Microsoft

End-to-End Verifiability in Real-World Elections

A report on the use of ElectionGuard and Hart InterCivic's Verity precinct-scan voting system in the Franklin County, Idaho 2022 General Election

HART intercivic

MITRE

Center for Civic Design

Enhanced Voting

InfernoRed TECHNOLOGY

Oxide

January 2023

Table of Contents

Foreword

On November 8, 2022, Franklin County, Idaho offered voters in a district in Preston, Idaho the choice of using Hart InterCivic's Verity scanner integrated with Microsoft's ElectionGuard open-source software to cast their ballot instead of simply submitting their ballot into a traditional ballot box.

This pilot of an independently verified election (what the Election Assistance Commission's Voluntary Voting System Guidelines 2.0 Requirements refer to as a Cryptographic End to End Verifiable System Architecture) was one of the first opportunities to see how this technology works in a real election, with voters casting ballots at their polling place in the 2022 General Election.

Microsoft is proud of this investment in ElectionGuard, demonstrating its value in promoting transparency and verifiability of election results to increase confidence in U.S. elections at a time when their fundamental administration is being called into question.

Microsoft would like to thank the Franklin County Clerk and the Idaho Secretary of State's Office for the opportunity to use it in a real-world election while remaining true to legal and procedural requirements. We owe a debt of gratitude to Franklin County Clerk Camille Larsen, Deputy Clerk over Elections Cessilee Carter, and the wonderful poll workers and voters of Preston, Idaho for their faith and support of our effort. We would also like to thank EAC Commissioner Hovland for attending and observing the election.

The team itself modeled the best values of open development, bringing together technology researchers and innovators, a top voting system vendor with decades of elections experience, communicators and civic design researchers, and election administrators to demonstrate an independently verified election. The Microsoft Democracy Forward team would like to extend a thank you to our mighty team of partners: Hart InterCivic, Enhanced Voting, The MITRE Corporation, Center for Civic Design, Oxide Design, and our partner developers InfernoRed.

Based on the experience in this election, we strongly advocate for explicit recognition of the validity and necessity of an incremental, pilot-based approach based on real-world rather than laboratory demonstrations.

By any measure it should be considered a new investment in voting technology that could help build confidence in voting at this critical juncture in our democratic process. The ultimate measure of success of this – or any – election technology is through the eyes of those that administer elections and the voting public itself.

Democracy Forward Initiative
Microsoft

January 2023

Executive Summary

On November 8, 2022, Franklin County, Idaho offered voters in a district in Preston, Idaho the choice of using Hart InterCivic's Verity scanner integrated with Microsoft's ElectionGuard open-source software to cast their ballot instead of simply submitting their ballot into a traditional ballot box. Almost 50% of the over 240 voters in the Preston, Idaho district 4 polling place took advantage of the option.

How well did it work? The Center for Civic Design conducted exit polls of over 100 Preston voters and, whether they used the Hart/ElectionGuard option or not, found that it significantly improved their confidence in the election process and outcome.

Many factors contributed the positive outcome:

- Tight integration and quality assurance testing with the Hart InterCivic team
- Independent verifier development by MITRE and a confirmation-code lookup site built and hosted by Enhanced Voting, showing that open-source collaboration is possible
- Usability studies by the Center for Civic Design to understand how voters respond to terms and descriptions of the technology
- Careful coordination with Franklin County, including training administrators and poll workers
- Franklin County's outreach before the election via direct mail and in local media

The current lifecycle approach envisioned by the EAC and NIST to evaluate E2E-V algorithms addresses none of this. An algorithm can pass the proposed evaluation process yet fail to perform in an actual voting system in a real election.

Similarly, the long lead-time required for certification assumes a stable algorithm over time. By contrast, future versions of ElectionGuard will not only incorporate lessons learned in the November 2023 pilot, but also updated encryption and zero-knowledge proof innovations to achieve more efficient performance. This next-generation version anticipated in the second half of 2023 will include additional methods of voting, new capabilities such as recount support, and improved mechanisms for verifiers to scrutinize the election record. It is likely to be sufficiently different from the November 2022 deployment that a separate review process would be triggered in the proposed EAC process. That would be a shame and a mistake.

