

Election Audits and Election Security: A Report for the State of Utah

A Report to the Utah Lieutenant Governor's Office

Damon Cann

Dept. of Political Science
Utah State University

Quin Monson

Dept. of Political Science
Brigham Young University

Leah Murray

Dept. of Political Science & Philosophy
Weber State University

November 8, 2023

The authors thank John Hall, Adam Hubbs, and Noah Munk for excellent research assistance in this project and acknowledge their contributions to this report. We also thank the county clerks who met with us for their contributions.

Table of Contents

Executive Summary.....	3
Introduction:	4
Key Changes in Utah Law	4
Practices in Ballot Storage and Signature Verification	5
Security of Ballot Storage.....	5
Practices in “Batching” of Ballots.....	6
Signature Verification	7
Practices in Ballot Scanning and Processing.....	12
Utah’s Current Audit Practices: A Summary.....	13
Signature Audits.....	13
Post-Election Tabulation Audit	14
National Practices in Post-Election Audits.....	16
Traditional Tabulation Audit.....	16
Risk-Limiting Audit	16
Post-Election Logic & Accuracy Tests.....	20
What Course Should Utah Pursue on Post-Election Audits?	20
Preview of Survey of Utah Voters.....	22
Conclusion.....	22
Summary of Recommendations	23
References	25

Executive Summary

- Utah currently has a number of strong election audit practices in place, with requirements most recently updated in the 2023 session of the Utah State Legislature.
- Utah's audit and election administration practices are strongly developed and implemented. Utah's election audit and other election security policies and practices are similar to or stronger than those of many states, including states that use vote by mail elections.
- Utah currently employs reasonably strong signature validation processes. However, opportunities for improving policies - including management and implementation of those policies - is important.
- Perhaps the biggest challenge facing election integrity at present is that voters likely know very little about current election security practices in Utah. A future supplement to this report will provide more information about how Utah voters respond to more information about things like signature validation and audit practices.

Introduction:

In early 2023, the Utah State Legislature passed HB 448, which required the Lieutenant Governor's office to study methods of election auditing including risk-limiting audits and other confirmation methods. HB 448 further required the development of rules to conduct a signature comparison audit of 1% of ballots prior to separating the ballots from their envelopes, replacing an earlier practice of conducting the signature audit just prior to the canvass. The Utah Lieutenant Governor's Office has engaged us to assist in these efforts.

In preparing for this project, we have reviewed major changes and updates in Utah law regarding elections since 2006 with a particular focus on changes that have implications for election auditing. We have also reviewed academic literature and reports from practitioners on best practices in post-election audits. Per direction of the Lieutenant Governor's Office, our research considers election integrity broadly, including signature verification processes, ballot storage, and ballot processing as well as post-election practices. We extended multiple invitations to all county clerks to participate in interviews with us over a span of several weeks; ultimately about one-third of county clerks accepted our invitation. During our interviews we also spoke to county elections staff and former clerks. We also acquired information from other states on their election auditing practices. Finally, we have a study underway examining the effects of audit practices on public confidence in elections.

Our report proceeds in several sections. First, we summarize major changes to Utah election law. Second, we present findings from interviews with county clerks from 9 Utah counties (varied in geography, population, staffing capacity and more) that demonstrate practices in ballot storage, and signature verification. Third, we present findings from those same county clerks that demonstrate practices in ballot scanning and processing. Fourth, we present findings from those same county clerks that demonstrate auditing practices. Throughout we offer specific recommendations to the state to enhance our election processes. Finally, we believe that a central concern motivating audit procedure reviews is voter confidence in the elections process. As a result, we are conducting a survey of voters to see what procedures best meet voter expectations of a secure election. We explain that survey and what it may be able to tell us when data collection is complete at the end of this report.

Key Changes in Utah Law

Election law has been through a number of important changes in Utah since 2006. Many of these changes have taken place in response to broader changes in the election environment nationally. As of 2006, Utah was conducting voting primarily on direct-recording electronic voting machines, funding for which was primarily through the 2002 Help America Vote Act. While Utah was primarily voting on these machines, several changes in Utah law had important bearing on the subsequent development of practices related to signature verification

and audits. For example, HB 63 (2007) laid the foundation for signature validation in the state of Utah but did so in the context of validating signatures on petitions rather than ballot envelopes. This adjustment prepared the state for broader signature validation process changes.

One of the most pivotal changes in Utah elections in the last twenty years is HB 172 (2012). This legislation authorized counties to administer elections entirely by mail at their discretion. In 2014, only a handful of Utah counties chose to conduct elections by mail, and the only option for by-mail voting for most Utahns was through an absentee voting process. However, over the next several election cycles additional counties in Utah chose to administer elections by-mail until the full state went to vote by mail in the 2020 election cycle. Legislation in 2021 extended the requirements to conduct all elections by mail to include municipal elections as well; most cities and towns currently contract with their county clerks for election services.

2012 had another particularly significant piece of legislation, HB 339, which required county election officials to notify a voter if the voter's absentee ballot was rejected and supply the reason why. Prior to this time, a voter could have their vote disqualified by an election judge (for example, due to a mismatched signature) but never be made aware of the fact that their vote had not been counted. This was an important step in election transparency and also laid the foundation for a robust process by which voters can "cure" their ballot if the signature doesn't match.

A pilot election-day registration system was created in 2015 with the passage of HB 220. This allowed eligible individuals to register to vote on Election Day subject to certain requirements.

Perhaps the most substantial changes in election law have come in just the last two years. In 2022, HB 313 made a large number of improvements to election security. HB 313 also granted rule-making authority to the Director of Elections for purposes of ballot security, ballot processing, and counting of votes. This formal authority has allowed the statewide elections office to issue rules based on best practices in elections and to nimbly adapt to innovations in election security. HB 37 in 2023 strengthened the signature verification process primarily through delegation of rule-making authority to the Lieutenant Governor's Office. HB 448, which also passed in 2023, clarified the standing of the Lieutenant Governor's Office in oversight of elections, making their legal role clear and enshrining the requirements for election audits in law (while they had previously been conducted on the basis of executive direction).

