

Logic & Accuracy Testing

# Logic & Accuracy Testing

Establishing Voting System Integrity

Issued by the Elections Group



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## Introduction

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Election Officials have been testing voting machines since the late 19th Century, when lever machines were first introduced. The first tests were purely mechanical, testing the accuracy of the equipment. When computer based voting systems were introduced in the 1960s, simply testing the accurate functionality was no longer sufficient, so tests were added to verify the computer logic. The new practices are known as Logic and Accuracy (L&A) testing.

The use of machines, and computers in particular, increased the precision and accuracy of counts, but moved average citizens one step away from the tactile act of counting. In order to help candidates, the media, and the public understand and believe that automated systems are trustworthy, more education and proof has been required. Testing voting systems can take several weeks of painstaking work and many states require a public demonstration of the testing prior to each election to help secure trust and confidence. Public tests offer a powerful communication tool and can help demystify intimidating technology, dispel myths, demonstrate the accuracy of the vote counting machines and software, and provide a forum to respond to questions and concerns from the community.

Voting equipment also undergoes certification testing (to ensure election officials get the systems that meet standards), acceptance testing (to ensure what they receive is built to specification), and preventive maintenance testing (to ensure they do not degrade during use). These tests are valuable to ensure the viability of the technology. Importantly, L&A tests are performed prior to each election and use the actual data and ballots for a specific election to ensure they are programmed correctly (and sometimes after elections to prove nothing has been changed). The three main objectives of L&A testing are:

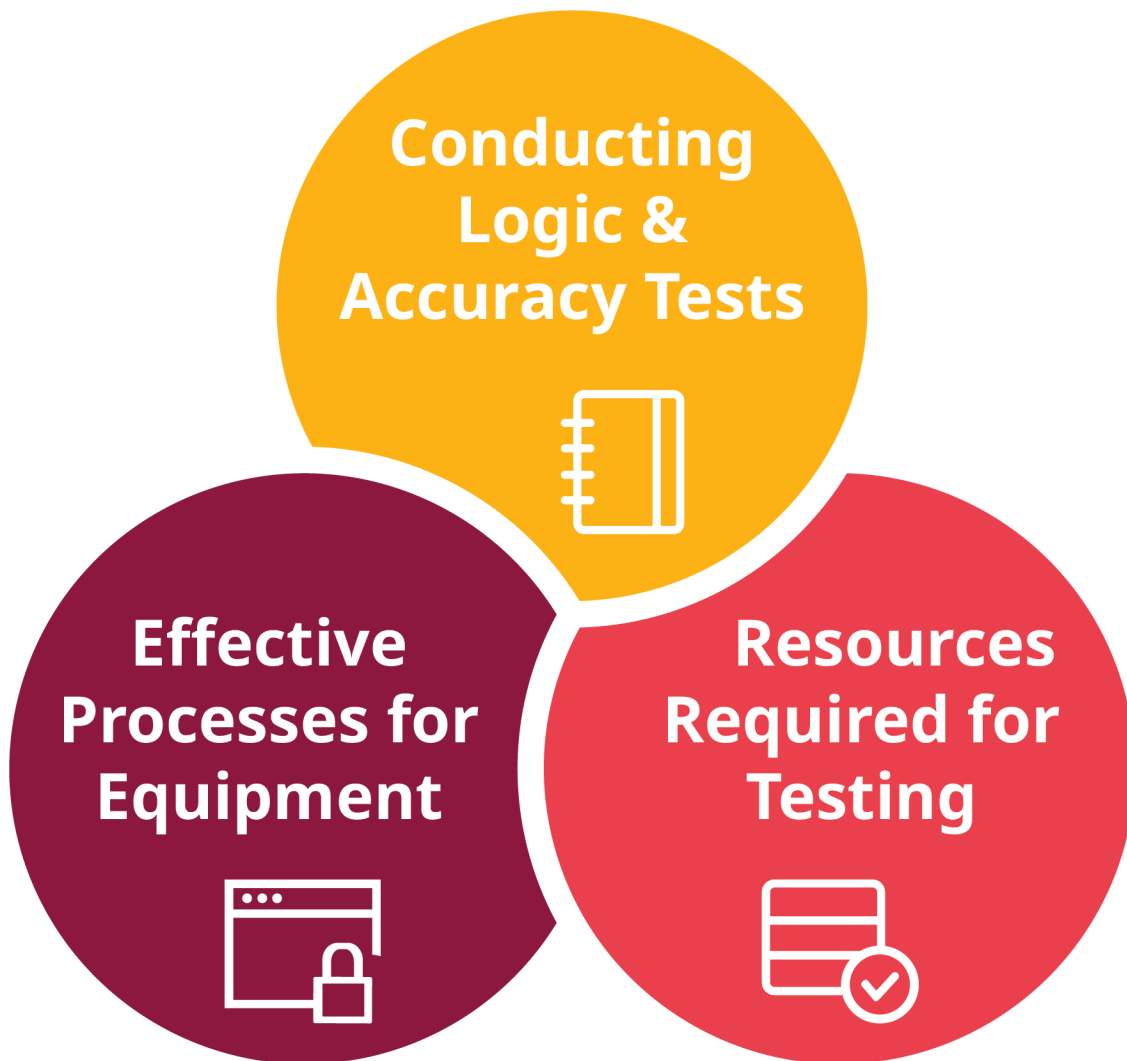
- 1. Verify that election specific data and ballots include every contest, candidate, and precinct;**
- 2. Ensure all components of the voting system are functional; and**
- 3. Verify the voting system can interpret voter markings and record and report vote totals accurately.**

L&A testing seeks to prove the system and its components are accurate and performing as intended by comparing the voting system reports of the scanner results to the known, expected results. Problems discovered during L&A generally derive from issues with data in the election database being tested rather than issues in the software or firmware of the voting system. That is, the issue results from *human errors* made entering election data, in the preparation of testing materials, or in the performance of the test. Errors are expected to be identified

and resolved early (through the testing process) rather than later, when voters are casting their ballots.

Public demonstrations are usually the culmination of the testing process. Additionally, some jurisdictions also conduct L&A post-election to demonstrate and document that the system was not altered during the election period and therefore performed accurately during the election.