Instead, the EAC should consider a different approach: demonstration of a successful e2e-v deployment in a real-world election. This would include:

- Integration into a voting system, in a manner that increases not impedes voter participation
- Generation of a tally that validates the results produced by those systems and their ballots
- Publication into at least one and ideally multiple publicly accessible confirmation sites
- Verification of the election record by at least one and ideally many independently developed verifiers

We encourage the EAC to recognize the success of Franklin County's use of ElectionGuard, and consider approving efforts such as this as a valid approach to developing this important capability going forward.

Introduction

A week before the November 8 General Election, the County Clerk of Franklin County, Idaho sent voters in Preston District #4 a letter alerting them to a new voting option. Voters would have the choice of using Hart InterCivic's precinct scanner integrated with ElectionGuard to cast their ballots or their usual method: depositing their ballots into a ballot box that would be tallied centrally in the Franklin County courthouse.

There was also a front-page article in the local paper, *The Preston Citizen* (see below). This outreach to voters in advance of the election was important. Most voters came to the polling place aware of the changes taking place, having read the mailing or news article, or both.

The Preston Citizen

VOL. 134, NO. 43 - DELIVERING THE NEWS TO FRANKLIN COUNTY SINCE 1890

The only newspaper in the world that truly cares about Franklin County

www.prestoncitizen.com • PRESTON, IDAHO • $1.50

WEDNESDAY, NOVEMBER 2, 2022

Local precinct chosen to pilot new voting software

By TERESA CHIPMAN
Citizen staff

One precinct in Franklin County will be under close observation during the Nov. 8 election this year.

The Preston #4 polling place at the North Stake Center was chosen to pilot a new program called ElectionGuard, which hopes to bring more security and transparency to elections by directly involving the voter.

This is the only precinct in the entire United States chosen to provide feedback on the real-life application of the program. If the pilot is successful, it will be expanded to other states for more testing. Each state has its own election rules requiring ElectionGuard to be tailored to the specific needs of each state.

Voters who participate will mark their ballots as usual and feed them into the specially modified Verity scanner instead of the ballot box. The scanner will display a summary of their vote, and allow the voter to cast the ballot and make changes before casting, or run a BallotCheck.

A BallotCheck spoils the ballot and sets it aside so it is not counted. Poll workers will issue a new ballot for the voter to cast. BallotCheck allows voters to verify that ElectionGuard is working correctly and counting only valid votes.

After voting, the voter will receive a unique confirmation code which is used to access a website showing whether that vote was recorded without revealing or even accessing any information about the vote, such as voter information or who they voted for. All information pertaining to the vote is encrypted when the vote is submitted and cannot be viewed or modified.

More SOFTWARE | A2

PHOTO BY TERESA CHIPMAN

This picture shows the Verity scanner voting machine to be used in the pilot run of the ElectionGuard software in the North Stake precinct.

Figure 1. Franklin County newspaper article alerting Preston voters to changes in this year's election process

By the end of Election Day. almost 50% of the voters, casting 111 ballots, used the Hart/ElectionGuard option. Exit interviews with voters, and informal interviews with poll workers and election guardians showed that sentiment around the *overall* voting experience of both the Hart scanner and the ElectionGuard features was overwhelmingly positive.

A variety of factors contributed to that perception, from simply the fact of investment in new voting technologies focused on improving confidence to the existence of a method for validating that a ballot was included in the published results.

While ElectionGuard was not the sole new technology introduced—voters previously did not use the Verity precinct scanner, either—the technologies were complementary. Voters used the Verity review screen to verify their selections, and the Confirmation Code receipt enabled them to check that their ballot was included in the total. In some cases, simply the fact of being able to check was sufficient to instill confidence, whether the voter actually went to the confirmation code lookup site or not.