Practices in Ballot Storage and Signature Verification

Security of Ballot Storage

In Utah's current election administration process, most ballots are mailed in or deposited in ballot drop boxes. Through our interviews with clerks, we found strong and sound practices in place across Utah in terms of ballot processing. Consistent with the recommendations of Cann, Hall, and Monson's (2014) report from a 3-university consortium of researchers to the Utah Lieutenant Governor's Office, we applaud the use of surveillance

cameras in election areas as required by HB 448 (2023), a log on entry and exit to the areas where ballots are stored, an alarm system, fire security for ballot storage areas (e.g. sprinklers or fire boxes), and protection against water damage for ballots (e.g. if the sprinklers went off). Several clerks indicated that space was a constraint, while other clerks had been able to find funds to expand their space or utilize temporary spaces during the election cycle. In terms of progress on implementation on these matters, we find that many counties have such protections in place. Still, in spite of offers of funding from the state elections office, a few counties still either do not use fire-protective storage safes (though sprinklers may be in place) and/or do not use plastic storage boxes to protect ballots from water.

Ballot storage and security practices still vary considerably across counties. At times we heard from clerks that funding is an issue, but in other instances the state elections office has already offered funding (e.g. for fireproof media safes and plastic storage totes) and implementation is the issue independent of funding. We recommend careful protection of the physical ballots on these fronts. In addition, the optical scan machines used in the state have the ability to capture digital images of the ballots (as well as a cast vote record [CVR] that tells what votes the machine recorded). These digital records require provisions for secure storage in terms of who has access to them and how those digital storage systems are protected from threats like fire and water damage.

Recommendation 1: State and county election administrators should review the recommendations of the 2014 report from Cann, Hall, and Monson in terms of ballot security to ensure that counties optimize practices, taking advantage of available funding to protect both paper and digital voting records securely. We recommend more uniformity on implementation of these practices.

Practices in “Batching” of Ballots

Utah law requires ballots to be put in batches which are logged and tracked. Prior to the advent of widespread by-mail voting, ballots were typically organized by geographic precinct, with mailed ballots handled separately. Because more than 90 percent of Utahns now vote by mail and those who vote in person typically do so at larger vote centers rather than in neighborhood precincts, sorting ballots by precinct is impractical. Instead, ballots are typically assembled in smaller groups called “batches” as they arrive in the county system. Ballots remain with the same batch throughout the counting process and even into longer-term storage known as ballot retention.

At present, there is no state-wide standard for the number of ballots that would be in a batch. In our conversations with county officials, we found that larger counties with larger numbers of vote totals generally use larger batches, with the most sizable counties using a target batch size of about 200 or 250 ballots. The smallest counties use batch sizes as small as 20-25 ballots. Given the unique needs of each county in managing elections, allowing for variation in ballot size serves a reasonable purpose.

Recommendation 2: At present, we recommend no change to the standard batch sizes currently used by counties unless a clear justification can be identified for adopting a statewide standard.

Signature Verification

Voter verification is a critical component of any election system. It is important to know that the individual casting the ballot is indeed the same individual legally registered to vote. Voter verification is done at the time of registration, and with in-person voting voters are re-verified at the polling place by requiring voters to show identification. For mail-in ballots, voter reverification happens by verifying the signature on the ballot envelope. The signature is usually placed on the outside of a ballot envelope where it can be verified before the envelope is opened and the ballot separated from the signature, thus protecting the secret ballot. This is the case in Utah, where only after a signature is properly verified can the actual ballot be separated and counted.

There are several components to a successful signature verification process. The first is gathering reference signatures—signatures that are known to have been produced by a particular voter against which signatures on ballots can be judged. The second is having strong mechanisms and processes for reliably comparing the signatures.

In Utah, reference signatures presently can come from a variety of sources. The VISTA system for the state of Utah stores up to 5 signatures on file for each voter. From our interviews with clerks, we find that only 1-3 signatures are in the system for most voters. Most of the reference signatures are gathered at the time of registration, often occurring when a driver's license is gained or renewed. This is a commendable practice because at the point of registration the state is already verifying that the voter is who they say they are. However, citizens can have different styles and types of signatures used in different situations, which makes it desirable to have multiple verified signatures on file for voters. Research by forensic handwriting specialists finds that there are modest differences between signatures captured digitally versus those captured as pen on paper (which can subsequently be digitized), but that such variations tend to be within the normal bounds of signature-to-signature variation (cite). Those authors note, though, that the quality of the digital signature capture device is important. It is particularly inadvisable to gather signatures that are traced with a finger digitally rather than with a stylus as there is clear evidence that digital handwriting differs significantly when no pen or pen-like writing implement is used (Prattichizzo et al., 2015). Several election administrators in Utah observed that reference signatures gathered on electronic pads as part of the driver license process were not always of the same quality as other signatures in the file.

We commend the state's initiative in HB 448 to study ways to improve the electronic capture of signatures at Driver License Division offices.¹ We recommend capturing additional

¹ One idea to consider here is a model used in Texas
([https://texreg.sos.state.tx.us/public/regviewer\\$ext.RegPage?sl=R&app=1&p_dir=&p_rloc=284065&p_tloc=&p_pl](https://texreg.sos.state.tx.us/public/regviewer$ext.RegPage?sl=R&app=1&p_dir=&p_rloc=284065&p_tloc=&p_pl))

valid signatures during the election process and updating them as possible, especially for voters who are contacted after a possible signature mismatch is detected but who prove their identity and provide an updated signature. Many counties have this in place as a custom of practice, but it strikes us as particularly important to update signatures and we would hope for this practice to become universal. While it is not an immediate necessity, in the longer term we recommend increasing the number of available signatures stored in the state's VISTA software to accommodate a larger number of valid reference signatures for voters and finding ways to increase the number of valid and reliable reference signatures. This could include sharing signatures between state agencies or through capture in all voting contexts.

When performed at the highest standard, signature verification must be more than a simple comparison of general style and appearance. There are a number of things to look for, including proportions of letters, slants, pen lifts, spacing, and more. Washington and Arizona have both developed particularly robust verification and training processes. Washington (WAC 434-250-120) requires that all election personnel engaged in signature verification must receive training. This includes a course on signature verification from the Fraud Unit of the Washington State Patrol. Although the exact content of the training is not specified, WAC 434-379-020 specifies the characteristics that should be evaluated in statute. These characteristics include whether the signature is handwritten, similarity in style and general appearance, proportions of individual letters, irregular spacing, slants, and sizes of letters, and agreement of the most distinctive traits of the signatures. Arizona requires all election officials who participate in signature verification to undergo training provided through their Secretary of State as well, based on a document prepared by the office for that purpose. (For example, see https://azsos.gov/sites/default/files/AZSOS_Signature_Verification_Guide.pdf).

