					
2	1	1	1	1	1	1	1	1	1	1	10					
3	1	1	1	1	1	1	1	1	1	1	10					
4	1	1	1	1	1	1	1	1	1	1	10					
5	1	1	1	1	1	1	1	1	1	1	10					
6	1	1	1	1	1	1	1	1	1	1	10					
7	1	1	1	1	1	1	1	1	1	1	10					
8	1	1	1	1	1	1	1	1	1	1	10					
9	1	1	1	1	1	1	1	1	1	1	10					
10	1	1	1	1	1	1	1	1	1	1	10					
11	1	1	1	1	1	1	1	1	1	1	10					
12	1	1	1	1	1	1	1	1	1	1	10					
13	1	1	1	1	1	1	1	1	1	1	10					
14	1	1	1	1	1	1	1	1	1	1	10					
15	1	1	1	1	1	1	1	1	1	1	10					
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17	1	1	1	1	1	1	1	1	1	1	10					
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19	1	1	1	1	1	1	1	1	1	1	10					
20	1	1	1	1	1	1	1	1	1	1	10					
21	1	1	1	1	1	1	1	1	1	1	10					
22	1	1	1	1	1	1	1	1	1	1	10					
23	1	1	1	1	1	1	1	1	1	1	10					
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25	1	1	1	1	1	1	1	1	1	1	10					
26	1	1	1	1	1	1	1	1	1	1	10					
27	1	1	1	1	1	1	1	1	1	1	10					
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29	1	1	1	1	1	1	1	1	1	1	10					
30	1	1	1	1	1	1	1	1	1	1	10					
31	1	1	1	1	1	1	1	1	1	1	10					
32	1	1	1	1	1	1	1	1	1	1	10					
33	1	1	1	1	1	1	1	1	1	1	10					
34	1	1	1	1	1	1	1	1	1	1	10					
35	1	1	1	1	1	1	1	1	1	1	10					
36	1	1	1	1	1	1	1	1	1	1	10					
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39	1	1	1	1	1	1	1	1	1	1	10					
40	1	1	1	1	1	1	1	1	1	1	10					
41	1	1	1	1	1	1	1	1	1	1	10					
42	1	1	1	1	1	1	1	1	1	1	10					
43	1	1	1	1	1	1	1	1	1	1	10					
44	1	1	1	1	1	1	1	1	1	1	10					
45	1	1	1	1	1	1	1	1	1	1	10					
46	1	1	1	1	1	1	1	1	1	1	10					
47	1	1	1	1	1	1	1	1	1	1	10					
48	1	1	1	1	1	1	1	1	1	1	10					
49	1	1	1	1	1	1	1	1	1	1	10					
50	1	1	1	1	1	1	1	1	1	1	10					

Handwritten notes: "W Yes", "450", "W No", "453", "W update Yes", "32", "W update No", "61", "483", "NI", "153+".