To set up the election, two respected local citizens, a former county clerk and a former member of the Election Oversight Committee, served as guardians in the ElectionGuard key and tally ceremonies and oversaw the generation of election results produced by the assistant county clerk that served as system administrator.

Investing in usability studies to test how voters respond to terms and descriptions of the technology also contributed to a positive outcome. The existing vernacular of end-to-end verifiable elections is complex and jargon-laden. In preparation for the election, usability studies explored words to describe the technology to voters. It was important to use easy-to-understand language that was still technically correct. *End-to-end verifiability*, for example, is a jargon-y term that has no inherent meaning to voters not already deeply familiar with new voting technologies and practice; *independent verification* resonated much more strongly with everyday voters in the testing.

Prior to working with Franklin County there was also a tendency to refer to the deployments as "pilot" elections, but we learned that when working in a real-world election, it is not a pilot, it is an election. Even something as innocuous as special "My vote counted" stickers was seen as problematic because all votes count irrespective of voting method used.

Fundamentally, the requirements of needing to fit within the confines and practices of actual real-world systems and elections drove the most significant innovations in ElectionGuard. Working with partners experienced in the processes and regulations followed by election administrators, as well as needing to be able to articulate the benefits and requirements to actual poll workers and voters, focused the effort on the proper priorities. Participating in the heat of election day activities and questions has already informed significant improvements underway in the next-generation ElectionGuard user experience.

The journey to the November 8, 2022 election

This is a report about conducting a pilot of an independently verified election in the November 8, 2022 General Election in Franklin County, Idaho. The pilot tested what the Election Assistance Commission's Voluntary Voting System Guidelines 2.0 Requirements refer to as a Cryptographic End to End Verifiable System Architecture).

In February 2021, the U.S. Election Assistance Commission (EAC) approved the Voluntary Voting Guidelines (VVSG) 2.0.[i] It contains updated requirements for voting system security, reliability, accessibility, and other principles of elections. Principles 9 focuses on voting system auditability.

The auditability principle is intended to improve accuracy and transparency, and thereby confidence for voters, in election outcomes by providing the means to independently validate election results and detect whether any tampering or system failures have occurred with ballots or tallies. It does so by introducing the concept of *software independence*[ii], defined as follows:

> A voting system is software-independent if an undetected change or error in its software cannot cause an undetectable change or error in an election outcome.

VVSG 2.0 recognizes two means of achieving software independence:

- Paper-based System Architectures
- Cryptographic End to End (E2E) Verifiable System Architectures[iii]

Microsoft has invested in the development of ElectionGuard[iv], an open-source software development kit[v] that enables vendors to incorporate E2E Verifiable capabilities into their systems since 2018. Its development is overseen by the Democracy Forward Initiative[vi] and is guided by the research and technical guidance of Dr. Josh Benaloh of Microsoft Research and other open-source contributors. Dr. Benaloh has published research and insights in this area since 1985[vii] [viii]. The first election in which ElectionGuard was used occurred in February 2020 in Fulton, Wisconsin[ix] [x] [xi]. ElectionGuard was also used to perform a risk-limiting audit in Inyo County, California in November 2020[xii], and the Democratic caucus of the US House of Representatives used ElectionGuard to elect several leadership positions in the first remote voting elections of the US Congress.[xiii]

In June 2021, Microsoft announced a partnership with Hart InterCivic, the third-largest voting system vendor in the US, to incorporate ElectionGuard into its Verity voting systems[xiv]. The Idaho election is the first demonstration of that partnership.

To enable the full spectrum of functionality necessary to demonstrate independently verified elections[xv], the ElectionGuard team welcomed additional partners to the fold. Enhanced Voting contributed its expertise in hosting election results to provide the confirmation-code lookup functionality[xvi]. MITRE's Center for Securing the Homeland wrote a verifier independently of the Microsoft team[xvii], and the Center for Civic Design performed usability testing, provided training materials, and performed usability observations and exit polling to determine the impact of this effort on the voters of Franklin County. Microsoft would like to thank our longtime development partner InfernoRed[xviii]; they have been part of the team since the first public demonstration of ElectionGuard at the 2019 Aspen Security Forum[xix].