Until recently, the State of Utah had relatively few requirements for signature verification training. However, HB 37 (2023) granted rulemaking authority to the Lieutenant Governor's Office to create signature verification training standards. In a commendably swift action, the Lieutenant Governor's Office developed a 30-minute video training module. While we applaud the training developed by the Lieutenant Governor's Office, we recommend more robust training. We would specifically recommend consulting the Arizona Secretary of State's Guide noted above as one possible source of information on this front in addition to a wide range of other options available in the growing field of forensic signature analysis. We anticipate that a more robust training period would require a timeframe of 2-4 hours of training for all workers involved in signature analysis. We also recommend that this training include not only signature verification basics, but also applied experience in reviewing actual signatures and perhaps even passing an assessment of basic skills. Finally, we recommend pairing a newly trained signature verifier with an experienced signature verifier for some predetermined number of signature reviews before completing verifications independently, a practice already

oc=&pg=1&p_reg=284065&ti=1&pt=4&ch=81&rl=58&issue=03/14/2014&z_chk=), where voters must be shown a copy of their signature and then be allowed to accept it or reject it and sign again. We would also recommend at this point a reminder that the quality of their signature is important as it may be used as a reference for future signatures they give to the state in voting.

used in several of the counties we spoke with. When implementing this training, the Lieutenant Governor’s Office should consider accessibility challenges related to in-person training for smaller and more remote counties; several of the smaller counties where we performed interviews stressed their appreciation for a webinar or video-based method of delivery where they can make excellent content available to their election workers without incurring the sizable costs of time and travel to obtain training.

Our interviews with county election administrators reveal that some counties in Utah rely solely on the training provided by the state. Several counties, though, have taken the initiative to seek out and provide additional training. We applaud counties and organizations supporting county officials (such as the Utah Association of Counties) in their efforts to provide additional training as consistent with applicable laws, regulation, and best practices.

There are four classes of outcomes from a signature verification based on whether the ballot was counted or not and whether the ballot was actually signed by the specific voter. The layout of these variables and the meanings of the combination of these scenarios are arrayed in Table 1.

Table 1: Types of Accuracies or Errors in Signature Verification

		Ballot was truly signed by the voter	
		Yes, should have been counted	No, should not have been counted
Disposition of the ballot for counting	Was actually counted	Correct Outcome, no error, ballot is counted	Type 1 error: An ineligible ballot was counted
	Was not actually counted	Type 2 error: An eligible ballot was not counted.	Correct Outcome, no error, ballot is not counted

From our interviews with county clerks, all evidence points to an overwhelming majority of ballots submitted falling into the upper-left cell of Table 1, with about 99% of ballots being verified as having a matching signature and being counted. The rates of Type 1 and Type 2 error can vary based on the stringency of a county’s signature verification policy. Policies that impose more stringent criteria for matches will generate more Type 2 errors (as slight and natural variations in signatures could result in ballots being uncounted) but fewer Type 1 errors (as any effort for someone other than the intended signatory to sign a ballot will be detected). Conversely, policies that use less stringent criteria for signature matching will generate more Type 1 error and less Type 2 error. As we interviewed clerks across counties in Utah, we found a strong preference for applying more stringent strategies because Type 2 errors can subsequently be clarified by contacting the voter. Utah counties do not separate the ballot from the envelope until after signature adjudication is complete; this is imperative because it preserves the secrecy of the ballot. Using the identifying information on the outside of the envelope the voter can be contacted to “cure” their ballot. Every county we spoke with

provides a cure process (as required by law). However, there is variation across counties on the specific cure processes they employ.

These processes are distinguished by the method of contact from the clerk's office and the methods by which voters can cure the ballot. Methods of contact used at present include a physical letter sent through postal mail, an e-mail, and/or a phone call. We observed counties that use only one of these methods for each voter, while others use two or even all three for each voter. Under HB 448 (2023), it is legal to use only one of these methods. However, given that the cure process is a vital part of protecting the right to vote, we recommend that counties employ multiple methods of contact to notify voters that their signature does not match. There are several reasons for this. First and foremost, every legitimately cast vote should be counted. Second, the cure process is a way to gather information about fraudulent voting should it occur. Finally, it is an opportunity to educate voters on how the signature verification process works and what the legal parameters are for signing ballots. We do not yet have systematic state-wide data on the number of general election ballots that go into the curing process, but the clerks we spoke with estimated an average of about 1% that yield unmatched signatures. The systematic data generated pursuant to the requirements of HB 37 will give a clearer portrait, but this is an important figure to monitor. We note that the Lieutenant Governor's office is already compiling this for the 2023 primary election.

Disappointingly, the clerks reported a rough average of only 40-60% of voters respond to the cure letter they receive (with significant variation in this figure across counties). Of those who respond, there are a number of commonalities. First, there is anecdotal evidence that some of these individuals had a physical impairment (e.g., a broken arm) that affected their signature. Other variations can be attributed to the effects of age or progressive disease that alter signatures. Nonetheless, many are enthusiastic about curing their ballots. If there is a factor that results in permanent alteration of an individuals' signature, we recommend that clerks scan the new signature that comes in with the ballot cure letter so that an updated signature is on file. Language for the cure letter specified in code (20A-3a-401) already indicates to voters that clerks may do so. Clerks are trained by the Lieutenant Governor's office to complete this practice and we recommend a focus on uniform implementation. There are several reasons why someone may not cure their ballot. Perhaps foremost among them is voters choose not to cure their ballots because preliminary results of the election are already known, and voters do not believe that their votes will make a difference in the outcome of the election. For this reason, we recommend that invitations to cure ballots include a note that curing their ballot in this election is key to having a good reference signature on file for future elections. Another common reason that voters may choose not to cure -or cannot cure - their signature is because a family member signed on behalf of the voter; this is illegal, but not uncommon among families of young people serving in the military or on church missions.