The following sections will describe typical tests: how to conduct the tests, resources required, and effective processes for each type of equipment. Taken together, they offer a detailed description of every important phase of L&A Testing, putting procedures in context and explaining why they're necessary. However, **these suggestions are not a substitute for vendor-supplied instructions and staff checklists.** Each voting system has unique aspects that must be addressed.



# Flow Chart TBD

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## ***Preparing the Election Database***



### **Import/Input Sources of Election Definition Data**

- Voter Registration (VR) System (precincts and political & taxing districts.)
- Candidate Filing for contests and candidates.



### **Set up the election in the Election Management System**

- Generating election definitions, ballot styles and memory cards for preparing BMDs and tabulation devices.



### **Proof ballots and approve database**

- See our Ballot Proofing Guide

## ***Conducting Logic and Accuracy Testing on the Voting Equipment***



### **All Devices**

- Verified election data loaded onto machines



### **L&A Ballot Preparation**

- L&A ballots created
- L&A ballots marked
  - by hand
  - by printer
  - by BMD



### **Voting Machines**

- Scan test ballots
- Compare machines results to expected results
- Output data file to portable memory cards (for central tabulation)



### **Election Management System**

- Results uploaded and aggregated
- Tabulated results compared to expected results by machine and in aggregate



### **Analysis**

- Discrepancies, if any, examined, root cause determined, and corrections made as necessary.
- Reprogram and retest as needed.



### **Public Test**

- Small-scale replay of L&A

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**Proofing ballot definition data and the resultant ballots is a critical precursor to the L&A testing process. For more information on ballot proofing, consult the Election Group's [Ballot Proofing guide](#).**

# Components to be Tested and Required Materials

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## Components

Most current voting systems are comprised of:

- **A Server or PC** that runs the election management software, aggregates vote totals, and generates election reports.
- **A Central Count Ballot Scanner** (i.e., multi-feed ballot scanner) which primarily counts absentee ballots, in some cases early votes, and in a few states, all votes.
- **Precinct Ballot Scanners** (i.e., single-feed ballot scanners) to scan in-person ballots at the time the ballot is cast, and in a few states, also for mail ballots.
- **Ballot marking devices** (BMDs) which present ballots in various languages and other accessible formats and may also be a primary marking method for all in-person voters.
- **Direct-recording electronic voting devices (DRE)** with and without voter-verified paper audit trail (we recommend not utilizing DRE devices, but recognize they are still in use).
- **Auxiliary systems**, including e-pollbooks, on-line ballot delivery for military and overseas voters, and other related systems that need to be tested in-line with the voting system because they require technical compatibility or rely on voting system data.

L&A testing should incorporate all components directly related to the creation, marking and tabulating of ballots, as well as the aggregation and reporting of results. Every individual voting machine should go through L&A. In addition, the process provides reassurance on electro-mechanical and other functional aspects

Peripheral systems and equipment, such as election night reporting applications, postal sorting equipment, and signature scanners should also be tested prior to use in each election. This testing is not L&A testing per se but is often run concurrently using L&A election data. Tests on peripheral systems (and making sure to properly document them) are part of a comprehensive testing protocol.

## Materials

- Testing Checklist
- Activation devices for ballot cards or smart-card activation
  - Cards should be activated as on election day, testing any relevant equipment (e-pollbooks with activation devices; printer to print barcode) to prove the logic
- Necessary memory cards (i.e., portable data storage media used to prepare BMDs and other devices)
- Ballots and ballot stock
  - Pre-printed but unmarked ballots and blank ballot stock (i.e., for ballot on demand)
  - Pre-marked test ballots
- Test scripts for marking ballots (i.e., how to prepare ballots to create the expected pattern, and all possible error conditions.)
  - For pre-printed test ballots
  - For hand marking test ballots
  - For BMD/accessible device
- Pens (various colors as well as various ink types)
- Expected test results
- Keys, locks, tamper-evident seals

L&A should test the full range of likely voting behavior using all ballot types that will be live (ballots from a print vendor, a BMD and an on-demand printer, for instance), along with various pens and different staff doing the marking for at least some ballots.

## Staffing

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Staffing election night materials intake may consist of selecting a few full-time staff to handle it, assigning temporary staff already hired for other election tasks, or in some jurisdictions, adding temps just for election evening. However it's handled, here are considerations to keep in mind.

- Select staff with the appropriate skills and training, including close attention to detail or troubleshooting skills.
- Consider a security screening of staff within the laws of your jurisdiction.
- Train staff to understand what they're doing, its value and how to speak to observers about it.
  - see Appendix 4 for a sample L&A explainer for staff and observers.
- Hire enough staff to get the job done in the small window of time.

If, as a result of this guide or concerns in your jurisdiction, you are changing your approach to L&A testing, it may be helpful to do a time-study in order to understand any new staffing needs to meet the L&A schedule. A delay in L&A can have cascading consequences on equipment delivery and other time-sensitive needs.

Loading the election definitions on a machine arms the machine for voting and increases need for greater tamper detection measures (such as security seals) and for a record of custody and access to the equipment.

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**L&A is often the final check of the equipment before it is deployed for early voting or Election Day. Part of L&A is to ensure that the voting equipment is election-ready. Election-ready means that all components are present and functional, the equipment is correctly configured, and security seals and tamper-evident indicators are applied and recorded in chain of custody logs.**



## Preparation

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The goals of Logic and Accuracy testing are to **ensure that the voting system has been duly configured to accurately report the votes as cast** for every contest and candidate, and to **ensure that each component of the voting system is functional**.

### Vendor Checklists and Directives

This guide is meant as a detailed description of every important phase of L&A Testing, putting things in context and explaining why they're necessary. However, it is not a substitute for vendor-supplied instructions and staff checklists. Each voting system has unique aspects that must be addressed.