Microsoft would also like to thank our partners for their commitment to this endeavor as well as Franklin County and the Idaho Secretary of State's Office for the opportunity to use it in a real-world election.

Pilots as a path to certification

We believe that the current lifecycle approach envisioned by the EAC and NIST to evaluate E2E-V algorithms is insufficient to support the innovation and experience truly necessary for widespread adoption of independently verified elections. An algorithm can pass the proposed evaluation process yet fail to perform in an actual device. The first ballot run through the Hart InterCivic Verity scanner during the development phase, for example, took over 4 minutes to process; significant investment in efficient execution was necessary to reduce encryption time to the sub second performance necessary before placing in front of voters.

Furthermore, the long lead-time required for certification assumes a stable algorithm over time. Already the next-generation version of ElectionGuard, expected to be released in mid-2023, will adopt many improvements to accommodate more efficient performance, additional voting methods and capabilities such as recount support, and improved mechanisms for verifiers to scrutinize the election record. Innovations such as ranked-choice voting will necessitate different approaches in the tally process, which will need to be recognized in any corresponding spec and associated verifier, even if the core encryption structures don't change. Demonstration of a successful deployment in the real world is a necessary and arguably sufficient condition for approval and use in other, similar scenarios. This would of necessity include the entire ecosystem deployed in Idaho:

- Integration into the voting systems used by voters, and in a manner that increases and doesn't impede voter participation

- Generation of a tally that validates the results produced by those systems and the ballots that contributed
- Publication into at least one and ideally multiple publicly accessible confirmation-code lookup sites
- Verification of the election record by at least one and ideally many independently developed verifiers

In this report

This report outlines the experience and learnings from conducting a pilot of an independently verified election (what the Election Assistance Commission's Voluntary Voting System Guidelines 2.0 Requirements refer to as a Cryptographic End to End Verifiable System Architecture) in the November 8, 2022 General Election in Franklin County, Idaho.

This report contains details of how we prepared for and ran the pilot, along with our conclusions about the benefits of ElectionGuard as a way to increase voter confidence in the administration and outcome of elections. Just as the project was a collaboration, each partner contributed to the report.

1. ElectionGuard's approach to end-to-end verifiable elections
2. Integrating ElectionGuard into the Verity precinct scanner (Hart InterCivic)
3. Hosting the confirmation-code lookup site (Enhanced Voting)
4. Developing an independent verifier (MITRE)
5. Developing voter information, training material, and branding (Center for Civic Design)
6. Major learnings and impact in a real-world election

We will close this report with final learnings, and recommendations for future pilots.

1. ElectionGuard's Approach to End-to-End Verifiable Elections

ElectionGuard is open-source software that improves transparency and confidence in elections. It encourages individual participation in verifying election results by enabling voting system vendors to generate *end-to-end verifiable*, or *independently verified*, election results *in addition to* the results their systems already produce.

Independently verified elections enable individual voters to verify both that their ballots were included in the published election tally and that the voting system is correctly recording their selections. They also allow the public to confirm all votes were correctly tallied without tampering or manipulation through verifiers- software tools that can be written by any interested third-party person or organization. ElectionGuard in integrated into, but does not replace, an existing voting system. It creates a separate encrypted copy of every ballot and uses advanced cryptographic techniques and security procedures to preserve the secrecy of the ballot and privacy of every voter. These encrypted ballots are made available to the public as part of the election record when the tallies and related artifacts are generated (see below).

ElectionGuard is intended to be used across all voting methods used in an election, so that all ballots cast can be included in a single, independently verified result. Different voting methods may require different processes for the voter, voting system vendor, or election administrator. However, all supported methods require the generation of an electronic version of a voter's ballot, referred to as a *cast vote record*.