We note that good practices in signature verification can be very helpful in reducing both Type 1 and Type 2 error as we discussed above. However, there is some amount of tradeoff between the two types of error. Overly stringent standards for signature verification could result in rightly cast votes being thrown out, while insufficient scrutiny could result in

inappropriately cast votes being counted. Careful policies can help minimize both types of error. However, we found that many counties, particularly in the initial stages of review, apply some version of a clever couplet, “When in doubt, kick it out.” It is important to note that in this phrase, “kick it out” means to flag it for further consideration, not to immediately end consideration of the signature. It means that if (particularly in early stages of review) a signature verifier has doubt about whether a signature matches, they flag it for further review and more careful comparison. We see wisdom in this practice based on this logic: If a signature is determined to be valid, the ballot will be counted, and no further action is taken. As a result, there is no additional verification or remedy for a Type 1 error once the signature is adjudicated. In contrast, if a Type 2 error is a possibility (because a signature is not determined to be valid), the voter can be contacted in an additional effort to validate the ballot. In essence, a Type 2 error can be fixed by verifying the signature with the voter while a Type 1 error cannot. There is certainly a point where this logic could be taken too far, but when practiced as described to us by clerks, this policy functions well. Upon further review, signature verifiers can consider not on the “primary” signature on file, but all signatures on file for the voter in the state’s VISTA database. This step is able to verify the vast majority of questioned signatures. However, if uncertainty remains upon further review, the voter can be contacted and asked to verify their signature and have their vote counted. This approach gives an ideal balance of strong protection against counting votes that shouldn’t be counted while ensuring that legitimate voters have every opportunity to have their ballots counted. Based on our interviews with clerks, we estimate that on average only about 1% of ballots are flagged to go through the cure process, though there is some variation across counties on this.

Several Utah counties mechanize a portion of the signature verification process. The two machines used in Utah are the Mail Ballot Verifier (MBV) from Election Systems & Software (ES&S) and the Agilis Election Mail Sorting & Processing System from Runbeck Election Services (RES). These machines scan and create high resolution ballot images and can process up to 18,000 ballots per hour. The machines then place the scanned signature images on a screen beside a reference image from VISTA to facilitate easy comparison of the signatures by a trained human election judge. Because of their large size and rapid processing capabilities, these machines are most practical in larger counties where the volume of ballots to process merits automated assistance. It would be impractical to utilize these machines in smaller counties given their size and the relatively small number of ballots these counties process, particularly given the cost of the machines.

The machines also have the ability to perform automated signature verification. The machines produce a score based on a user-set threshold (determined by county clerks) for how strictly to assess signatures. The automatic signature verification processes are good at quickly and accurately verifying signatures that closely match the reference signature from VISTA. We recommend that counties use stringent settings when utilizing automated signature verification to minimize Type 1 error. The signatures the machines are unable to verify are then reviewed by trained election staff. Clerks advised us that the state requires a two-tiered verification approach: when any ballot that was rejected in the first stage (whether by machine verification or by a human election judge) is rejected, a second evaluation must be made with comparisons

against all valid stored signatures in the VISTA system. While not required, some counties include a third level of review by the most experienced signature verifiers in the office. Both human and machine reviewed signatures are audited for accuracy.

While we have no evidence of characteristics beyond the signature itself being considered when determining a match, we note that California specifically prohibits reviewing or considering “a voter’s party preference, race, or ethnicity” when determining the validity of a signature (California Code of Regulations 2-7-8.3-20960). Wisely, the VISTA software used in Utah does not include information about any of these characteristics along with the signature being considered for validation.

Recommendation 3: The state should review the quality of signature capture devices at Driver License Division offices and other locations where signatures are captured digitally (a process already in motion from HB 448 (2023)). We further recommend implementing a practice where signers are prompted to review the signature for accuracy and given a chance to accept or reject their signature. This process should include a prompt indicating their signature may be used to verify the validity of their ballots in the future.

Recommendation 4: The state should consider increasing the number of signatures that can be stored in the VISTA system to hold more valid signatures from voters.

Recommendation 5: The state should expand its training, with remote counties in mind, on signature verification in terms of content and in terms of assessment to ensure new signature verifiers demonstrate their ability to independently and accurately verify signatures. We note that the Lieutenant Governor’s office is already in development of expanded training here.

Recommendation 6: Counties should make every effort to contact voters to notify them of the opportunity to cure their ballots; an ideal would be to contact voters by more than one means (mail, email, text, or phone) wherever possible. Giving voters a variety of ways to securely cure their ballot, including in person or online methods, is also desirable.

Recommendation 7: County clerks should accurately collect and report the important data required HB 448 (2023) regarding cure rates. The state should plan to review and analyze the data provided by counties and follow up with counties with unusually low cure rates.

Recommendation 8: We recommend that communications about curing ballots include an explanation for the voter that outlining future implications: a better signature on file for future elections in addition to having their vote added to preliminary election results.

Practices in Ballot Scanning and Processing

All counties that we spoke with confirmed that they use optical scan machines to count ballots. The scholarly literature affirms this practice, with repeated studies showing that machines count ballots more accurately than humans (e.g., Ansolabehere et al., 2018; Ansolabehere and Reeves, 2012). This is not to say that hand counts have no place—they are an important part of election audits. In these audits, Utah election officials review samples of ballots during the election to ensure that election equipment, staff, and systems all functioned

properly. In the audit context, hand counts function well, but a hand count of an entire election is a massive, complicated, and error-prone task.

One important element of election security is the pre-election logic and accuracy test. In this process, ballots are run through a machine prior to the actual election to ensure the machine is functioning properly, and ballots are counted properly. All counties in Utah are required to conduct a logic and accuracy test that is open to the public. We recommend that clerks continue to broadly promote the opportunity for members of the public. Such transparency enhances the legitimacy of election processes for those who observe the logic & accuracy test. It also enhances legitimacy as individuals see that election officials are willing to open their processes for observation.

Each county has at least two optical scan machines. If requirements are changed for machinery to have additional capabilities, it will be important to ensure that counties continue to have redundancies in machinery meeting that meets applicable standards.

Recommendation 9: The state should collect data on what ballot scanning machines are in use in each county. The state already has an inventory of machines in possession, but at the point of the post-election audit it may be helpful to indicate which machines were actually used.

Utah's Current Audit Practices: A Summary

Signature Audits

The State of Utah currently requires an audit of the signature verification process in the amount of 1% of all signatures. Utah signature audits were formerly performed at the end of the election near the time of the canvas. At that time, a sample of signatures that was certified as matching was reviewed. While helpful as an audit to review how well things went in signature verification, any issues found in signature verification were uncorrectable at this point because ballots had already been removed from envelopes and there was therefore no way to link a ballot to a voter and give an opportunity for a cure of an incorrectly disallowed ballot or for removal of an improperly allowed ballot from vote totals.

This process was recently changed to have the signature audit to take place as part of the workflow of the audit process. For each batch of ballots processed, 1% of signatures are flagged for an audit. These signatures are reviewed by a person who is trained but who did not participate in earlier review of signatures. We applaud the move of signature auditing to this earlier stage of the process so that in the event an error is detected it can be addressed.