## Creating a Test Script

To achieve these goals, it's necessary to test every selection in every ballot style (logic) and to test some selections on every machine, with every type of ballot in use (accuracy). We use the term *ballot style* to describe each unique collection of districts, contests, and sometimes, precincts. **The steps necessary to create the set of ballots is the *Test Script*.**

We describe **the set of ballots necessary to test every selection in every ballot style as a *complete set of ballots, complete set, or test deck*.**

- Central count scanners for mail ballots and precinct ballot scanners should always be tested with a complete ballot set.
- The best practice is to run a complete set on every machine.
- In jurisdictions with large numbers of central count scanners for early vote (EV) sites or vote centers it may not be feasible to run a complete set on every machine.
  - A complete ballot set in a large jurisdiction may run up to 10,000 cards.
  - Each time the set is run it takes the better part of a day.
  - Some such jurisdictions have 80 or more EV machines.
- Such jurisdictions typically divide ballot styles across the machines available (e.g., the first 10 styles on machine A, 11-20 on machine B, etc.).
  - It's important to run a robust test on each machine, since each will be handling many more votes than any single precinct machine.

- **There is no reason to limit the test to one complete set.** A jurisdiction with 80 ballot styles and 80 jurisdiction-wide machines to test might run 10 ballot styles on each, resulting in 10 runs of the complete set—a very substantial test.

Similarly, while we stress the use of some ballots from every ballot creation mechanism (pre-printed ballots, BMD ballots, UOCAVA-generated ballots, ballots created with an on-demand printer), it is not feasible to test every selection on every machine **with every type of ballot**.

The bulk of your test deck should consist of the ballots most voters will use, typically hand-marked paper ballots and BMD ballots.

In addition to testing every potential selection, **the ballot set must include ballots that confirm the proper reading of error conditions** such as blank ballots and overvoted contests, if such screening is allowed or required under state law.

## Expected Results and Test Patterns

It is imperative that there is a known—or expected—set of results. Most jurisdictions use a test pattern that staff can recognize. For instance, the first candidate gets one vote, the 2nd gets two, the 3rd gets three, but the 4th goes back to one vote. This is often expressed as a *1,2,3,1,2,3* pattern. It's pretty easy to glance at a results tape and see whether they follow this pattern. Test results are then compared to an appropriate report for the ballots tested.

Jurisdictions using a test pattern should introduce variations. At minimum, introduce minor discrepancies from pattern and verify that these departures from pattern are accurately reported, in order to avoid any allegations that the test results were simply programmed to produce the pattern rather than based on tabulating the test ballots.

We recommend a pattern that varies across consecutive contests to the degree possible. For instance, if President uses *1, 2, 3*, then US Senate might use *3, 2, 1*. Generally, it's important **to balance the need to make various types of errors visible with the need for a simple pattern that staff can recognize at a glance to identify discrepancies**.

## Randomizing Marking

Some jurisdictions use randomized marking to prove no one could guess the expected outcome and program the results. One must still generate the expected

outcome independently from the scanners, so this may work best in small jurisdictions or if a printer can create pre-marked ballots with randomized selections whose totals are known. If random marking is done by hand, proof the set to ensure that every selection has been marked on at least one ballot.

**LOGIC AND ACCURACY  
TEST BALLOT**

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**Contest #1**

Candidate A  
 Candidate B  
 Candidate C  
 Candidate D

**Contest #2**

Candidate E  
 Candidate F  
 Candidate G  
 Candidate H

**LOGIC AND ACCURACY  
TEST BALLOT**

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**Contest #1**

Candidate A  
 Candidate B  
 Candidate C  
 Candidate D

**Contest #2**

Candidate E  
 Candidate F  
 Candidate G  
 Candidate H

**LOGIC AND ACCURACY  
TEST BALLOT**

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---

**Contest #1**

Candidate A  
 Candidate B  
 Candidate C  
 Candidate D

**Contest #2**

Candidate E  
 Candidate F  
 Candidate G  
 Candidate H

**LOGIC AND ACCURACY  
TEST BALLOT**

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---

**Contest #1**

Candidate A  
 Candidate B  
 Candidate C  
 Candidate D

**Contest #2**

Candidate E  
 Candidate F  
 Candidate G  
 Candidate H

## Preparation – Election Management System Procedures

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Prior to the start of formal testing, the Election Management System (EMS) must be configured and verified, and ballot styles and images created and proofed. Typical configuration settings include precincts and districts, voter counts, contests appearing on the ballots, candidates associated with contests, the “vote for” count in a contest, reporting methods, and technical settings for exception handling (e.g., overvotes, write-ins, marginal marks, etc.). Increasingly, encryption and other advanced security features are embedded in the election definition as an additional defense to ensure memory cards come from legitimately prepared voting machines. Where they exist, such controls supplement methods like L&A and post-election audits, which confirm system integrity.

Memory cards must be created in the EMS to prepare voting machines and other relevant devices.

Typically, the EMS is locked down after testing is complete. No changes can be made after the completion of testing without potentially compromising the integrity of the election. If changes are necessary due to judicial review or error correction, consult with your vendor on possible implications. Most changes will require re-conducting L&A

### Create/Load Election Definitions

- If receiving election definition files from vendor, load them onto the EMS

### Print Zero Report

A zero report from the EMS should be produced prior to scanning any test ballots.

**Closing out must also be repeated prior to any early voting or voting on election day to ensure that there are no residual results from previous elections or testing.**

### Create Memory Cards

- Burn memory cards with election definition files to program devices
  - Program cards to be readable only by the intended machine, where possible

- Create the necessary authentication/security keys, as applicable
  - Poll worker
  - Technician
  - Administrator
  - Security keys

## Preparation – Readyng All Devices

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Before starting L&A testing, or as part of your enhanced L&A testing protocol, every machine assigned for deployment must be approved for use. This is a good moment to verify software versions and security details to ensure the integrity of the systems remains intact.

### Machine Inventory

- Inventory/verify all serial numbers
- Check all locks – including port blockers
- Ensure seals (if used) are intact and match the chain of custody records from last use
- If devices are not permanently assigned to a particular voting location, assign them to locations based on their warehouse location and the order in which they will be shipped.
- For instance, if scanners are kept on shelves, and several will go to a single Early Voting location, assign the serial numbers from a given area of shelving to that location, rather than assigning randomly and having to organize them for shipping later.