SIGN CERTIFICATE ON FRONT COVER

TALLY SHEET

NUMBER OF VOTES CAST FOR EACH CANDIDATE

Ballot No.	1	2	3	4	5	6	7	8	9	0	TOTAL	DEF.	UND.	ABSEN.	BLANK	UNR.
1	1	1	1	1	1	1	1	1	1	1	10					
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3	1	1	1	1	1	1	1	1	1	1	10					
4	1	1	1	1	1	1	1	1	1	1	10					
5	1	1	1	1	1	1	1	1	1	1	10					
6	1	1	1	1	1	1	1	1	1	1	10					
7	1	1	1	1	1	1	1	1	1	1	10					
8	1	1	1	1	1	1	1	1	1	1	10					
9	1	1	1	1	1	1	1	1	1	1	10					
10	1	1	1	1	1	1	1	1	1	1	10					
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13	1	1	1	1	1	1	1	1	1	1	10					
14	1	1	1	1	1	1	1	1	1	1	10					
15	1	1	1	1	1	1	1	1	1	1	10					
16	1	1	1	1	1	1	1	1	1	1	10					
17	1	1	1	1	1	1	1	1	1	1	10					
18	1	1	1	1	1	1	1	1	1	1	10					
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20	1	1	1	1	1	1	1	1	1	1	10					
21	1	1	1	1	1	1	1	1	1	1	10					
22	1	1	1	1	1	1	1	1	1	1	10					
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24	1	1	1	1	1	1	1	1	1	1	10					
25	1	1	1	1	1	1	1	1	1	1	10					
26	1	1	1	1	1	1	1	1	1	1	10					
27	1	1	1	1	1	1	1	1	1	1	10					
28	1	1	1	1	1	1	1	1	1	1	10					
29	1	1	1	1	1	1	1	1	1	1	10					
30	1	1	1	1	1	1	1	1	1	1	10					
31	1	1	1	1	1	1	1	1	1	1	10					
32	1	1	1	1	1	1	1	1	1	1	10					
33	1	1	1	1	1	1	1	1	1	1	10					
34	1	1	1	1	1	1	1	1	1	1	10					
35	1	1	1	1	1	1	1	1	1	1	10					
36	1	1	1	1	1	1	1	1	1	1	10					
37	1	1	1	1	1	1	1	1	1	1	10					
38	1	1	1	1	1	1	1	1	1	1	10					
39	1	1	1	1	1	1	1	1	1	1	10					
40	1	1	1	1	1	1	1	1	1	1	10					
41	1	1	1	1	1	1	1	1	1	1	10					
42	1	1	1	1	1	1	1	1	1	1	10					
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46	1	1	1	1	1	1	1	1	1	1	10					
47	1	1	1	1	1	1	1	1	1	1	10					
48	1	1	1	1	1	1	1	1	1	1	10					
49	1	1	1	1	1	1	1	1	1	1	10					
50	1	1	1	1	1	1	1	1	1	1	10					

Handwritten notes: "Provisional Yes", "No", "450", "Provisional No", "453", "W update Yes", "32", "W update No", "61", "483", "NI", "153+".

SIGN CERTIFICATE ON FRONT COVER

Background ○○○○ Big Ideas ○○○○ Status Quo ante ○○ What should audits do? ○○○○ Risk-limiting audits ○○○○ Pilot audits ○○○○ Batch size ○○○○○○ Evidence ○○○○○○ ○

Presidential General Election
YOLO COUNTY
November 04, 2008

Proposition 8
ELIMINATES RIGHT OF SAME-SEX COUPLES TO MARRY. INITIATIVE CONSTITUTIONAL AMENDMENT.

Changes California Constitution to eliminate the right of same-sex couples to marry. Provides that only marriage between a man and a woman is valid or recognized in California.

Fiscal Impact: Over next few years, potential revenue loss, mainly sales taxes, totaling \$1.1 in the several tens of billions of dollars, to state and local governments. In the long run, likely increases. Fiscal impact on state and local governments.

Yes
 No

Proposition 9
CRIMINAL JUSTICE SYSTEM, VICTIMS RIGHTS, PAROLE INITIATIVE. CONSTITUTIONAL AMENDMENT AND STATUTE.

Requires notification to victims and opportunity for input during phases of criminal justice process, including bail, plea, sentencing and parole. Establishes victim safety assessment for parole.

Fiscal Impact: Potential loss of state savings on judicial operations and increased County jail costs amounting to hundreds of millions of dollars annually. Potential net savings in the low tens of millions of dollars annually on parole operations.

Yes
 No

Proposition 10
ALTERNATIVE FUEL VEHICLES AND RENEWABLE ENERGY BONDS INITIATIVE STATUTE.

Authorizes \$1 billion in bonds paid from state's General Fund, to help consumers and others purchase or lease alternative and other energy-efficient vehicles, and to fund research in renewable energy and alternative fuel vehicles.

Fiscal Impact: State cost of about \$1 billion through 2019. State's net gain through increased state and local revenues, primarily issuing bonds, amounting to about \$2 billion through 2019. Potential state administrative costs up to about \$10 million annually.

Bonds Yes
 Bonds No

Proposition 11
REDISTRICTING INITIATIVE. CONSTITUTIONAL AMENDMENT AND STATUTE.