This process strikes us as robust and well-implemented. Our only recommendation on this front has bearing on what action to take in the event that an issue is detected with a signature during this signature audit. We note this is a minor issue as the clerks we interviewed found

few, if any, errors in the signature audit. However, the state should consider what implications should ensue in the event of a different judgement being rendered on a ballot in a signature audit. One approach could be to simply correct the treatment of that particular ballot packet (e.g., diverting it to the cure process or removing it from the cure process). A more cautious approach would be to re-verify all signatures in the batch where the error was found to ensure that all signatures that had been subjected to the process found to fail in the audit were re-evaluated.

Post-Election Tabulation Audit

As per the Lieutenant Governor Office's direction, we reviewed Utah's current processes and practices in election audits. While some of the foregoing material interacts with Utah's processes already, a brief overview and assessment of current post-election audit practices is an important part of this report.

Two days after an election, county clerks are required to submit to the Lieutenant Governor's office a detailed summary of all batches of ballots processed, including an identifying number for each batch and the number of ballots in each batch. This level of detail is important for having a high degree of confidence that all ballots are accounted for. We note with interest, though, that additional ballots may arrive after this date. We would recommend that the Lieutenant Governor's office consider whether the number and volume of ballots arriving after this date warrants additional auditing beyond the post-election audit imposed by the 2-day timepoint. If the number of ballots is very small, such consideration may not be necessary. If the number is large, the state may consider moving the date of these reports back (though we note this comes with a tradeoff of allowing less time to complete the audit before the canvass).

The Lieutenant Governor's office randomly selects batches of ballots (or in the case of a few of the smallest counties, specific ranges of ballots) in the amount of 1% of ballots cast or 1,000 ballots, whichever is fewer.² We commend the Lieutenant Governor's office as the rightful place for these random selections to be made to ensure distance and independence between the individuals who conducted the election count and the individuals controlling audit procedures. Fifteen minutes before the appointed audit time, the Lieutenant Governor's Office notifies counties which batches are to be audited. This short timeline is a creative check as it leaves no time for a county election official to redistribute or shift ballots in such a way that they control the ballots that would ultimately be selected for audit. Only the batches of ballots that have been selected should be opened for review during the process. Once these batches of ballots have been opened, the audit staff begin the process of reviewing the ballots.

A quick word about audit staffing is in order. Optimal practices in independence of the audit would call for having individuals conduct the audit who were not part of the original vote

² The state recently imposed a 50-ballot minimum as the 1% figure in some of the smallest counties in the state could result in fewer than 10 ballots being audited. This is a welcome change.

counting process. At present, our understanding is that one member of the two-person audit team must be someone from outside the clerk's office, such as a member of the board of canvassers for the county. We applaud this practice, and, where feasible, would encourage raising that number to two. It is certainly helpful to have election counting staff available to assist with the audit, but independence of the audit team provides an extra layer of protection.

There are three election records that could be subject to comparison as part of the audit—the original physical ballot, the electronic scan of the ballot, and the cast vote record (CVR) that describes how the optical scan machine translated the ballot's markings into votes for particular candidates. Across the country, the most common practice (and we might add the most secure practice) is to compare all three of these records to make sure they are all consistent. The U.S. Election Assistance Commission (2020) points out that a number of jurisdictions in the U.S. save time by examining only the electronic scan of the ballot and the CVR, a process which is much faster and easier. While this process is simpler, it leaves the translation of paper ballots to electronic scans as an unaudited part of the process. While the risk involved may be modest, a higher level of assurance can be gained by including the physical ballots in the process.

The current audit policy holds that all three records should be compared (physical, electronic, and cast vote record). In our interviews with county clerks, we found that most Utah counties indeed compare all three records, though a few do not do so. However, being able to compare the paper ballot with the electronic scan and CVR with certainty requires having a ballot serial number to provide a definitive match between the paper and electronic records. Some counties piece this together by approximation using the order of the ballots (in both the scanned files and the ballot batches), but this process is not foolproof because ballot order in these files can be disrupted. Further checking for matches can be conducted by matching the format of the ballot (which varies across precincts), but it is inadvisable to match ballots across paper and electronic formats based on who votes were cast for because such patterns are the very thing being audited. The most certain way to perform this match is to print a serial number on each ballot that matches it to the electronic records (but again this number is not linked to a voter). We recommend this practice for a variety of reasons, including facilitating the matching of all three of these records. The lack of serial numbers was cited by at least one county clerk as a reason for reviewing only digital images. We recommend that state and county election administrators work toward a more unified implementation of existing policies that include evaluation of the paper ballot.

Recommendation 10: The state should indicate what action should be taken in the event that a signature audit finds a discrepancy (e.g., whether the just one ballot should be adjusted in terms of its disposition for counting or whether this should trigger a broader review of an entire batch or of a particular verifier's work).

Recommendation 11: The state should consider whether the current 2-day timing of the election audit is the best balance between auditing the maximum number of ballots and completing the audit in a timely way.

Recommendation 12: The state should consider whether all members of the audit team must be individuals who did not participate in the original processing of votes, pending a determination of the feasibility of such a requirement for counties.

Recommendation 13: We recommend printing a unique serial number on each ballot that connects it with electronic images of the same ballot and its CVR. It is imperative that this number not be linked to voter information. This recommendation should be gradually implemented with appropriate precautions for protecting the ballot and for handling ballots that must be scanned more than once due to paper jams or related issues.

Recommendation 14: County clerks should improve their audit processes to promote better implementation of current rules regarding comparison of paper ballots, the scanned ballot, and the CVR.

National Practices in Post-Election Audits

Most states conduct some type of post-election audit. The purposes accomplished by each audit depend on the type of audit performed. Audit types also vary in cost, resources required, time to complete, and, of course, method.

Traditional Tabulation Audit

The most common approach to a post-election audit is known as a tabulation audit (or sometimes a “traditional” post-election audit). This is the approach used in Utah as previously described. In this type of audit, election officials look at a fixed percentage of ballots cast or voting machines to compare the paper ballots (or in states that use direct-recording voting machines, the paper trail produced by those machines). Sampling of ballots is usually done in clusters of ballots, such as by batches in vote-by-mail states or by machine or voting district in other states. The purpose of a post-election tabulation audit is to ensure that the results of the election are accurate by ensuring that the equipment used in the election process functioned properly and accurately. These audits are based on actual ballots cast in the election, which gives an elevated level of protection. However, they can be accomplished with a relatively small and fixed number of ballots since verifying the functionality of the equipment does not require a large sample. Because the selection of ballots is random at the cluster level (and ideally the random selection of ballot clusters is selected by someone other than the local election official), there is protection against the audit being based on ballots known in advance to be confirmable. Note that with the small numbers of ballot clusters selected, though, the results of a post-election audit are not intended to be precisely representative of an election outcome. Thirty-five states in the U.S., including the state of Utah, conduct a post-election tabulation audit. Two additional states (Michigan and Oklahoma) allow counties to conduct such audits if they wish, but do not require it (National Conference of State Legislatures 2022).