### Prepare an inventory list of devices and a testing checklist for each device to be tested. System & Configuration Checks

- Validate the software/firmware version(s)
- Confirm system settings, security and hardening
- Voting system vendors will provide a list of configurable options that need to be set, and vendors or county IT will provide security recommendations.
- During L&A prep, the goal is to verify that these settings were accurately established for the upcoming election.
- Set or check passwords and other authentication measures (e.g., security keys, tokens, poll worker/technician cards, etc.)

#### Readyng Machines

Many jurisdictions complete most of the steps in this section during L&A testing rather than as a preliminary. At minimum, you should confirm storage locations to avoid confusion as you pull machines for testing.

## Preparation – Marking Ballots Using All Ballot-Related Systems

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Logic & Accuracy Testing begins with the marking of test decks. Above we described creating the *test script*, the plan for marking ballots, with the default as a complete ballot set on every precinct and central count mail machine.

Now, this guide focuses on actually generating ballots using every ballot creation mechanism that will be used in the election, which might include BMD ballots (potentially activated by e-pollbooks), pre-printed ballots marked by hand, on-demand printed ballots, and ballot duplication systems for UOCAVA or for corrections.



### Purpose

Preparing ballots from all ballot sources ensures that all ballot preparation devices are using the same data as the voting system and that they produce ballots compatible with the scanners. The types of errors that can be identified and resolved include:

- e-pollbooks or ballot printers loaded before final VR or EMS updates, and other discrepancies between the e-pollbooks and the voting system.

- updates in the voting system that were not updated on printed ballots (or vice versa).
- corrupted data in any such systems.
- incorrect paper thickness.
- blurred or poorly printed barcodes, timing marks, or other printing errors.

If ballots are created on ballot marking devices (BMDs) using an *activation card* or a ballot card whose QR or barcode is generated by an e-pollbook, an e-pollbook should be used to generate some by hand during L&A, even if the vendor can provide pre-printed ballot cards or activated smart cards. In addition:

- Some paper ballots should be marked by hand, using a range of pens.
- Some ballots printed by a printing vendor and by any ballot-on-demand printer should be used
- Some ballots should be prepared using any system that replicates ballots, prepares military/overseas ballots and/or re-generates them in a scannable format.

The procedure for each system is described under the headers below. **In general, the steps are:**

- Using an e-pollbook or activation device (as applicable), activate cards or generate ballot cards for the BMD.
- Using the BMD, with the test script as guide, mark and print ballots.
- Mark pre-printed ballots by hand, using the test script.
- Print ballots using the ballot-on-demand printer and mark them according to the test script.
- Print ballots using the UOCAVA ballot duplication system and mark according to the test script.

## Misprinted Ballots

When a discrepancy between a ballot and the EMS database is found, it can be tempting to create a second version of the database to match the printed ballots, in order to avoid reprinting. This is a dangerous workaround that we caution against. It creates the potential for using the wrong version of the database and generating incorrect totals. Use one database and make the necessary corrections, even if it means having to reprint.

## E-Pollbooks

- Program e-pollbooks using the final set of street files and address-contest relationships.



- The relationships should not change after the EMS is loaded with ballot creation data. Changes create significant risk of error, particularly if changes cross precinct lines.
- Generate ballot activators - in the form of a digital card or a ballot card

When a discrepancy between a ballot and the EMS database is found, it can be tempting to create a second version of the database to match the printed ballots, in order to avoid reprinting. This is a dangerous workaround that we caution against. It creates the potential for using the wrong version of the database and generating incorrect totals. Use one database and make the necessary corrections, even if it means having to reprint.

## **Ballot Marking Devices (including remote ballot marking tools)**

In some jurisdictions, BMDs are used exclusively as “accessible” voting machines. In other jurisdictions, a large proportion of voters use BMDs to mark their ballots. Creating and tabulating one or more complete set of ballots from the BMDs ensures that:

- Ballot definition files were generated and loaded accurately
- Voters can access and use the electronic display
- The device successfully produces correct ballot styles with their contests and candidates, and records selections made.
  - The logic is appropriate not only visually and when voted by touch, but in the accessibility modes and as generated by all relevant activation methods.

### **Prepare the BMDs**

- Some inventorying steps described on p. 9, such as validating software, firmware and security settings, can be completed at this point if not done earlier.
- Load Election Definitions
  - Use the removable memory cards created by the EMS

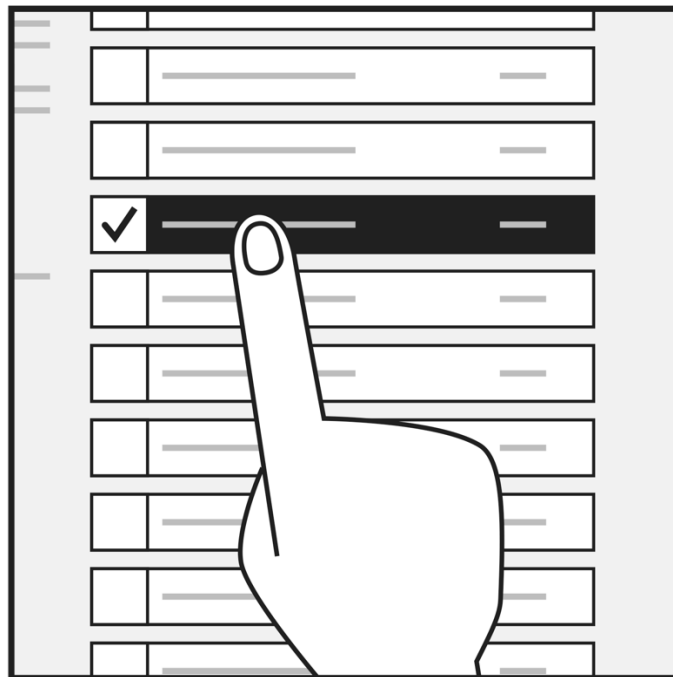
- Use memory cards created by vendor, if applicable
- Verify date, time, serial number and program versioning as relevant.
  - If a daylight savings time change intervenes between machine prep and usage, verify proper handling
- Verify jurisdiction name, polling place, and/or precinct where relevant

### Ballot Activation

- Test all activation methods
  - Cards activated by e-pollbooks or activation devices
  - Manual activation from the BMD
- Use any and all accessible voting modes
  - Test the audio, including each language
  - Test the accessible tactile device(s), including binary switches

### Mark the Ballots

- Mark ballots in accordance with the test script
  - Include a write-in
  - Attempt an overvote
  - Attempt a second (and third) selection in a contest where more than one candidate can be chosen (ie, a “vote for two” contest)
- Verify ink/toner sufficient for election usage, and perform other routine maintenance checks.



