

Checking the Paper Record:

A Guide for Public Oversight of Tabulation Audits

Verified Voting, August 2018

Verified Voting

Introduction

A healthy democracy depends on public confidence in elections. Post-election audits can build public confidence in the outcome of the election if they provide reasonable assurance that the reported outcomes are correct. When people take the trouble to observe the audits, they witness the procedures that are aimed at confirming election results, and public confidence in electoral outcomes is strengthened. Among the various kinds of post-election audits, one crucial type is a tabulation audit. In the United States, 99% of votes are tabulated by computers -- computers decide what selections each voter intended, and computers add up the vote totals. A tabulation audit is a routine check on the accuracy of the computer tabulations. This guide is designed to help groups and individuals who wish to observe tabulation audits.

You'll learn a lot and help safeguard democracy even if all you do is show up to watch the auditing process. If you choose to go beyond showing up, this guide will help you make your oversight efforts as effective as possible.

Verified Voting, a non-partisan, not-for-profit organization working toward security, accuracy, integrity and verifiability of elections, has resources to support your election oversight project. Please visit VerifiedVoting.org, or contact us at audit@verifiedvoting.org to let us know what you are learning about your local audit process.

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Prepare Ahead of Time

Get Informed

Tabulation Audits in General

Tabulation audits are intended to provide a quality control check that the reported results of an election match the intent of the voters. There are other valuable audits of the electoral process, but tabulation audits are particularly important because they assess the direct evidence of voter intent for a particular election -- the voters' marks on ballots. Tabulation audits may detect errors or interference with the elections in time to correct those errors. Different kinds of tabulation audits exist, including fixed-percentage, Bayesian and risk-limiting audits. Even within the category of risk-limiting audits, different kinds have been described, such as ballot comparison or ballot polling, among others. Some of these are described in this guide. You can learn more about tabulation audits, especially risk-limiting audits, from:

- White papers and blog posts
 - [Risk-Limiting Post-Election Audits: Why and How](https://www.stat.berkeley.edu/~stark/Preprints/RLAwhitepaper12.pdf)¹
 - Neal McBurnett's [Colorado's Risk-Limiting Audit Project page](http://bcn.boulder.co.us/~neal/elections/corla/)²

¹ <https://www.stat.berkeley.edu/~stark/Preprints/RLAwhitepaper12.pdf>

² <http://bcn.boulder.co.us/~neal/elections/corla/>

- Free & Fair's [Risk-Limiting Audit page](#)³
- Policy websites
 - [Verified Voting](#)
 - [ElectionAudits.org](#)
 - [National Conference of State Legislatures](#)
 - [US Election Assistance Commission](#)
 - [Fair Vote](#)
- Conference presentations and videos such as
 - [Post Election Audit Summit 2007](#)⁴
- Software
 - Philip Stark's [Audit Tools](#)⁵
 - [Open source risk-limiting audit system](#)⁶ developed by Free & Fair

Tabulation Audits in Your Jurisdiction

Election procedures vary from state to state and even within states. There is a wide variety even in the names of the agencies in charge of elections. To find out what happens in any particular place (say, your hometown), start by finding contact information for the agencies charged with elections.

- The US Election Assistance Commission website has [links to the official election agencies](#)⁷ of each US state and territory. The Federal Voting Assistance Program (FVAP) collects [contact information](#)⁸ for all local jurisdictions.
- An internet search on the name of a place, along with the phrase “election authority” or “board of election,” will usually find contact information.
- In any local or state elected official’s office there is usually someone who will take your call and help you identify the local and state election agencies.

As of this writing (2018), tabulation audit theory, laws and practices are evolving. Many jurisdictions are on the road to ideal tabulation audits but haven’t yet reached that goal. Reaching the ideal in every US jurisdiction is a process that will take several years. You can make note of any imperfections you observe in your jurisdictions’ audits and plan to discuss them in a constructive way with your election administrator at an appropriate time. Local election administrators may be under time pressure, balancing many priorities, in the critical period after Election Day and before final certification of results. Procedures are planned in advance and usually cannot be changed for the current election. An excellent way to find out what timing works best for your local election administrator is to ask directly, either at any public meeting of the Board of Elections or by phone.