Risk-Limiting Audit

Three states currently require a different approach to post-election audits known as a risk-limiting audit (RLA). Eight more states have pilot projects in progress and four allow it as an audit option at local discretion. Two practices distinguish this approach from a traditional

the ballot comparison method to be successful, each ballot must be individually compared with the cast vote record (CVR, an electronic record generated by optical scan ballot machines). This approach requires each ballot to be marked with a serial number that corresponds to a tracking number automatically generated for each ballot image. It is essential to note that this number is not linked or associated with a voter in any way so the secret ballot is preserved (we note that at least one county clerk expressed reservations that such an imprint could compromise the secret ballot and appropriate procedures would be key to preventing such a problem). In our interviews with clerks, we found that most (but not all) of the counties we spoke with have equipment that is capable of printing a serial number on a ballot. In some counties it would require a simple add-on to enable their equipment to do this. Several counties already apply such a serial number to a ballot but others do not. The parameter of focus here is the match rate between the paper ballots and the physical ballots, which is very, very high. As a result, there is generally a smaller number of ballots required for this approach to achieve a high degree of confidence. Indeed, the ballot comparison approach will often require fewer ballots to execute than a traditional tabulation audit, offsetting to some extent the extra time and effort that go into drawing the random sample of ballots. Even in a reasonably competitive election, a risk-limiting audit can be carried out with a 5% risk limit with only several hundred ballots randomly selected. Another advantage of this approach is that any errors found can be corrected as the physical ballot and cast vote record can be directly aligned.

An alternative approach to the ballot comparison is the ballot polling approach. The ballot polling approach similarly requires a random sample of ballots (and therefore requires a ballot manifest and similar precise tracking and management of ballots). However, this approach compares the percentages from the original full count of the election with a recount of a random sample of ballots. In this approach, thousands of ballots may need to be reviewed in order to achieve the specified risk limit. However, because this approach does not require a serial number to be imprinted on the ballot (as no match to the cast vote record is required), it can be conducted with virtually any type of election equipment. The time (and therefore cost) involved with this approach is more substantial. However, because ballots polled are not directly linked to a cast vote record, there is no opportunity to identify a ballot as an “error” in need of correction.

It is also possible to conduct a risk limiting audit by selecting batches of ballots at random rather than individual ballots. However, when ballots are selected in clusters rather than individually, it takes a very sizeable number of batches to get a representative sample. As a result, this approach can result in recounting tens of thousands of ballots. As with ballot polling, the batch polling approach affords no opportunity to detect errors and correct them.

Statistical software makes the calculation of the necessary figures and the recording of data in the course of a risk-limiting audit much simpler and more straightforward. Further, it can be used as states develop and optimize their selection among these options. It is important to note that the mathematics behind risk-limiting audits becomes very complex in the context of ranked choice voting (RCV) elections. Not all RCV election types, especially multiple-winner RCV elections as applied in the Utah municipal context, are compatible with *any* existing

software in use for RLAs in the United States. While some solutions are under development, it would not currently be feasible to audit Utah's RCV municipal elections using RLA methods as of this writing. We recommend keeping a close eye on developments in technology, but if RLA approaches were adopted in Utah, it would be essential to allow some alternative post-election audit for those races where RCV is being employed.

Our initial impression is that all forms of risk-limiting audits involve a substantial addition in terms of the complexity of audit processes. Indeed, every clerk we spoke with expressed the belief that they *could* perform a risk-limiting audit if asked to do so, but that it would lead to significant increases in cost and additional time to complete the audit. As such, making changes to Utah's audit system is possible, but would require great planning and care, as well as additional funding. In considering risk limiting audits, the state would need to carefully weigh whether any benefits from doing so would outweigh the costs. If the state of Utah were to move to adopt risk limiting audits, a deliberate and gradual approach would be essential to successful implementation. We wish to be clear that we are not making a formal recommendation to adopt or not adopt a risk-limiting audit approach in Utah. However, in the event that policymakers in Utah opt to allow for risk limiting audits, the process should proceed as follows:

- Extend a request for public demonstrations of software capabilities to a variety of vendors who have software with RLA capabilities. We strongly recommend the participation of both the Lieutenant Governor and county clerks in this process to ascertain compatibility with current systems and practices as none of the clerks we interviewed were aware of any compatibility (or lack thereof) with their current machinery and software. The state can make a determination from there about which software options meet their expectations for security and accuracy.
- The transition to RLA should be gradual and implemented over time. The state of Colorado, which made a careful and orderly transition to use of risk-limiting audits, initially began investigating RLAs in 2009. This was followed by study, several years of pilots within single counties and ongoing discussions about what reasons the state was interested in RLAs, and finally statewide RLA implementation in 2017. A shift this significant and profound is a major undertaking, and a mistake in audit procedures could lead to less confidence in a new audit approach rather than more. A careful, gradual, and reasoned transition offers the best promise to learn about RLAs by experience for Utah's elected officials and voters with several steps along the way to determine whether it is the right policy choice. We would recommend that if the state wishes to adopt RLAs (or even just learn more about them on a trial basis), it would be wise to begin with a pilot effort in 1-3 counties. From our interviews with clerks, we believe that one or more volunteers would come forward. An additional reason for a careful transition is that the costs of using risk-limiting audits are unclear. All county clerks we met with felt like there would be additional costs in terms of staff time. A basic amount of funding (the precise size of which would depend on the size of county volunteering) would be essential in supporting counties exploring such changes.