### **Ballot Proofing**

Prior to L&A, all ballot styles should be rigorously proofed, including verifying the accuracy of ballot presentation on BMD screens. Refer to our Ballot Proofing guide for tips.

## **Hand-Marked Paper Ballots**

Since most jurisdictions will see a majority of electors vote on hand-marked paper, whether voting by mail or in person, the test of this stream of ballots must be robust. Best practice would generate at least one complete set of hand-marked paper ballots to test central count scanners, and sufficient ballots that every voter-facing scanner undergoes a test of every ballot style and selection locally available.

- Mark ballots according to the defined Test Script
  - Use a variety of pens.
- Create enough complete sets of ballots to test all scanners that will be in use
  - If multiple central count scanners are in use, or if some ballot styles are valid in multiple voting locations, marking multiple sets or subsets will improve efficiency of L&A.
- Incorporate some ballots from each method of ballot preparation, as appropriate to the machine being tested. For instance,
  - Central count jurisdictions should create test decks for all ballot types including military/overseas ballots, BMD ballots, provisional ballots, mail ballots, etc.
  - Precinct-count mail jurisdictions should incorporate some mail ballots (ie, ballots printed as they would be when sent to mail voters) in precinct scanner test decks.

Using hand-marked paper ballots ensures that:

- Ballots were generated using the appropriate logic and printed to specification with correct paper weight and thickness.
- Scanners accurately read selections,
  - including when marked across a normal range of pens and styles of marking
- Tabulation systems accurately read and record selections

## **Ballot on Demand**

- Prepare the printer using final election definitions from the EMS.
  - Or use PDFs from a locked down file with up-to-date ballot images.
- Print ballots
- Mark ballots
- Verify ink/toner sufficient for election usage and perform other routine maintenance checks.

## **Military/Overseas Ballots / Ballot Duplication System ("Remote Marking Tools")**

- Prepare relevant systems using final election definitions from the EMS.
- Generate a set of Military / Overseas Ballots for testing
  - Mark them, if marking isn't an inherent part of ballot generation.
- Manually replicate ballots mirroring election practices
  - For systems that read QR codes printed on regular paper - test that code by generating voted ballots on printer paper using the test script, then using the system to read the QR code,
    - For systems that use the QR code to create a machine-readable ballot, create the duplicate ballots and tally them.
    - For systems that read selections into tally directly from the QR code, tally the ballots.
- Verify the logic of any system-created identifying number that ties duplicate ballots to originals.

## Central Count Scanners (High-Speed Scanners)

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This step involves a full dry-run election. As discussed above in the discussion of planning the test deck, every mail ballot machine should be tested with a complete set of ballots. If the number of Early Voting machines makes it infeasible to run a complete set on every machine, all machines must receive a robust test, dividing the test deck into sections and running these partial sets on every machine. When results are aggregated from the full complement of machines, the result should be that multiple complete ballot sets have been run.

The deck can only be split for use on early voting machines that are clones of each other, prepared using either the same memory card or memory cards copied from a single master. Otherwise, the split deck might not flag a machine prepared with a previous election version if the change was to a ballot style not included in that machine's deck.

If in the course of preparations, any different versions of the master were created, the best practice would be to verify the correct version on every machine before using a split deck.

Following the L&A procedures below ensures that:

- Devices and ballots are prepared using the same election definitions
- Security and authentication factors are as required
- Scanner(s) open and close properly
- Scanners recognize the logic of each ballot style and record selections accurately

The test also ensures that at the time of testing, mechanicals such as feed mechanisms and optics involved in reading ballots are in working order.

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**Errors commonly made by L&A staff may trip up voters too. For instance, L&A staff may recognize that 2-card ballots may jam scanners if inserted quickly, and develop a protocol for preventing it. If staff faced the issue, voters will too. Remember to communicate relevant tips to poll worker trainers and mail ballot staff.**

### Load Election Definition

- Use the removable memory cards created by the EMS or cards created by vendor, as applicable
- Check the Election Definition for accuracy

- Verify the name and date of the election
- Verify the scanner ID, jurisdiction name, or polling place name used to identify the scanner .

## Run the Test

- Open the polls
- Verify the *Zero Report*
- Scan ballots
  - Scan some in all four orientations
  - Close out a batch of test ballots (for mail ballot scanners, where applicable)
  - Verify batch information such as batch numbering and accurate piece counts.
  - Continue scanning the rest of the test deck.
- Close Polls
- Verify results on the printed results tape
- Power down machine and remove memory cards
- Reset each device
- Run and print *Zero Reports*

**General Election  
Zero Report**

---

**Contest #1**

**Candidate A.....0 votes**

**Candidate B.....0 votes**

**Candidate C.....0 votes**

**Candidate D.....0 votes**

**Contest #2**

**Candidate E.....0 votes**

**Candidate F.....0 votes**

**Candidate G.....0 votes**

**Candidate H.....0 votes**

## Precinct Scanners

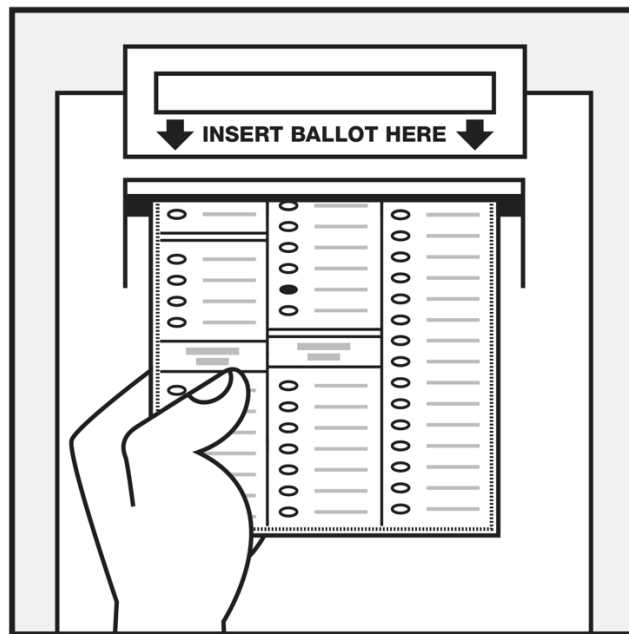
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Each precinct scanner counts only an assigned subset of ballots based upon location. For L&A testing, each scanner is prepared with the election definition files and then a complete subset of ballots is run and tabulated.