³ <http://freeandfair.us/blog/risk-limiting-audits/>

⁴ <https://electionaudits.org/node/2.html>

⁵ <https://www.stat.berkeley.edu/~stark/Vote/auditTools.htm>

⁶ <http://freeandfair.us/blog/risk-limiting-audits/>

⁷ <https://www.eac.gov/voters/register-and-vote-in-your-state/> ⁸
<https://www.fvap.gov/search-offices>

Some tabulation audits are required by state law. Others are done at the discretion of state or local election officials. Contact your state and local election agencies (before the election, if possible) to find out what is planned. It's useful to ask:

- What kinds of post-election audits will be carried out?
- Are tabulation audits required by law? If so, which law exactly?
- Are there administrative rules, regulations or directives relevant to the audit? If so, how can you obtain copies?
- How many different kinds of ballots are there?
- Under what circumstances might the Board of Elections copy a voter's choices to a "remade" ballot for scanning? (Remaking ballots is not unusual if, for example, the original ballot is damaged or submitted by electronic means.)
- How many ballots will consist of more than one card (i.e., more than one piece of paper)?
- What process will be used to select ballots at random?
- What standards are used to interpret voter marks on ballots?
- When and where will the audits take place?
- How will the results of the audit affect the official outcome of the election?
- What documentation is available about the auditing process?
- What technology will be used to carry out the audit? If computer systems are involved, what user documentation, design documents or source code is available for public review?

In addition, there are some details of the tabulation audit process that will vary from jurisdiction to jurisdiction. If your goal is to carry out complete, ideal oversight of the audit process in the upcoming election -- an ambitious goal! -- then you will need to research the following details of election administration in your jurisdiction. Several of these topics are addressed in more detail in the [Technical Details](#) section of this document.

- What safeguards are in place to secure the chain of custody of the ballots between casting and tabulation, and between tabulation and auditing? (See the "Chain of Custody" step of the observation.)
- How are the people chosen who will hold, look at and interpret the paper ballots in the course of the audit?
- How will the *Ballot Manifest* be created and verified? (See the "Manifest" step of the observation.)
- How will the *Ballot Manifest* (and, in the case of a ballot comparison audit, the *Cast Vote Record File*) be publicly finalized before the random sequence of ballots is chosen? (See the "Commitment" step of the observation.)
- How will the random sequence be determined? (See the "Random Sequence" step of the observation.)
- What *Stopping Rule* will be used to determine when enough ballots have been audited?

These details of a complete, ideal oversight of a tabulation audit are not required of every oversight project. Just as an election jurisdiction may fine-tune their audit procedures over several election cycles, public audit oversight will improve with time and practice. Showing up and observing is a great, simple start.

Assemble Your Team

The cast of characters below isn't required. You'll learn a lot and help safeguard democracy even if all you do is show up to watch the auditing process. For detailed oversight of a risk-limiting audit, though, you'll want to try to recruit a full team.

Statistical Advisor

Tabulation audits involve statistical techniques. It's helpful to have a statistical advisor. Such a person can help you evaluate the quality of the audit design and check that statistical procedures are being carried out properly. Fortunately many colleges and universities have statisticians on the faculty. Academic statisticians are often pleased to do a bit of work in the public interest, and may require no compensation beyond the satisfaction of being of service to democracy. Here are some ways to find a statistician:

- Contact the Statistics Department or the Mathematics Department of a nearby college (or university). You should be able to find contact information on the college's website. Explain your project and ask whether anyone on the faculty might want to be helpful.
- Contact the [American Statistical Association](http://www.amstat.org).⁹

Data Wrangler

Tabulation audits involve a lot of data. It's helpful to have someone on your team who is comfortable importing, manipulating and analyzing data in a spreadsheet program (such as Excel). Students of engineering and economics often have these skills. Here are some ways to find such a person:

- Ask friends, family and co-workers if they know someone who is good with spreadsheets.
- Contact the Computer Science, Engineering or Economics Department of a nearby college (or university). You should be able to find contact information on the college's website. Explain your project and ask whether any students or faculty might want to be helpful.