To this point ElectionGuard has been deployed in two pilot elections: a system developed by VotingWorks used a ballot-marking device coupled with a printer in Fulton, Wisconsin in February 2020, and Hart InterCivic's Verity precinct scanner used ElectionGuard in Preston, Idaho in their November 2022 general election.

Figure 2: Hart InterCivic Verity scanner printing confirmation code

Core Principles of Independently Verified Elections

Guardian key and tally ceremonies

The use of multiple people acting as guardians to oversee the key and tally generation is a core security feature of ElectionGuard.

Figure 3: Guardians and administrator performing key ceremony to generate software package used by Hart InterCivic precinct scanner to encrypt ballots during election

The keys allow encrypted ballots and results to be made available to the public in encrypted form, while maintaining ballot secrecy. Guardians are analogous in function to election canvassing boards: respected individuals in the community that lend independent scrutiny and oversight to election processes. They are independent actors who work together to create the cryptographic keys used to both encrypt ballots and generate the final tally and public election record. The key and tally ceremonies can be observed by the general public, adding to the transparency of the technical processes.

There are multiple guardians involved so no single individual can generate tallies or decrypt ballots. ElectionGuard enables a quorum of guardians to perform a tally in the event not all guardians are available. The number of guardians as well as the quorum necessary to perform a tally are set by an election administrator.

During the key ceremony, the guardians and administrator create the cryptographic keys used to encrypt ballots during the voting process. Each guardian creates a public-private "key pair"[xx] on their own dedicated offline device. The public key from each guardian's device is copied to the administrator device and combined with all the other guardian public keys to form a combined encryption key. That encryption key is then combined with the ballot manifest of the election and deployed to the Verity scanners.

When the election is closed, the encrypted ballots are removed from the scanner(s) and imported into the administrator device. The administrator then re-invites the guardians to join the tally ceremony. When a sufficient number of guardians has joined, the process begins. Encrypted ballots are sent to the guardian devices and partially decrypted using the guardians' individual private keys to yield a tally across all the participating guardians. No cast ballot is ever decrypted, nor its contents revealed.

Generation of ballot confirmation code

A *ballot confirmation code* is an alphanumeric code unique to each voter's ballot generated during the ballot encryption process. For precinct-scan voting, the ballot is encrypted, and the confirmation code generated when the voter submits a completed ballot into the scanner.

In the Idaho pilot, the Hart InterCivic Verity scanner (see Figure 4) printed the confirmation code as soon as the voter submitted their ballot into the device and prior to giving the voter the chance to cast or challenge/spoil their ballot (see below).

Figure 4: Sample confirmation code generated by Hart InterCivic Verity scanner

Confirmation-code lookup site

When the election is closed and the tally generated, a publishable election record is created that includes each and every encrypted ballot included in the tally. Each encrypted ballot is identifiable by its associated confirmation code. A confirmation-code hosting site enables voters to search for and review the status of the ballot associated with their confirmation code.

A confirmation-code lookup site should allow voters to enter part of the code and then be able to select their code from a list of eligible options. Confirmation code receipts may also include QR codes that allow voters to be taken directly to the URL for that ballot.

➔ See **Section 3: Hosting the confirmation-code lookup site** for more details

Ability to challenge ballots

Challenging ballots refers to the ability for a voter to check that the voting system is encrypting their correctly recorded ballot. This is an essential component of public verifiability.

A challenged ballot is decrypted and its contents revealed to the voter. To preserve ballot secrecy, the decrypted ballot cannot be (and is not) included in the final tally generated by the voting system and the ElectionGuard tally process. A voter who has completed a challenge is then given a new a new ballot to mark and cast. The option to challenge a ballot occurs after the voter has been presented with a review screen showing a summary of their choices, the confirmation code has been generated, and the ballot has been encrypted. Requiring the encryption be performed before the challenge decision is made serves an important security function, as it prevents a malicious or faulty system from varying how it will record ballots based on whether they are challenged or not.