This ensures that:

- Devices and the ballots are prepared using the same election definition files.
- security and authentication factors are as required.
- Scanner(s) open and close properly.
- Scanners recognize the logic of each relevant ballot style and record selections accurately.

The test also ensures that at time of test, mechanicals such as feed mechanisms and optics involved in reading ballots are in working order.



### Load Election Definition

- Use the removable memory cards created by the EMS or memory cards created by vendor, if applicable
- Check the Election Definition for accuracy
  - Check date, time, serial number, device version number (on the device and on the printout), as applicable
  - Verify the jurisdiction name, polling place, and precincts

## Run the Test

- Open the Polls
- Verify the *Zero Report*
- Scan ballots in all four orientations
- Close Polls
- Verify results on the printed results tape
- Power down machine and remove memory cards
- Reset each device
- Run and print *Zero Reports*

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**Sealing and Shipping -- L&A Testing should be the last moment when voting machines are open. Finishing L&A leads directly to sealing machines and preparing to ship. This process is not inherently part of testing logic and accuracy, but you need to integrate it into your plan of attack. For an idea of what must be done, see the Seal Team Checklist” – Appendix 3.**



## EMS – Verifying Complete Results

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Ultimately, L&A must verify that the system follows the intended logic and produces accurate results—from top to bottom and start to finish. This process is not complete until results have been verified in the EMS.

Results must be verified both at the level of the EMS and for every individual vote tabulation machine: DRE, Precinct Count Scanner, and Central Count Scanner. Staff handling these different tasks may have different capacities for recognizing discrepancies. Jurisdictions must determine which stage—verification of results at each machine, or verification of results from the EMS—is the **primary** stage for verification and ensure that **every discrepancy is caught and evaluated at that stage**. Both stages provide opportunities for catching errors and neither should be ignored.

Verifying final results on the EMS validates that every machine created accurate results **which can be incorporated successfully into the official results database**. It provides evidence that:

- Cartridges have not been corrupted.
- The logic has not changed.
- The central system and its various devices remain in sync.
- It also tests that the EMS aggregates results accurately.
- Finally, in jurisdictions where this is relevant, it allows a test of the ability to manually or digitally resolve any ballots not correctly processed after scanning. This includes ballots with write-ins and a variety of voter intent issues.

### Upload Removable Memory Cards from Tabulating Devices

- Reset results if necessary and run a zero report
- Load results, ballot images, audit log files, as applicable, from all memory cards

### Verify Results

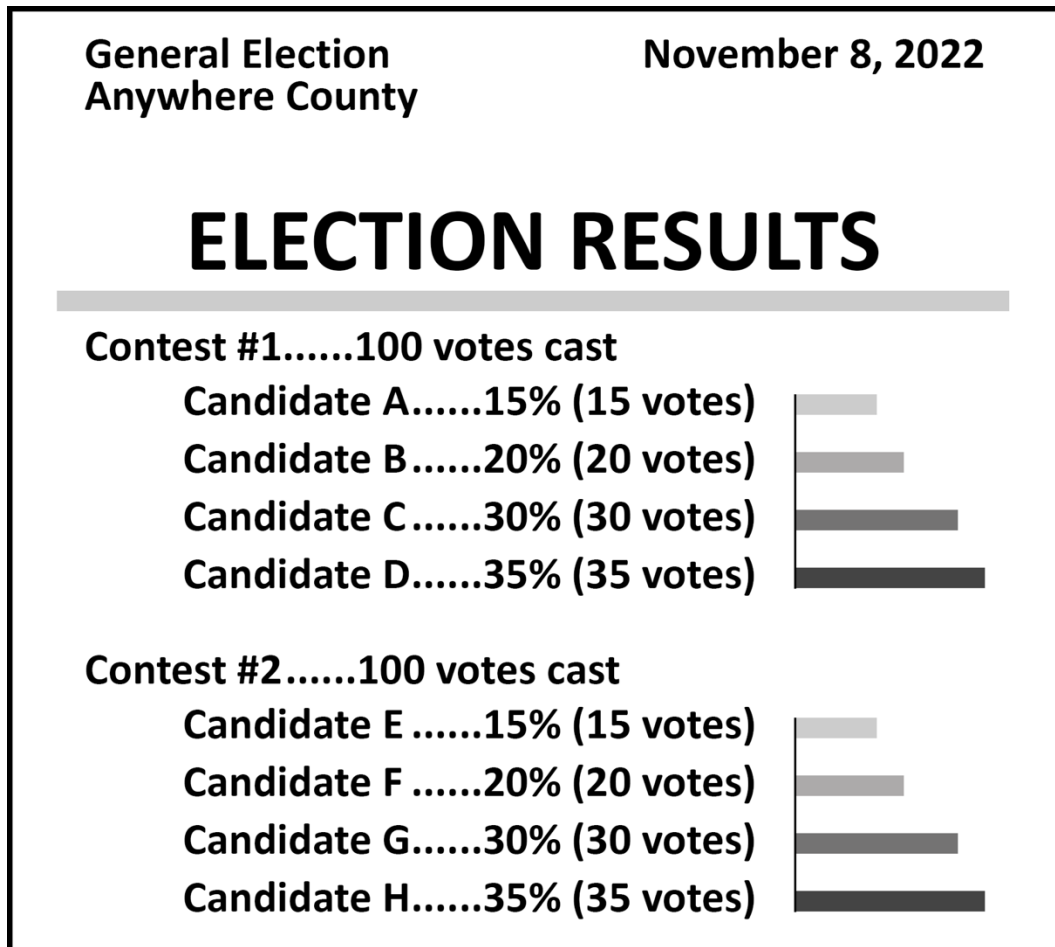
- Print results
  - Per machine without adjudication – this should match the printouts from each machine
- Adjudicate votes, if applicable (e.g., write-ins, marginal marks, overvotes, etc)
- Print final results
  - Aggregate with adjudication

## Interdependent Results Systems

The election reporting system produces the results voters see and perceive to be official. It should be tested in the same manner as the central tabulation/aggregation system, to prove the logic and ensure election reporting incorporates results files accurately from the official database of the EMS and displays them correctly.. This step also helps ensure that various reports, filters, etc., are displaying the applicable criteria correctly.