Observers

You will need people to be physically present at places where the audit activity will be carried out. These people will need to watch the process and take careful notes. And, being people, they will need lunch, get tired, sometimes get sick, etc. If you want to be sure to have an observer present at all times, plan for breaks and cancellations. You will want to recruit enough people to cover the times, but it is certainly possible for one person to observe the entire proceeding, assuming the officials conducting the audit will also require lunch and will not work 24/7.

⁹ <http://www.amstat.org>

Diplomatic Yet Firm Spokesperson

The people who are paid to run elections in your jurisdiction -- the staff of the election agency -- are your partners in democracy. Sometimes it's easy to forget the common goal during the official vote-counting and result-certifying process. Election officials are professionals working under time pressures. As observers, your team may have questions. The more straightforward and polite your group's interaction with the election officials, the more likely you are to get full, timely answers to your questions.

Risk-Limiting Audits

A risk-limiting audit is a type of post-election tabulation audit that uses statistical methods to achieve confidence that reported election results are correct (when such confidence is justified). Risk-limiting audits are the best known way to get firm evidence about the correctness of vote counts. They can give us a high degree of certainty that the winners -- the people who take over the powers of government offices, or the consequences of referendum questions -- are the ones indicated by the marks on the ballots. If the voting system tabulation of the marks on the ballot has an error large enough to put the wrong person in office, then the risk-limiting audit, conducted properly, has a good chance of finding and correcting the error.

Just how good is that good chance? That depends on the *Risk Limit*. The *Risk Limit* is a percentage limiting the chance that the audit would let an incorrect winner actually take office. If the voting system tabulation would put the wrong person in office, and if the risk limit is 5% (one in twenty), then at least nineteen audits out of twenty (on average) will correct the error. In other words, with a 5% *Risk Limit*, the audit has at least a 95% chance of correcting the error.

On the other hand, if the voting system tabulation is correct, a risk-limiting audit won't disturb the correct result.

Two main kinds of risk-limiting audits are *ballot comparison* and *ballot polling* audits. While they both provide evidence for correct election outcomes, they provide slightly different information and the details of your oversight process will depend on which type you are overseeing. So each audit type has a slightly different checklist.

Checklist #1: Overseeing a Ballot Comparison Audit

Note: if you are overseeing a ballot **comparison** audit (which compares human interpretations of individual ballots to the interpretations reported by the voting system), you'll want Checklist #1. For a ballot **polling** audit (where human interpretations of individual ballots are used by themselves) use Checklist #2.

There are three kinds of items on the checklist below. **Observation** requires a person physically present to see and listen to activities by election officials and other participants. **Data** usually requires release of data by election officials, but can also refer to data collected by observers.

Calculations are performed on data either from election officials or collected by observers, and range from simple line-by-line comparisons to the use of mathematical formulas.

The checklist is phrased in terms of auditing a single contest, but can be used to oversee audits of several contests at once. You can check off each item on the checklist when you are certain that its statement is true. All items are essential to the integrity of the audit.