Changes authority for establishing state office boundaries from elected representatives to commission. Establishes multistep process to select commissioners from registered voters. Commission comprised of Democrats, Republicans, and representatives of neither party.

Fiscal Impact: Potential increase in state redistricting costs since every ten years due to less service performing redistricting. Any increase in costs probably would not be significant.

Yes
 No

Vote Both Sides

Vote Both Sides

Precinct 100063

Davis Joint Unified School District Measure W
Shall the Davis Joint Unified School District preserve existing classroom programs including math and science, English, music, physical education, literature, secondary data arts education, robotics and environmental programs including drama, debate, and journalism by being authorized to keep a special tax for a period of three years not to exceed the annual rate of \$0.01 per dwelling unit for multi-dwelling units and \$0.020 per parcel for all other parcels?

Yes
 No

Proposition 12
VETERANS' BOND ACT OF 2008.

This act provides for a bond issue of one hundred million dollars (\$100,000,000) to provide farm and home aid for California veterans.

Fiscal Impact: Costs of about \$1.8 billion to pay off both the principal and interest on the bonds, over 30 years. Potential net savings to the state of about \$100 million over 30 years.

Bonds Yes
 Bonds No

Los Rios Community College District Measure M
Shall the Los Rios Community College District be authorized to issue \$475 million in bonds at the lowest available interest rates to improve student academic performance by building classrooms, facilities and labs throughout the district including for teaching green technologies, nursing and healthcare programs, architecture, engineering and construction management, computer sciences, early childhood development, and fine and applied arts public safety programs at the American River, Colusaes River, El Dorado, Folsom, and Sacramento City College campuses?

Bonds Yes
 Bonds No

City of Davis Measure N
Shall the Precinct Number of the City of Davis Be Adjusted?

Yes
 No

Vote Both Sides

Presidential General Election
YOLO COUNTY
November 04, 2008

Proposition 8
ELIMINATES RIGHT OF SAME-SEX COUPLES TO MARRY. INITIATIVE CONSTITUTIONAL AMENDMENT.

Changes California Constitution to eliminate the right of same-sex couples to marry. Provides that only marriage between a man and a woman is valid or recognized in California.

Fiscal Impact: Over next few years, potential revenue loss, mainly sales taxes, totaling in the several tens of billions of dollars, to state and local governments. In the long run, likely increases. Fiscal impact on state and local governments.

Yes
 No

Proposition 9
CRIMINAL JUSTICE SYSTEM, VICTIMS RIGHTS, PAROLE INITIATIVE. CONSTITUTIONAL AMENDMENT AND STATUTE.

Requires notification to victims and opportunity for input during phases of criminal justice process, including bail, plea, sentencing and parole. Establishes victim safety assessment for parole or for input.

Fiscal Impact: Potential loss of state savings on judicial operations and increased County jail costs amounting to hundreds of millions of dollars annually. Potential net savings in the low tens of millions of dollars annually on parole operations.

Yes
 No

Proposition 10
ALTERNATIVE FUEL VEHICLES AND RENEWABLE ENERGY BONDS INITIATIVE STATUTE.

Authorizes \$5 billion in bonds paid from state's General Fund, to help consumers and others purchase or lease alternative and other energy-efficient vehicles, and to fund research in renewable energy and alternative fuel vehicles.

Fiscal Impact: State cost of about \$1 billion over 30 years to repay bonds. Increased state and local revenues, primarily issuing bonds, amounting to about \$2 billion through 2019. Potential state administrative costs up to about \$10 million annually.

Bonds Yes
 Bonds No

City of Davis Measure N
Shall the Precinct Number of the City of Davis Be Adjusted?

Yes
 No

Proposition 11
REDISTRICTING INITIATIVE. CONSTITUTIONAL AMENDMENT AND STATUTE.

Changes authority for establishing state office boundaries from elected representatives to commission. Establishes multistep process to select commissioners from registered voters. Commission comprised of Democrats, Republicans, and representatives of neither party.

Fiscal Impact: Potential increase in state redistricting costs since every ten years due to two entities performing redistricting. Any increase in costs probably would not be significant.