## Election Night Reporting and other Ancillary Systems

- Take final results and load them into any election results reporting systems or programs, as applicable
- Review aggregate results against the expected results from your test scripts or from the EMS.
- Review a sampling of filtered results or “click-throughs” to precinct, district or other subsets of results.



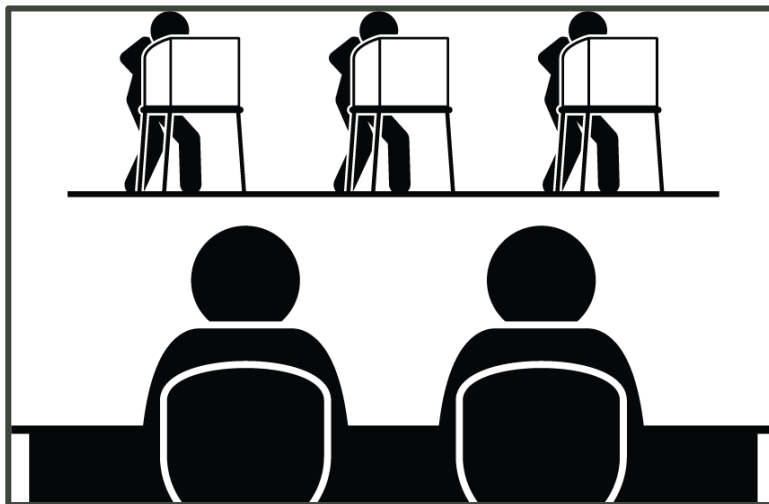
## Observers, L&A Testing and Public Demonstrations

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L&A and public testing are closely related but are usually distinct processes. L&A is a rigorous and complete test of the voting system database to ensure equipment is prepared correctly. L&A is generally conducted by staff, sometimes with bipartisan teams of workers, and typically requires several days, and sometimes weeks, for a number of staff.

Many states require a more circumscribed public demonstration of system integrity on a specific and publicized date. The “public test” or public demonstration usually involves voting on a small number of machines. Many jurisdictions allow members of the public to participate by marking ballots, choosing which machines will be pulled and tested, and/or tallying results by hand to compare to the machine tally.

Even jurisdictions conducting a public test should consider how to make L&A testing itself public and observable. The more genuine the opportunity for observance, the more likely you can dispel inaccurate criticism. Someone on staff will need to be available to explain the process to observers—its purpose, emerging issues, and what the office must do to address them.



## Final Security Measures

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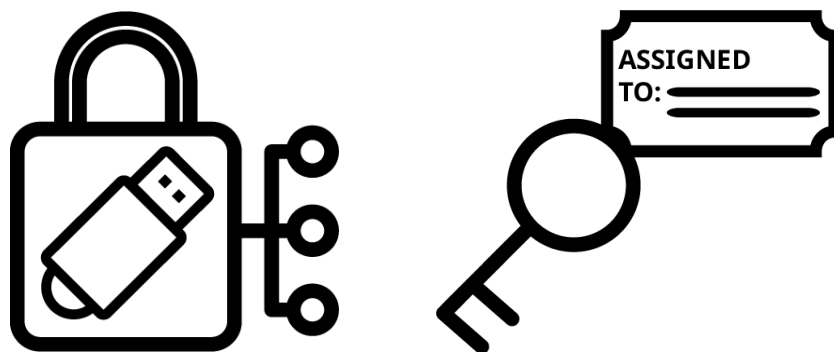
These steps ensure that the election official can verify chain of custody for every device, showing that it was transported to its point of use with no ballots cast, ready for official election use.

### Re-zero All Devices and Systems that Tabulate

- Back up all necessary data coming from L&A
- Re-zero any devices not previously zeroed out
- Print zero tapes/reports as appropriate
- Verify zero tapes were printed for all devices on which work is complete

### Implement protective and detective measures for shipping

- Lock every lock
- Seal unused port
- Place the necessary tamper-evident seals on the devices
- Maintain a log of the seals



## Appendix 1 - Management Checklist

One way to use this checklist is to enlarge it and post it somewhere visible in the office to keep track of progress on L&A.

<b>Logic &amp; Accuracy Testing – Management Checklist</b>			
<b>Preparing for L&amp;A</b>			
<b>Target Date</b>	<b>Item or Task</b>	<b>Notes</b>	<b>Complete (Initials)</b>
	Supply Orders / Facilities Prep		
	Staff Training		
	Prepare the Election Management System		
	Create the “Test Script”		
	Inventory and Assign Voting Equipment		
<b>Ballot Marking</b>			
	Prepare E-pollbooks and Activate Cards or Ballot Cards		
	Prepare BMDs		
	Mark Ballots on BMDs according to the Test Script		
	Hand mark paper ballots according to the Test Script		
	Use Auxiliary Devices (UOCAVA, ballot on demand, etc.) to mark a set of ballots		
<b>Scanning Ballots</b>			
	Run test decks on central count scanners (mail)		

	<ul style="list-style-type: none"> <li>• verify results</li> </ul>		
	<p>Run test decks on precinct scanners</p> <ul style="list-style-type: none"> <li>• verify results</li> </ul>		
	<p>Zero all devices to prepare for voting.</p>		
	<p>Run any "Seal Team" or pre-shipping procedures</p>		

## Appendix 2 - Sample Staff Checklist

This checklist is schematic, not definitive. You will need to create a checklist based on your vendor recommendations. The point is to have a checklist that goes step-by-step and asks staff to sign off on completion.