1. **Chain of custody:** The paper ballots selected for audit and reviewed by the auditors have not been compromised. Requires:
 - a. Observation: Details of observation depend on local practices (see [Technical Details: Chain of Custody](#) below).
2. **Tabulation:** *Vote Counts* calculated from the *Cast Vote Records* used for the audit match officially announced *Vote Counts*. Requires:
 - a. Data: A *Cast Vote Record* for each counted ballot.
 - b. Data: The *Vote Count* for the contest according to election results made public by the election agency after all validly cast ballots – including military, accepted provisional, absentee and any other special types of ballots – have been counted.
 - c. Calculation: Use the *Cast Vote Records* to count the number of votes for each choice, and compare this *Vote Count* to the reported results. These should match.
3. **Manifest:** The set of ballots catalogued in the *Ballot Manifest* exactly matches the physical set of ballots, which exactly matches the set of *Cast Vote Records*.¹⁰ Requires:
 - a. Data: The *Ballot Manifest*.
 - b. Data: The *Cast Vote Records*.
 - c. Observation: Creation of the *Ballot Manifest* from the physical set of ballots (see [Technical Details: Ballot Manifest](#) below).
 - d. Calculation: Check that the *Ballot Manifest* matches the set of *Cast Vote Records*.
4. **Commitment:** The *Cast Vote Records* and *Ballot Manifests* are finalized before the *Random Sequence of Ballots* is determined. Requires:
 - a. Observation and Data: Details depend on local protocols (see [Technical Details: Commitment to Cast Vote Records](#) below).
5. **Random selection:** *Random Sequence of Ballots* has been properly selected according to the specified algorithm and seed. Requires:
 - a. Data and Observation: Confirm that the algorithm and the random seed produce the *Random Sequence of Ballots* used in the audit. (This depends on local practices and may require some technical expertise. See [Technical Details: Random Selection](#) below.)
6. **Ballot retrieval:** The list of ballots in the *Random Sequence of Ballots* matches the set of physical ballots made available for *Human Interpretation of Voter Marks*.

¹⁰ In certain situations it may be permissible to have some discrepancies between the *Ballot Manifest* and the *Cast Vote Records*, as long as those discrepancies are properly handled and disclosed.

- a. Data: *Random Sequence of Ballots*.
 - b. Observation: Physical retrieval and preparation of ballots for *Human Interpretation of Voter Marks*.
7. **Ballot interpretation and data entry:** Voter intent is determined from each ballot in the *Random Sequence of Ballots* in a manner consistent with law and local standards, and those standards were fairly applied.
- a. Observation: Observe each audited ballot. Record your interpretation of voter marks, as well as any discrepancies between your interpretation and the interpretation of the official auditor. Note that a discrepancy might result if the auditor appropriately applies a standard that, in your opinion, misinterprets the marks. It may be useful to note the cause of each discrepancy.
8. **Ending the interpretation of ballots in the random sequence:** The examination of ballots in the *Random Sequence of Ballots* can end in only two ways: either the *Risk Limit* has been achieved, or a *Full Hand Count* of the contest has been ordered.
- a. Data: Has a *Full Hand Count* been ordered?
 - b. Data: The required *Risk Limit*.
 - c. Data: The algorithm for calculating whether the *Risk Limit* has been achieved
 - d. Calculation: If a *Full Hand Count* has been ordered, or if the algorithm shows that the *Risk Limit* has been achieved, then the interpretation of ballots in the *Random Sequence of Ballots* can stop.
9. **Hand count:** Any required *Full Hand Counts* are correctly performed.
- a. Observation: Observe the *Human Interpretation of Voter Marks* and the tabulation of the votes. (Note that third-party observation of full hand recounts may be limited according to law.)

Checklist #2: Overseeing a Ballot Polling Audit

Note: if you are overseeing a ballot **comparison** audit (which compares human interpretations of individual ballots to the interpretations reported by the voting system), you'll want Checklist #1. For a ballot **polling** audit (where human interpretations of individual ballots are used by themselves) use Checklist #2.

There are three kinds of items on the checklist below. **Observation** requires a person physically present to see and listen to activities by election officials and other participants. **Data** usually requires release of data by election officials, but can also refer to data collected by observers. **Calculations** are performed on data either from election officials or collected by observers, and range from simple line-by-line comparisons to the use of mathematical formulas.