- For initial efforts at risk-limiting audits, a lower risk limit should be used at first to accommodate the transition. All three states that have ongoing requirements for statewide RLA began at a 10% risk limit (90% confidence). Rhode Island and Virginia continue to use a 10% risk limit, while Colorado (after refining processes and improving capacity) has moved to a 3% risk limit. We found no state with a more stringent limit than Colorado but no state with a more relaxed limit than 10%. We recommend establishing this limit through a rule-making process such that changes can be easily and nimbly made consistent with improvements in practices, refinements in available software, and local needs without an act of the full legislature.
- Carefully assess the interaction between RLA approaches and RCV in municipal elections to be sure that RCV elections can still have a robust post-election audit of some form.
- Carefully study and develop a plan for selecting which races would be subject to RLAs. In most states using RLAs on a full statewide basis, this usually means selecting one statewide race and at least one race in each county. Auditing all races on a ballot with an RLA becomes burdensome (a tradeoff with traditional tabulation audits that can look more easily at all races on a given ballot).

Post-Election Logic & Accuracy Tests

While there has been growth in the application of both traditional post-election audits and, in recent years, risk-limiting audits, some states take a simpler approach and focus instead on a basic repeat of the logic & accuracy test typically performed at a pre-election stage. Recall from our earlier discussion of pre-election logic & accuracy testing that such a test is performed not on actual ballots but rather on a test stack of ballots. Repeating this test after an election is perhaps the simplest approach to evaluating the functionality of equipment. However, it also provides no check on any ballots cast in the election, and therefore provides a lower degree of check on the integrity of the election. While this is a method in use in a few states in the U.S., we see it as a post-election audit approach that provides less security than Utah's current post-election audit and recommend against it.

What Course Should Utah Pursue on Post-Election Audits?

We have made a number of recommendations throughout this report. We recommend against an immediate state-wide implementation of risk limiting audits. While we make no formal recommendation in favor or against the overall RLA framework, we invite election stakeholders (including the legislature, the Lieutenant Governor's office, and election administrators across the state) to consider the pros and cons of such a system, and if they are interested in risk limiting audits, to allow for an optional program that, after experience is developed with the system in a Utah context, could be further considered for expansion. We share a few considerations that we invite legislators to weigh as they consider this course.

- Few states remain that have not developed some type of robust post-election audit practices. Utah has a history of performing such audits going back some years; in recent years Utah has strengthened its processes through policy changes made by the Lieutenant Governor, legislation and rule-making. Recommend against stepping away

from the progress Utah has made in this area. This includes a recommendation against stepping back to the use of only a post-election logic and accuracy test in lieu of the formal tabulation audit currently in place.

- In our assessment, the most difficult choice lies in selecting between a traditional post-election tabulation audit and a risk-limiting audit. If the goal is to evaluate a sample of actual ballots and assess the accuracy and effectiveness of the equipment in counting ballots, this goal is well met with current election audit practices. This can be done oftentimes more efficiently with a basic post-tabulation audit of the sort Utah already performs. The combination of careful signature verification, assessment of machine performance, and the review of actual ballots provides formidable protections and assurances against fraud. The only major difference between this type of audit and a risk-limiting audit is the random selection of individual ballots.⁴ It also easily allows for the auditing of every race on a ballot rather than one (or a few) selected races. On that basis, one reasonable course could be to simply strengthen and refine Utah's existing tabulation audit per the recommendations included throughout this report. If the state were to pursue this direction, it would be important to engage in significant public outreach to explain the goals and purposes of a tabulation audit. However, the extra effort of drawing a random sample of ballots does allow for one benefit that a traditional tabulation audit cannot provide—the ability to make a specific statistical statement about the level of risk that an election was incorrectly decided. While only 3 states have enacted ongoing state-wide use of RLAs, a dozen additional states have either adopted pilot programs or allow counties the option to use them if they wish. We anticipate that the use of risk limiting audits among states is likely to continue growing.
- One stated reason given for adopting risk-limiting audits is to increase public confidence in the integrity of election results, but we do not have any specific evidence that the adoption would increase public confidence. The complexity of the risk-limiting audit framework, the need to still rely on election workers and mechanized systems could mean that individuals who express skepticism over traditional election audits may well be equally skeptical of risk-limiting audits. We have a survey in process to help provide insight into this very question.
- In addition to being concerned about whether RLAs help voters to have more confidence in the election system, it is important for incumbent elected officials and candidates to also have a high degree of confidence in the integrity of the election system. We suspect that even a state with excellent post-election audit processes would struggle to maintain its legitimacy if the elected officials and candidates in that state were consistently critical of it. As a result, if legislators and elections staff themselves would feel more confident Utah's election system with risk-limiting audits, that alone might be reason to investigate making changes.

⁴ We note with interest that the Utah Lieutenant Governor's Office now randomly selects batches of ballots for auditing as part of their post-election audit. This moves their current approach to something akin to the batch polling RLA approach. However, the number of batches randomly selected in each county is not sufficiently large to carry out a true batch polling RLA, though it may be close to enough to complete a statewide batch polling RLA.

Recommendation 15: We recommend that election stakeholders carefully consider the pros and cons of Utah’s current system, which is strong, and of risk-limiting audits as a reasonable alternative. While we leave that decision to said stakeholders, if the state opts to allow RLA, we recommend a gradual approach, similar to the state’s approach to by-mail voting, that allows a few jurisdictions to opt-in and develop expertise through a pilot project, consistent with the guidance we’ve given here on pages 19-21 for a successful adaptation of such an approach.

Preview of Survey of Utah Voters

The final part of our investigation into post-election audits is a survey of Utah residents to assess their reactions to varied options in election procedures, including post-election audits. The integrity of Utah’s election system continues to be a matter of concern to a variety of stakeholders in the state. While confidence in Utah’s election system is high (Dunphey 2022; Carter et al. 2023), it remains a matter of great importance to understand what facets of the election system can most influence citizens’ perceptions of election integrity.

To address this, we have designed a conjoint survey experiment. This approach, increasingly applied in market research, allows us to assess which factors in election administration have the greatest effect on voter confidence. We have developed a sampling strategy to draw a probability sample of likely voters in Utah elections that we anticipate will yield a sample of approximately 600 respondents. We will ask each respondent to evaluate several pairs of election system choices and ask us to tell us in each instance which type of election system would give them the greatest degree of confidence that their vote would be counted as they intended. Using plain language that describes basic options (rather than technical terms that are not accessible to the general public) we assess how individuals react to a variety of election system features, including different approaches to post-election audits, signature verification, status updates on their ballots, and more.

We will submit our findings from that survey to the Lieutenant Governor’s office as soon as they are available in the form of an addendum to this report.

Conclusion

Elections are fundamental to good governance. They are the mechanism through which the will of the people is expressed in our system. As such, it is imperative that votes be counted properly as they were intended by the voter. While our research finds no evidence of large-scale election fraud or major security worries in the current system, it is always possible to improve and refine a system. A constant improvement mentality is essential and is a key part to helping maintain the confidence of voters in our election system.