Yes
 No

Proposition 12
VETERANS' BOND ACT OF 2008.

This act provides for a bond issue of one hundred million dollars (\$100,000,000) to provide farm and home aid for California veterans.

Fiscal Impact: Costs of about \$1.8 billion to pay off both the principal (\$100 million) and interest (\$200 million) on the bonds, costs paid by participating veterans. Average payment for principal and interest of about \$20 million per year for 30 years.

Bonds Yes
 Bonds No

Los Rios Community College District Measure M
Shall the Los Rios Community College District be authorized to issue \$475 million in bonds at the lowest available interest rates to improve student academic performance by building classrooms, facilities and labs throughout the district including for teaching green technologies, nursing and healthcare programs, architecture, engineering and construction management, computer sciences, early childhood development, and fine and applied arts public safety programs at the American River, Colusaes River, El Dorado, Folsom, and Sacramento City College campuses?

Bonds Yes
 Bonds No

City of Davis Measure N
Shall the Precinct Number of the City of Davis Be Adjusted?

Yes
 No

Precinct 100063

Davis Joint Unified School District Measure W
Shall the Davis Joint Unified School District preserve existing classroom programs including math and science, English, physical education, literature, secondary data arts education, robotics and environmental programs including drama, debate, and journalism by being authorized to keep a special tax for a period of three years not to exceed the annual rate of \$0.01 per dwelling unit for multi-dwelling units and \$0.020 per parcel for all other parcels?

Yes
 No

Vote Both Sides

Background
○○○

Big Ideas
○○○

Status quo ante
○○○

What should audits do?
○○○○
○○○○

Risk-limiting audits
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Pilot audits
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○○○

Batch size
○
○○○○

Evidence
○○○○○ ○

Nuts!
○

Precinct 100063

Measure W
 Davis Joint Unified School District
 Shall the Davis Joint Unified School District
 provide existing classroom programs
 including math and science, English, music,
 physical education, librarians, secondary class
 size reduction, athletics and co-curricular
 programs including drama, debate, and
 job training by being authorized to levy a
 special tax for a period of three years not to
 exceed the annual rate of \$50.00 per dwelling
 unit on multi-dwelling parcels and \$120.00 per
 parcel for all other parcels?

Yes
 No

Bonds Yes
 Bonds No

City of Davis
Measure N
 Shall the Proposed Charter of the City of
 Davis Be Adopted?

Yes
 No

Background
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Big Ideas
○○○

Status quo ante
○○

What should audits do?
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○○○○

Risk-limiting audits
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Pilot audits
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Batch size
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Risk! (implied)
○○○○○

Nuts!
○

2009 Yolo County, CA Measure P Audit

10000170100046 10000170100059	<p>Special Election November 2009 City of Davis November 03, 2009</p> <p>Precinct</p>	<p>Special Election November 2009 City of Davis November 03, 2009</p> <p>Precinct 10</p>
	<p>Instruction Text: Please use a black or blue ink pen to mark your choices on the ballot. To vote for your choice in each contest, completely fill in the box provided to the left of your choice.</p> <p>MEASURE P Shall Resolution No. 09-132, amending the Davis General Plan to change the land use designations for the Wildhorse Ranch property from agriculture to residential uses, as set forth in the Resolution and establishing the Base Line Project Features for development of the Wildhorse Ranch Project be approved?</p> <p><input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>	<p>Instruction Text: Please use a black or blue ink pen to mark your choices on the ballot. To vote for your choice in each contest, completely fill in the box provided to the left of your choice.</p> <p>MEASURE P Shall Resolution No. 09-132, amending the Davis General Plan to change the land use designations for the Wildhorse Ranch property from agriculture to residential uses, as set forth in the Resolution and establishing the Base Line Project Features for development of the Wildhorse Ranch Project be approved?</p> <p><input checked="" type="checkbox"/> Yes <input type="checkbox"/> No</p>
	<p>10000170100046</p>	<p>10000170100059</p>

Background
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Big Ideas
○○○

Status quo ante
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What should audits do?
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Risk-limiting audits
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Pilot audits
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○○○

Batch size
○
○○○○

Evidence
○○○○○

Nuts!
○

Special Election November 2009
City of Davis
November 03, 2009

Precinct 1

Instruction Text:
Please use a black or blue ink pen to mark your choices on the ballot.
To vote for your choice in each contest, completely fill in the box provided to the left of your choice.