The checklist is phrased in terms of auditing a single contest, but can be used to oversee audits of several contests at once. You can check off each item on the checklist when you are certain that its statement is true. All items are essential to the integrity of the audit.

- 1. **Chain of custody:** The paper ballots selected for audit and reviewed by the auditors have not been compromised. Requires:

- a. **Observation:** Details of observation depend on local practices (see [Technical Details: Chain of Custody](#) below). Note that some ballots may be remade because of physical damage or other reasons, and the auditors should be reviewing the ballot marked by the voter, which might not be the ballot scanned into the tabulation system.
2. **Manifest:** The set of ballots catalogued in the *Ballot Manifest* exactly matches the physical set of ballots. Requires:
 - a. **Data:** The *Ballot Manifest*
 - b. **Observation:** Creation of the *Ballot Manifest* from the physical set of ballots (see [Technical Details: Ballot Manifest](#) below).
3. **Commitment:** The *Ballot Manifest* is finalized before the *Random Sequence of Ballots* is determined. Requires:
 - a. **Observation and Data:** Confirm that the *Ballot Manifest* is produced before the *Random Sequence* is determined, and that this *Ballot Manifest* is used unchanged in the audit.
4. **Random selection:** *Random Sequence of Ballots* has been properly selected according to the specified algorithm and seed. Requires:
 - a. **Data and Observation:** Confirm that the algorithm and the random seed produce the *Random Sequence of Ballots* used in the audit. (This depends on local practices and may require some technical expertise. See [Technical Details: Random Selection](#) below.)
5. **Ballot retrieval:** The list of ballots in the *Random Sequence of Ballots* matches the set of physical ballots made available for *Human Interpretation of Voter Marks*.
 - a. **Data:** *Random Sequence of Ballots*.
 - b. **Observation:** Physical retrieval and preparation of ballots for *Human Interpretation of Voter Marks*.
6. **Ballot interpretation and data entry:** Voter intent is determined from each ballot in the *Random Sequence of Ballots* in a manner consistent with law and local standards and those standards were fairly applied.
 - a. **Observation:** Observe each audited ballot. Record your interpretation of voter marks, as well as any discrepancies between your interpretation and the interpretation of the official auditor. Note that a discrepancy might result if the auditor appropriately applies a standard that, in your opinion, misinterprets the marks. It may be useful to note the cause of each discrepancy.
7. **Ending the interpretation of ballots in the random sequence:** The examination of ballots in the *Random Sequence of Ballots* can end in only two ways: either the *Risk Limit* has been achieved, or a *Full Hand Count* of the contest has been ordered.
 - a. **Data:** Has a *Full Hand Count* been ordered?
 - b. **Data:** The required *Risk Limit*.
 - c. **Data:** The algorithm for calculating whether the *Risk Limit* has been achieved (depends on local protocol).
 - d. **Calculation:** If a *Full Hand Count* has been ordered, or if the algorithm shows that the *Risk Limit* has been achieved, then the interpretation of ballots in the *Random Sequence of Ballots* can stop.
8. **Hand count:** Any required *Full Hand Counts* are correctly performed.

- a. Observation: Observe the *Human Interpretation of Voter Marks* and the tabulation of the votes.

Other Post-Election Audits

Tabulation Audits That Are Not Risk-Limiting

Checklist #3: Overseeing a Fixed-Percentage Tabulation Audit

Some jurisdictions perform an audit by randomly selecting a flat or fixed percentage of precincts. Ballots from these precincts are then interpreted by hand, and the resulting vote counts are compared to the counts from the computer tabulations. (Similar audits may use not precincts, but other natural batches of ballots such as all ballots cast on a particular voting computer.) While these audits are rarely risk-limiting -- they are not designed to have a specific maximum chance of detecting a wrong outcome -- they often give insights about the quality of reported results and can sometimes detect information that might lead to further investigation or a full recount.