For election administrations, challenging a ballot mimics the process of "spoiling" ballots. For precinct scan systems, a ballot is spoiled when a voter decides not to cast it (for whatever reason) and requests a new one. For example, the voter could have mistakenly marked a selection for the wrong candidate, or overvoted a contest (selecting more candidates than allowed). When this happens, the voter can instruct the scanner to return the ballot rather than depositing the ballot in the ballot box. Election poll workers follow the local administrative process for taking the ballot from the voter and giving them another blank ballot to begin again.

Although challenged ballots are not included in the final published tally, they are released along with the election record. The same confirmation-code lookup site used by voters to determine that their ballots were included with the tally is also used to show the contents of decrypted challenge ballots.

Verifier support

Verifiers are software tools that validate the election record produced by the tally process, which also includes every encrypted ballot included therein. There is no canonical ElectionGuard verifier; instead, we encourage independent development of multiple. Having multiple verifiers gives voters choice in determining who they most trust to perform this important public function

It is not sufficient for a verifier to simply pass or fail an election record. When a verifier finds a problem, it must articulate which aspect failed and how. Since the verifier is making assertions about the validity of the election, only by allowing review of the methodology used to produce the error can a proper determination be made of whether the fault lay within the election record itself or the mechanism of review. Issues can arise due to the format of the constituent ballots, the structure and methodology of the computed tally, or their associated proofs. It is through verifiers that we can determine whether the "tamper evident seal" of the election record and its ballots can be determined.

➔ See Section 4: Developing an independent verifier for more information

Additional Security Practices and Considerations

Beyond the core capabilities outlined above, additional security provisions are built with the ElectionGuard SDK or followed by the devices and software user experience.

Offline processes

ElectionGuard, as is true for the vast majority of election systems, is always operated in an offline environment. Even though the key and tally processes use multiple guardian devices operating simultaneously and mediated by an admin device, the entire experience occurs offline. The ElectionGuard software UX for the Idaho election connected all the devices via a local intranet and router that were isolated from the internet.

Security of guardian private keys

In addition to operating offline, the biggest risk from a security perspective with respect to the ability to decrypt ballots and perform tallies involves the guardian private keys. As such, the ElectionGuard tally process pushes all decryption activity to the guardian devices themselves, so the private keys stay resident on the individual guardian devices.

In the case of the Idaho election, guardian and admin devices were stored in the custody of the election administrator in safes secured with fingerprints of the relevant actor, each guardian securing their device and the administrator securing theirs. To provide remediation in the case of device failure, the private key was exported to a thumb drive and stored in the associated safe with the device itself.

Future versions of the ElectionGuard software user experience envision a device-independent, biometrically-controlled storage mechanism of guardian private keys and partial decryptions, as well as an offline wireless capability to mediate the key generation and tally processes, eliminating the need for cumbersome wires, adapters, an offline IP router, and a dedicated device for each guardian.

2. Integrating ElectionGuard into the Verity Precinct Scanner

By Hart InterCivic

The core product used in the election was a Hart InterCivic Verity Scan precinct scanner and election management tools integrated with Microsoft's ElectionGuard E2E-V technology. The pilot election was the culmination of more than a year of collaborative work with our partners at Microsoft to mature an end-to-end Verifiable Voting SDK and integrate it into a voting device.

Hart InterCivic participated in the pilot because we believe our customers benefit by having access to a wide variety of tools to increase voter confidence and election transparency. E2EV technology is not a silver bullet but an additional tool in an election official's toolkit. It supplements rather than replaces critical election verification processes such as logic and accuracy testing, paper ballots, election audits, hash validation, the presence of independent poll watchers along with other mechanisms.

While existing verification methods are important, they are restricted to election officials, thus limiting the voter's or other third parties' role in the process. Integrating E2EV technology into the Verity Voting system allows any interested member of the public to directly participate in verification. Voters can confirm their own ballot was counted and/or perform a live test of ElectionGuard's recording using a challenge ballot. Anyone can verify the accuracy of the overall tabulation by examining the published dataset or using a third-party verifier application.