MEASURE P
Shall Resolution No. 09-132, amending the Davis General Plan to change the land use designations for the Wildhorse Ranch property from agriculture to residential uses, as set forth in the Resolution and establishing the Base Line Project Features for development of the Wildhorse Ranch Project be approved?

Yes
 No

Neatness counts

10000170100059

Special Election November 2009
City of Davis
November 03, 2009

Instruction Text:
Please use a black or blue ink pen to mark your choices on the ballot.
To vote for your choice in each contest, completely fill in the box provided to the left of your choice.

MEASURE P
Shall Resolution No. 09-132, amending the Davis General Plan to change the land use designations for the Wildhorse Ranch property from agriculture to residential uses, as set forth in the Resolution and establishing the Base Line Project Features for development of the Wildhorse Ranch Project be approved?

Yes
 No

10000170100059

Background
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Big Ideas
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Status quo ante
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What should audits do?
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Risk-limiting audits
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Pilot audits
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Batch size
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Evidence
○○○○○

Nuts!
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2011 Orange County, first audit under AB 2023



Background
○○○

Big Ideas
○○○

Status quo ante
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What should audits do?
○○○○
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Risk-limiting audits
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Pilot audits
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Batch size
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Evidence
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Nuts!
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Background
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Big Ideas
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Status quo ante
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What should audits do?
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Risk-limiting audits
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Pilot audits
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Batch size
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Evidence
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Nuts!
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Background
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Big Ideas
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Status quo ante
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What should audits do?
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Risk-limiting audits
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Pilot audits
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Batch size
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Evidence
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Nuts!
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Background
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Big Ideas
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Status quo ante
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What should audits do?
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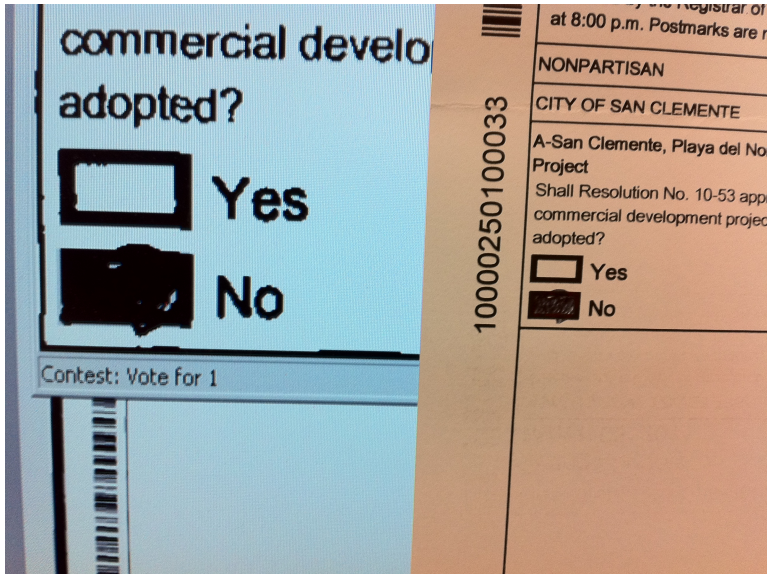
Risk-limiting audits
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Pilot audits
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Batch size
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Evidence
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Nuts!
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Background
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Big Ideas
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Status quo ante
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What should audits do?
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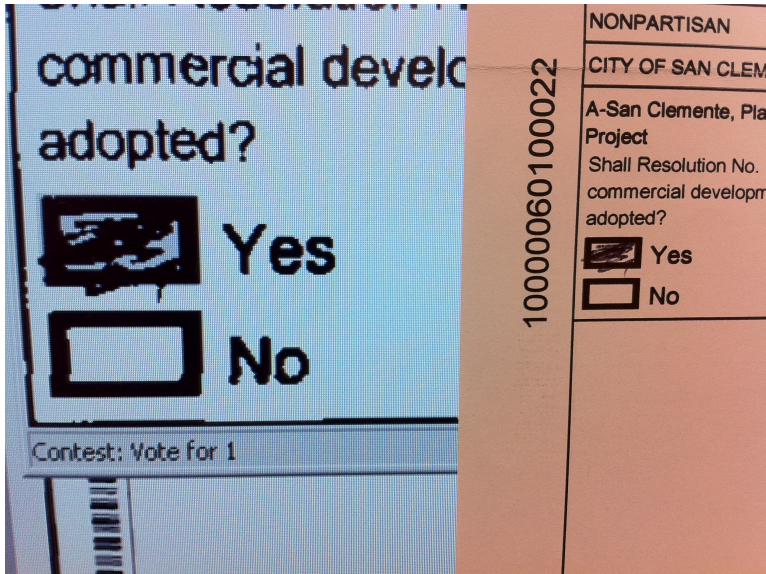
Risk-limiting audits
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Pilot audits
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Batch size
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Evidence
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Nuts!
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Background
○○○