1. **Chain of custody:** The paper ballots selected for audit and reviewed by the auditors have not been compromised. Requires:
 - a. Observation: Details of observation depend on local practices (see [Technical Details: Chain of Custody](#), below). Note that ballots may be remade because of physical damage or other reasons, and the auditors should be reviewing the card marked by the voter, which might not be the ballot scanned into the tabulation system.
2. **Manifest:** The list of precincts (or voting machines, or other groupings of ballots) from which the random selection will be made exactly matches the real-world set of precincts (or voting machines, or other groupings of ballots). Requires:
 - a. Data: The list.
 - b. Comparison: Check that the list matches reality.
 - c. Observation: The list is finalized before the random selection is made.
3. **Random selection:** Random sample of ballot batches has been properly selected. Requires:
 - a. Data and Observation: Confirm that the method for choosing ballot batches used in the audit is truly random. (This depends on local practices and may require some technical expertise. See [Technical Details: Random Selection](#) below.)
4. **Ballot batch retrieval:** The list of ballot batches chosen matches the set of physical ballot batches made available for *Human Interpretation of Voter Marks*.
 - a. Data: List of chosen ballot batches.
 - b. Observation: Physical retrieval and preparation of ballot batches for *Human Interpretation of Voter Marks*.
5. **Ballot interpretation and data entry:** Voter intent is determined from each ballot in each selected batch in a manner consistent with law and local standards.

- a. Observation: Observe each audited ballot. Record your interpretation of voter marks, as well as any discrepancies between your interpretation and the interpretation of the official auditor. Note that a discrepancy might result if the auditor appropriately applies a standard that, in your opinion, misinterprets the marks. It may be useful to note the cause of each discrepancy.
6. **Hand count:** Any required *Full Hand Counts* are correctly performed.
 - a. Observation: Observe the *Human Interpretation of Voter Marks* and the tabulation of the votes.

Audits of Other Election Processes

Beginning-to-end, evidence-based auditing of an election contest requires more than auditing of the tabulation outcomes. A beginning-to-end election audit might examine the following:

- The full chain of custody for ballots from the time they are cast until election outcomes are finalized.
- The translation of voter intent from sources other than a paper ballot verified by a voter, such as electronically-implemented UOCAVA ballots (emails, faxes, and other forms of Internet voting, etc.).
- The process for accepting or rejecting provisional ballots.
- Signature verification on vote-by-mail ballot envelopes.
- Timely processing of voter registration applications and change requests.

And there are other kinds of tabulation audits, such as Bayesian audits, which base statistical risk assessments not just on the random selection of ballots but on statistical assumptions about how people vote. For more information on Bayesian audits, see [Bayesian Tabulation Audits Explained and Extended](#)¹¹, by Ron Rivest.

To develop your own checklist for observing these other kinds of audits you may find it helpful to:

- Observe the process being audited one or more times.
- Learn what law, regulation or administrative goal led to the implementation of the audit.
- Use common sense.

Follow Up

After you have completed your observation there are a variety of ways to follow up.

Share What You've Learned

Verified Voting wants to know about your audit observation. Please email us at audit@verifiedvoting.org or tweet us [@verifiedvoting](https://twitter.com/verifiedvoting). Others -- including local organizations and media -- may be interested as well.

¹¹ <https://arxiv.org/abs/1801.00528>

- How was the experience, overall?
- Who or what was particularly helpful?
- What, if anything, was missing from the audit process?
- What, if anything, were you not able to observe? Why?
- What particular laws or procedures affected the audit or your observation?
- Did the audit avoid placing trust in a computerized system of any kind?
- How could this guide be improved?

Plan for Next Time

Protecting elections is an ongoing process. As this audit observation ends you can build a base for your next audit.

- How might you find answers to any questions that arose during the audit?
- Which people -- e.g., election administrators, other observers, reporters -- would you like to keep in touch with? Who deserves a thank you?
- What worked well?
- What would you do differently next time?
- Who has the authority to change any legal or administrative barriers you may have encountered while trying to observe the audit?