Hart's goal for this pilot was to learn how the ElectionGuard solution would operate in a real election, and understand the following questions: Does the solution increase voter confidence? Does it provide value to election officials? What other challenges remain to be solved?

Learnings

During the integration effort, we learned that the integration needs extend well beyond the cryptographic packaging used for E2EV. Real world election constraints impact the way the cryptographic solution must be implemented. For example, confirmation codes created by the system should be repeatable if the ballot is scanned multiple times. This supports necessary election procedures such as rescanning ballots to recover from a hardware failure, while retaining end-to-end verifiability.

Additionally, in most cases the E2EV technology cannot impose artificial constraints on an election. Election activities are proscribed by a variety of legal requirements, best practices, logistical needs, and traditions. All are important and most cannot be changed when adopting new technology. We worked with Microsoft to ensure the solution would be able to adapt to the needs of election officials, not vice versa. An example of this was our reworking of overvote behavior. While overvotes do not need to be recorded by ElectionGuard to provide E2EV, the SDK was originally designed to disallow overvotes entirely. Many jurisdictions do allow voters to choose to cast an overvote on a precinct scanner, thus requiring ElectionGuard to support this voting behavior.

We also learned that simplicity is critical. The mechanisms behind E2EV are far from simple and can be challenging to explain. However, to increase voter confidence and support the needs of the diverse voting population in the United States, the presentation of the technology within the solution must be simple. Confusing voters could lead to both usability issues and decrease in confidence. Both are counter to our goals. This is equally true for its use by election officials and poll workers. If the technology is not simple and usable, election officials will not see the value in it nor embrace it.

Outcome

The pilot election was a clear success by all criteria:

- The Verity tabulation, the ElectionGuard tabulation, and the manual hand count all matched.
- The results were independently verified by MITRE, as detailed in their report.
- The majority of voters understood and valued the technology, as detailed in the Center for Civic Design study and report.
- The Franklin County clerk's office saw value in both the solution and in their participation in the pilot.

Next steps

First, more pilots are needed. Each state has its own rules, regulations, and way of running elections. E2EV technology should be explored and tested in jurisdictions to better understand unique jurisdictional challenges. Pilots should also be run with different voting methods, such as by-mail voting, and with different voting technologies. Furthermore, the technology will need to be piloted in larger jurisdictions. Lastly, the technology must mature. The solution is not yet robust enough to accommodate all common voting types and methods. More work is needed to add redundancy, disaster recovery, and protection from human error.

3. Hosting the Confirmation Code lookup site

By Enhanced Voting

While voting in the Idaho election, voters received a printout containing a QR code along with a URL. These pointed to a website hosted by Enhanced Voting at https://www.egvote.us that allowed a voter to verify that their cast ballot was included in the final tally, or to verify the selections of a spoiled ballot. The site also served as a means of hosting the full electronic election record for use in allowing third parties to perform verifications of the election.

Voter Experience

A voter had two ways to get to the confirmation code site:

- Manually type in the URL printed on their receipt. In the case of this pilot, this was https://www.egvote.us/cc/id/22.
- Scan the QR code printed on their receipt. The code appended their confirmation code to the URL.

When a voter manually entered the URL, the site them presented with a search box to type in their confirmation code. Because confirmation codes tend to be long and random, a "typeahead" experience automatically displayed codes that began with the characters they entered to auto-complete for them. A voter could use this to verify that Enhanced Voting had their confirmation code in the system.

If no codes were found that matched what was typed, the voter was presented a list of codes similar to what they typed, in case they incorrectly typed in their code.

After selecting a code or navigating directly to a code via scanning the QR code (second option), the voter saw one of two interfaces.