Big Ideas
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Status quo ante
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What should audits do?
○○○○
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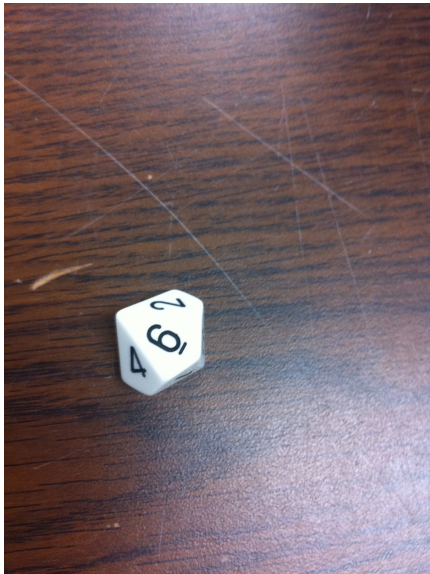
Risk-limiting audits
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Pilot audits
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Batch size
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Evidence
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Nuts!
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Background
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Big Ideas
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Status quo ante
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What should audits do?
○○○○
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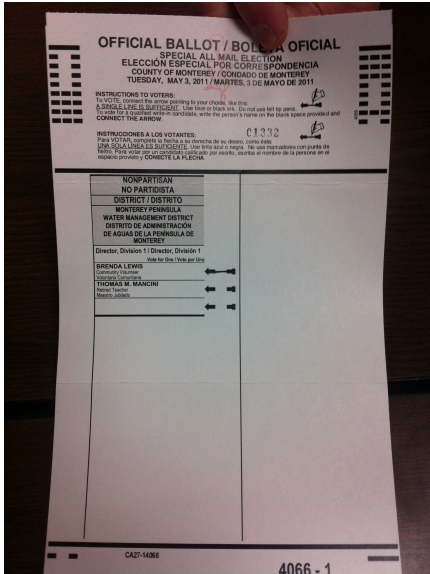
Risk-limiting audits
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Pilot audits
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Batch audits
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Evidence
○○○○○

Nuts!
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Background
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Big Ideas
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Status quo ante
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What should audits do?
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Risk-limiting audits
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Pilot audits
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○○●

Batch size
○
○○○○

Evidence
○○○○○

Nuts!
○



Soup to jelly beans: batch size matters

100 bags of 100 jelly beans, various flavors.

What fraction are coconut?

Compare pulling a bag at random to stirring all the beans together in a big pot and sampling 100 beans.

Vote-tabulation errors are like coconut jelly beans.

Less information in checking bags of beans—or batches of ballots—than in checking the same number drawn individually from the “pot.”

Advantages of ballot-level RLA

Like sampling jelly beans from a big pot, instead of sampling bags of jelly beans.

- cheap (if technology supports it—working with vendors)
- fast and observable
- easy computations and easy sampling
- easy to explain (relatively speaking)

Tested in Yolo, Orange, and Monterey Counties.