Some Finer Points

Glossary

- **Ballot Manifest** is a catalog prepared by the staff of the election agency, listing all the physical paper ballots and their locations in sequence.
- **Cast Vote Record** is a record of the system's interpretation of the voter's choices on the ballot that is created and stored by the electronic voting system. The voting system should be able to produce a report of these data. If the electronic system can export a file of the *Cast Vote Records* for all the ballots in a way that allows each ballot to be associated to its interpretation by the voting system, the file can be used for auditing purposes.
- **Full Hand Count** of an election contest is a tally of *Vote Counts* carried out by *Human Interpretation of Voter Marks* on the original paper record for every ballot cast in the contest.
- **Human Interpretation of Voter Marks** requires real people to use their eyes to examine marks on a piece of paper that has been marked by a voter.
- **Incorrect Outcome** means an electoral outcome that differs from the outcome that would be found by a full manual tabulation of the votes on all ballots validly cast in the election. ("Outcome" refers to the consequence of the election -- for instance, who takes office -- not to the exact Vote Count.)
- **Random Selection of Ballots** is a list of ballots to be audited, chosen at random (see [Technical Details: Random Selection](#) for more detail).

- **Risk Limit** is the maximum probability, given a tabulation that reports an *Incorrect Outcome*, that the audit would not lead to a full manual tabulation that would correct that outcome.
- **Stopping Rule** for a risk-limiting post-election audit is a set of instructions for checking whether the information gathered so far by *Human Interpretation of Voter Marks* is sufficient to meet the required *Risk Limit*, or whether the audit should continue. Audits that are not risk-limiting often also have Stopping Rules that, similarly, determine when an audit should continue.
- **Vote Count** is the number of votes recorded for each choice in a contest.

Technical Details

Chain of custody

How can a member of the public assess the security of the chain of custody of the ballots? This question is complicated enough to warrant a guide of its own. The short answer is that to assess chain of custody, you will have to understand and observe local practices.

Confidence that the set of tabulated ballots reflects the will of the people requires a trustworthy chain of custody from the time of casting to the time of tabulation; confidence in the post-election audit requires a trustworthy chain of custody from the time of tabulation to the time of the audit. The shorter these time intervals, and the shorter the distance the paper ballots must travel, the simpler it is to secure the chain of custody in an observable way. If votes were tabulated and the tabulation audited at the polling place at the end of the voting day, the chain of custody could be easily verified.

For a variety of reasons, this ideal is almost never attained. State laws and local election agencies must balance various considerations (e.g., how to allow absentee voting, how to prioritize the many critical tasks between voting day and the final certification) against the chain-of-custody observability. One way to start understanding the complex tradeoffs required for election administration is to listen to the people involved, including election agency staff and poll workers.

In general, chain of custody observation requires the ability to see the process from the time that ballots leave the custody of the election agency, until they arrive at the polling place and then, after the voting, how the materials are handled and transported back to the election jurisdiction. This kind of observation may be difficult to see from beginning to end. Alternatively, observers may ask their local election agency questions about how the agency handles these various steps in the election administration process. See *Tabulation Audits in Your Jurisdiction*.

Note that some ballots may be remade because of physical damage or other reasons, and the auditors should be reviewing the ballot marked by the voter, which might not be the ballot scanned into the tabulation system.