Logic & Accuracy Testing – Scanner Checklist		
Site / Precinct: _____		
Item or Task	Issues Noted:	Completion (Date & Initials)
Verify Machine Number against Site Assignment List		
Verify software Version 3.2.22		
Verify firmware Version 4.0		
Insert memory media and initiate election prep		
When prep is complete, enter L&A Mode (if applicable)		
Run BMD-created ballots		
Run hand-marked ballots		
Run ballots from auxiliary systems (if applicable)		
Close polls		
Print a results tape and verify against expected results		
Zero out all results and run a zero tape		
Run close-down / sealing / shipping prep procedures (see		



Appendix 3 for more info.)		
Provide results tape and zero tape to supervisor		
Supervisor to verify zero tape time-stamp is after results tape time-stamp.		



## Appendix 3 - Seal Team Checklist Sample







**Best practice is to incorporate these steps into the L&A checklist, sealing containers immediately.** If sealing is done later, prior to shipping, this checklist can be used separately.


**Team Member:** \_\_\_\_\_ **Precinct/Site:** \_\_\_\_\_ **Date** \_\_\_\_\_

Confirming Scanner Ready		
1.	Confirm (or insert) 2 extra printer rolls (vendor should supply)	
2.	Confirm (or add) Power Strip and Extension Cord	
3.	Confirm (or add) two ballot bags inside the storage area.	
Sealing the Scanner		
1.	Sticker seal the "Administrator" door Sticker Seal Number _____	
2.	Sticker seal the "Poll Worker" door Sticker Seal Number _____	
3.	Zip seal the Key Lock area Zip Seal Number _____	
4.	Zip seal the Ballot Bin Access Panel Zip Seal Number _____	
5.	Place lid on top of scanner	

6.	Zip seal the Lid Zip Seal Number _____		
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## “Seal Team” Checklist - Ballot Marking Device

Confirming BMD and Cart Are Ready		
1.	Confirm (or add) 1 package of ballot paper in the printer.	
2.	Confirm (or add) power strip and extension cord	
3.	Wrap BMD cart power cable around the attached handle	
Packing Extra Materials (ADA Device Only)		
1.	Confirm this is the ADA device with Power Supply & Accessible Equipment. If not, skip to “Sealing the Ballot Marking Device” below.	
2.	Pack 2 extra packages of ballot paper. Do not open and do not place in printer.	
3.	Pack PPE: Hand Sanitizer, Handful of Gloves, Pack of Masks, Wipes (if available)	
Sealing the Ballot Marking Devices & BMD Cart		
		
1.	Zip seal the “Election Data” door  Zip Seal Number _____	
2.	Zip seal the “Accessories” door  Zip Seal Number _____	
3.	Put down the Screen and close the lid.	
4.	Zip seal the Back Door, Top Latch  Zip Seal Number _____	
5.	Zip seal the Front Door, Top Latch  Zip Seal Number _____	

6.	Zip seal the Lid  Zip Seal Number _____		
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# Appendix 4 - Sample of Explanatory Handout for Observers

## Logic and Accuracy Testing Protocols



### What is Logic and Accuracy Testing?

Logic and Accuracy (L&A) Testing is a set of procedures performed to ensure there are no errors on ballots or ballot displays and that voting machines are properly programmed. These tests occur prior to every election.

### How Does Testing Work?

Each type of device is tested with different protocols and for specific purposes. For each piece of equipment, the steps listed below will be completed to ensure the voting system operates as expected. Certain tasks such as candidate name proofing have already been completed.

### Testing Processes

#### Ballot Marking Devices

7. Ballot styles are loaded on the ballot marking device.
8. Verify the collection of contests and candidates are correct.
9. Make pre-determined selections on the ballot marking device then complete the ballot.
10. Review the printed ballot card to ensure it matches the on screen selections.
11. Compare results from the printed ballot card to the expected results to verify accuracy.
12. Repeat the process for each ballot marking device being used.

Insert Picture(s) of your Equipment

#### Precinct and Central Count Scanners

3. Insert pre-determined test ballots into the scanner to ensure that:
  - a. There are no paper size or stock issues
  - b. All ballot styles (collections of contests and candidates) can be counted by the scanner
  - c. Error conditions, such as smudged ballots, ballots with marginal marks, ballots with over-voted contests, tears, etc., are outstacked or otherwise recorded for future review, and adjudication or replication by staff.
4. Tabulate the results from test ballots cast on the scanner and compare them to the expected results to verify accuracy.

Insert Picture(s) of your Equipment

*Note: This is why the test ballots are marked with a predefined set of choices.*

**The Tabulation System** is tested by aggregating results from each scanner into the system. Each scanner has a removable media that loads the results into the central tabulation system to be aggregated with the other scanners. These results are combined with the results from the central county scanners, to ensure all results are added up and reported correctly.

Insert Picture(s) of your Equipment

**The Election Night Reporting System** is not part of the voting system but is what displays the results to the public on the internet. It is tested by transferring results data from the tabulation system on a secure memory device and loading it into a separate computer to ensure the public display of results reflect what is in the Tabulation System.

Insert Picture(s) of your Equipment

## Appendix 5 - Additional Resources on L&A Testing

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- 📄 [https://www.eac.gov/sites/default/files/eac\\_assets/1/6/ess-3011-Logic\\_Accuracy-use-procedures.pdf](https://www.eac.gov/sites/default/files/eac_assets/1/6/ess-3011-Logic_Accuracy-use-procedures.pdf)
- 📄 <https://www.eac.gov/voting-equipment/managing-election-technology>
- 📄 [https://www.eac.gov/sites/default/files/document\\_library/files/2\\_Logic\\_and\\_Accuracy\\_Final\\_2.0\\_031416%28EAC%29.pdf](https://www.eac.gov/sites/default/files/document_library/files/2_Logic_and_Accuracy_Final_2.0_031416%28EAC%29.pdf)
- 📄 <https://www.ohiosos.gov/globalassets/elections/directives/2022/eom/dir2022-09-ch05.pdf>
- 📄 [https://www.michigan.gov/documents/test\\_deck\\_manual05\\_131814\\_7.pdf](https://www.michigan.gov/documents/test_deck_manual05_131814_7.pdf)