Expect ballot level audit of two contests simultaneously in San Luis Obispo County in September 2011.

Expect ballot-level audit of multi-jurisdiction contest in 2012.

Hope to have ballot-level audits in at least 15 California jurisdictions and 5 Colorado jurisdictions in 2012.

Savings examples for ballot-level RLA

Yolo County Measure P, November 2009: For 10% risk limit, initial sample 6 batches, 1,437 ballots (11.33%).

Could have gotten 10% risk limit by checking 6 individual ballots (less than 0.05%).

Orange County Statutory Audit

Votes in one precinct counted by hand. No errors found.

Chance the 1% audit would find no errors even if the outcome is wrong could be over 88%.

The error rate in the sample says little about the error rate in the whole contest because batches are large:
One bag might have no coconut jelly beans, even though the rest have many.

Orange County Audits: Costs

Statutory Audit: \$257.68

Scales as the size of the contest: a contest twice as large would cost about twice as much to audit.

AB 2023 risk-limiting audit (10% risk): \$483.79 (not including my time or airfare)

Would have cost essentially the same for any contest with the same percentage margin, no matter how large the contest.

Only have to taste a teaspoon of soup to tell if the soup is too salty, no matter how big the pot—if it's stirred well.

Regulate evidentiary standards?

- **Have: regulations for voting technology instead of outcome accuracy.**
- Have: ad hoc audits of a fixed percentage of ballots, with no sensible rule for requiring more to be counted—where there are audits at all.
- 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 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.

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Bold claims. (Shoot me down!)

- Incentives of current system are in the wrong place.
- Certification gets in the way: economic barrier to entry, expensive maintenance contracts for proprietary systems, etc. Certification favors the vendors more than the jurisdictions or voters.
- If LEOs had to demonstrate to some evidentiary standard that the apparent outcomes are right, would have incentive to buy/build/use most accurate system that enables confirmation with the least hand counting. Such systems *could* be very cheap.
- Instead, opacity and huge financial disincentive to upgrading technology.

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Reality bites

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

- Enormous variety of voting systems in place, even within individual states.
- Most don't support efficient auditing because don't generate or export or associate CVRs with ballots.
- Building production systems is not academic research. No funding, no academic incentive for PhD students.
- Auditing IRV Mayoral contest in SF in 2011—not.
- Estimated 480,000 pieces of paper to scan in about 2 days. Team of 25–30 people, three \$70,000 machines or ten \$16,000 machines.
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What do we need?

- Voting systems that produce CVRs linked to individual ballots: voting system should commit to its interpretation of each ballot.
- Good regulations, practices, and audits to provide affirmative evidence that the audit trail is intact when the risk-limiting audit starts.
- Willingness to have a re-vote if there is not enough evidence that the audit trail is reliable.
- 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.
- Good ways to explain what we do and why we do it.

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- Technical needs:
 - Data exchange formats.
 - Uniform naming conventions for contests and candidates in multi-jurisdiction contests.
 - Data plumbing for prompt statewide reporting adequate to support audits.
 - Jurisdictional cooperation to audit multi-jurisdiction contests.
 - Methods to audit ballot manifests (have ideas).
- Stop-gap measures, such as transitive auditing using a second scan.
 - Need to touch paper twice before audit.
 - Draconian limitations on throughput, especially for larger jurisdictions.
 - Need production-quality software to interpret voters' marks from digital images.
 - Need user-friendly interface to describe ballots, vote targets, and codings.
 - Room to have huge impact on election integrity for at least a decade—but it isn't research.
 - Clear Ballot. True Ballot. TEVS?

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The Frontier

- Simultaneous audits (next month)
- Multi-jurisdiction contests (next year)
- IRV (next year)

Back to the nuts: what do local elections officials fear?

I don't know. I'm pretty sure they don't fear somebody hacking the software in a COTS scanner, but I think I'd fear

- Printer doesn't deliver ballots.
- Warehouse fire.
- Volunteers don't show up.
- Massive hardware failure.
- Cars/trucks crash with ballots on board.
- Recounts.
- Don't finish canvass on time.
- That makes us all nuts to them.

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