Ballot Manifest

The amount of information on the *Ballot Manifest* depends on how the election agency sorts and stores ballots. Ballots might be sorted by precinct, or by ballot style, or not at all. The *Ballot Manifest* will be a list of batches, with a location and the number of ballots in each batch:

| Batch Name | Batch Location | Number in Batch |
|-------------------|----------------|-----------------|
| Scanner 1 Batch 1 | Bin 1 | 99 |
| Scanner 1 Batch 2 | Bin 5 | 101 |
| Scanner 2 Batch 1 | Bin 1 | 98 |
| etc.... | | |

The *Ballot Manifest* fixes an order for the ballots that can't be changed after the *Random Selection*. In other words, after the *Random Selection* has determined that, say, the 17th ballot in the 91st batch from Scanner 1 needs to be examined, changing the order of the batches, or changing the order of the ballots within the 91st batch could affect which ballot is examined, which compromises the validity of the audit. Because the audit requires retrieving the paper ballots, the *Ballot Manifest* should indicate the physical locations of ballots. The *Ballot Manifest* must be created, or at least verified, independently from the computer voting system, so the process will involve physical interaction with each ballot, such as weighing stacks of ballots on a precision scale or counting ballots by hand.

Random Selection

You can tell how salty a big vat of soup is by tasting one teaspoonful, as long as the soup is well-stirred. In the same way, audits can give evidence about the outcome of an election contest by looking at only a few ballots, as long as those ballots are chosen truly at random. Choosing “truly at random” means using a statistically sound method. One sound approach is to have several (ideally 20 or more) stakeholders and observers roll ten-sided dice to generate a random “seed” for a well-designed pseudo-random number generator (PRNG).

The PRNG will produce a list of numbers (e.g., 3627, 6617, 2474,...) which correspond to ballots in order (e.g., the 3627th ballot, the 6617th ballot, the 2474th ballot, ...). Because the *Ballot Manifest* determines an order for all the ballots, it is possible to find these specific pieces of paper (e.g., the 20th ballot in the 36th batch from Scanner 1, the 54th ballot in the 16th batch from Scanner 2, the 80th ballot in the 24th batch from Scanner 1, ...). A statistician or data specialist should be able to generate the same *Random Selection* of ballots from the random seed, the PRNG algorithm and the *Ballot Manifest*. No expertise is required to observe people tossing dice, though.

The list of ballots may contain duplicates -- in other words, a ballot might appear more than once in the random sequence. A version of the list, re-sorted by the locations of the ballots, is generally used to find and collect the ballots.

Commitment to Cast Vote Records

Publishing the *Cast Vote Record* before the determination of the *Random Sequence of Ballots* begins is the most straightforward way to ensure the integrity of the *Cast Vote Records* used in the audit. But there are other ways. One other way involves a cryptographic technique called “hashing.” To ensure the integrity of the *Cast Vote Records* used in the audit via hashing, the election agency must:

1. Use a well-defined, publicly available cryptographic hashing algorithm that securely creates a string of characters (called the “hash”) from a data file.
2. Publish the hash of a file containing all the *Cast Vote Records* before the determination of the *Random Sequence of Ballots*.
3. In a timely fashion (but not necessarily before the determination of the *Random Sequence of Ballots*) publish the file containing all the *Cast Vote Records*.

Then the public may apply the hashing algorithm to the file containing all the *Cast Vote Records*. If the resulting hash matches the hash published before the determination of the *Random Sequence of Ballots*, then the public can be sure that the *Cast Vote Records* used in the audit match the *Cast Vote Records* in the published file.

Multi-card ballots

Some elections involve ballots that run onto more than one sheet of paper, often called “ballot cards.” Depending on the local protocols for storing ballot cards (are the separate cards of one voter’s ballot always stored together?) and the format of the *Cast Vote Records* (is there one *Cast Vote Record* for each ballot, or for each separate ballot card?), it may make sense to treat separate cards as separate ballots for the purpose of the audit.

Subset contests

Not every contest appears on every ballot. Often there are local contests (for mayor of a small town, for example) or district contests (for state representative, for example). Or there are primary contests restricted to one party. Or the audit is treating separate ballot cards as separate ballots for the purpose of the audit. In this situation it is wise to pay careful attention to the difference between the total number of ballots (or ballot cards) available to audit, which should be known from the *Ballot Manifest*, and the (smaller) number of ballots on which the contest appears, which may or may not be known from the *Ballot Manifest*.