Utah has a long and successful history of effective election administration, and a tradition that we hope will continue as stakeholders and decisionmakers continue to strive to maintain and improve Utah's election systems.

Summary of Recommendations

Recommendation 1: State and county election administrators should review the recommendations of the 2014 report from Cann, Hall, and Monson in terms of ballot security to ensure that counties optimize practices, taking advantage of available funding to protect both paper and digital voting records securely. We recommend more uniformity on implementation of these practices.

Recommendation 2: At present, we recommend no change to the standard batch sizes currently used by counties unless a clear justification can be identified for adopting a statewide standard.

Recommendation 3: The state should review the quality of signature capture devices at Driver License Division offices and other locations where signatures are captured digitally (a process already in motion from HB 448 (2023)). We further recommend implementing a practice where signers are prompted to review the signature for accuracy and given a chance to accept or reject their signature. This process should include a prompt indicating their signature may be used to verify the validity of their ballots in the future.

Recommendation 4: The state should consider increasing the number of signatures that can be stored in the VISTA system to hold more valid signatures from voters.

Recommendation 5: The state should expand its training, with remote counties in mind, on signature verification in terms of content and in terms of assessment to ensure new signature verifiers demonstrate their ability to independently and accurately verify signatures. We note that the Lieutenant Governor's office is already in development of expanded training here.

Recommendation 6: Counties should make every effort to contact voters to notify them of the opportunity to cure their ballots; an ideal would be to contact voters by more than one means (mail, email, text, or phone) wherever possible. Giving voters a variety of ways to securely cure their ballot, including in person or online methods, is also desirable.

Recommendation 7: County clerks should accurately collect and report the important data required HB 448 (2023) regarding cure rates. The state should plan to review and analyze the data provided by counties and follow up with counties with unusually low cure rates.

Recommendation 8: We recommend that communications about curing ballots include an explanation for the voter that outlining future implications: a better signature on file for future elections in addition to having their vote added to preliminary election results.

Recommendation 9: The state should collect data on what ballot scanning machines are in use in each county. The state already has an inventory of machines in possession, but at the point of the post-election audit it may be helpful to indicate which machines were actually used.

Recommendation 10: The state should indicate what action should be taken in the event that a signature audit finds a discrepancy (e.g. whether the just one ballot should be adjusted in terms of its disposition for counting or whether this should trigger a broader review of an entire batch).

Recommendation 11: The state should consider whether the current 2-day timing of the election audit is the best balance between auditing the maximum number of ballots and completing the audit in a timely way.

Recommendation 12: The state should consider whether all members of the audit team must be individuals who did not participate in the original processing of votes, pending a determination of the feasibility of such a requirement for counties.

Recommendation 13: We recommend printing a unique serial number on each ballot that connects it with electronic images of the same ballot and its CVR. It is imperative that this number not be linked to voter information. This recommendation should be gradually implemented with appropriate precautions for protecting the ballot and for handling ballots that must be scanned more than once due to paper jams or related issues.

Recommendation 14: County clerks should improve their audit processes to promote better implementation of current rules regarding comparison of paper ballots, the scanned ballot, and the CVR.

Recommendation 15: We recommend that election stakeholders carefully consider the pros and cons of Utah's current system, which is strong, and of risk-limiting audits as a reasonable alternative. While we leave that decision to said stakeholders, if the state opts to allow RLA, we recommend a gradual approach, similar to the state's approach to by-mail voting, that allows a few jurisdictions to opt-in and develop expertise through a pilot project, consistent with the guidance we've given here on pages 19-21 for a successful adaptation of such an approach.

References

- Ansolabehere, Stephen, Barry C. Burden, Kenneth R. Mayer, and Charles Stewart III. 2018. "Learning from Recounts." *Election Law Journal* 17(2): 100-116.
- Ansolabehere, Stephen, and Andrew Reeves. 2012. "Using Recounts to Measure Accuracy of Vote Tabulations: Evidence from New Hampshire Elections 1946-2002." Chapter 12 in *Confirming Elections: Creating Confidence and Integrity Through Election Auditing*, R. Michael Alvarez, Lonna Rae Atkeson, and Thad E. Hall. Palgrave MacMillan: New York.
- Cann, Damon M., Thad Hall, and Quin Monson. 2014. *Evaluating the Feasibility of Vote-by-Mail in Utah*. Report to the Utah Lieutenant Governor's Office, October 1, 2014.
- Carter, Luke, Ashlan Gruwell, J. Quin Monson and Kelly D. Patterson. 2023. "From Confidence to Convenience: Changes in Voting Systems, Donald Trump, and Voter Confidence " Unpublished paper. Brigham Young University.
- Dunphey, Kyle. 2022. "Poll: Are Utahns confident their government conducted a fair and accurate election?" *Deseret News*, 7 December, <https://www.deseret.com/utah/2022/12/7/23494610/deseret-news-poll-do-utah-voters-trust-2022-midterm-election>.
- Heckerroth, J., E. Kupferschmid, T. Dziedzic, N. Kalantzis, B. Geistová Čakovská, C. Fernandes, M.J. Branco, K. Axelsson Spjuth, A. Kerkhoff, P. Vaccarone, J. Zimmer, and P. Schmidt. 2015. "Features of digitally captured signatures vs. pen and paper signatures: Similar or completely different?" *Forensic Science International* 318: 110587.
- Lindeman, Mark, and Philip B. Stark. M. Lindeman and P. B. Stark, "A Gentle Introduction to Risk-Limiting Audits." *IEEE Security & Privacy* 10(5): 42-49.
- Prattichizzo, Domenico, Leonardo Meli, and Monica Malvezzi. 2015. "Digital Handwriting with a Finger or a Stylus: A Biomechanical Comparison." *IEEE Transactions on Haptics* 8 (4): 356-370.
- National Conference of State Legislatures. 2022. "Post Election Audits." Report available online at <<https://www.ncsl.org/elections-and-campaigns/post-election-audits>>.
- National Conference of State Legislatures. 2022b. "Risk-Limiting Audits." Report available online at <<https://www.ncsl.org/elections-and-campaigns/risk-limiting-audits>>.
- U.S. Election Assistance Commission. 2020. "Post-Election Audits." Report available online at <https://www.eac.gov/sites/default/files/electionofficials/postelection/Post_Election_Tabulation_Audits.pdf>.