- If the ballot was cast, the voter was told that their ballot was included in the count, shown the time that their ballot was cast, and a note that the ballot was still encrypted so Enhanced Voting could not show their selections.
- If the ballot was spoiled, the voter was told the ballot was not included in the count, shown the time the ballot was spoiled, and presented the decrypted selections that were on the ballot as marked.

The site also provided a location to collect feedback from voters as well as a link to learn more about how ElectionGuard works.

Administrator Experience

In the pilot election, Enhanced Voting performed the actual upload of data to the confirmation code site in conjunction with Microsoft, but the administrator section of the site but any election administrator can follow the process outlined below.

Prior to the election, the administrator first logs into the confirmation code administrator portal (https://www.enhancedresults.com) and uploads the manifest for their election. This creates the necessary data in the system to begin using it. This can be done any time after the manifest is ready, usually more than a month prior to the election.

At this time, they can configure the colors of the site, logos and a banner image, as well as the URL that the site will display on. This URL is required for final set up of the machines that will be printing the confirmation codes for voters and follows a predictable format. The format is https://www.egvote.us/{jurisdiction}/{electionidentifier}.

"Jurisdiction" should be consistent across elections for a county or state implementing the system, and the election identifier can be set by administrators.

On the night of the election, when the decrypted tally is available in the election record, the record is uploaded to the administrator portal. At this point, the tally and other information can be checked for accuracy before publishing the data to voters.

Third Party Verifier Experience

Anyone can come to the site and download the full electronic election record once it is available by going to the website for the election (https://www.egvote.us/cc/id/22) and clicking the link to download the full electronic election record. This will download a zip file containing all encrypted ballots, unencrypted spoiled ballots, the unencrypted tally, as well as all proofs and information necessary to run a cryptographic verification of the election.

4. Developing an Independent Verifier

By MITRE Center for Securing the Homeland

The MITRE ElectionGuard Verifier was designed to analyze the Franklin County election records, with three specific goals:

1. The software is easily understood so that independent readers of the source code could gain confidence in its correctness.
2. When the software found a problem, it could identify the equation(s) in the ElectionGuard specification that had been violated.
3. To improve performance, the software could make use of multiple computer cores in a way that did not conflict with the first goal.

The Verifier played a key role in verifying the election at the end of the night, after the Admins and Guardians created a tally and produced the election record. The election record was transferred electronically from the ElectionGuard Surface computer to the MITRE laptop, where the Verifier then validated the election record. MITRE staff then shared the results with a group on the laptop and to its wider community.

Overall, the MITRE ElectionGuard Verifier achieved its goal of validating the election record produced by the Franklin County election pilot. The verification team learned that it is essential to provide means in which others can participate in the verification experience. The team is ready to adapt the Verifier as ElectionGuard itself evolves.

Future Plans

For future elections, MITRE recommends publicizing the election so that external groups can develop software to verify cryptographic claims of end-to-end verifiability technology. At the time of the announcement, the technology should have:

- A clear algorithmic description of the scheme for theoretical review by experts
- A complete specification sufficient for verifiers to be written without review of any code
- A robust set of test data sufficient to check that a verifier is written correctly. This genuine call for public development of verifiers will increase public awareness that verification is important, including by voters themselves.

For the next phase of ElectionGuard (2.0), MITRE will make significant changes to its verifier. It will likely simplify the computations performed by the verifier, but complicate other pieces due to the fact that 2.0 will be focused on a more diverse range of voting methods. Given that future elections will also likely have substantially more votes, MITRE will focus on parallelizing the verification process. To scale up the processing performance of the Verifier, it will have to distribute verification tasks to multiple computing machines, and then coordinate the collection of the results of the tasks into a form that is equivalent to what would have resulted had only one machine been employed. However, even this is not an ideal solution because members of the public will not generally have access to multiple computing machines for their private use. Instead, it would be far better if instead of compounding records into a single large election record, the smaller units were tallied separately and published separately. This would break the problem into reasonably sized computational jobs that are not out of reach of ordinary members of the public, but this does leave behind a problem of combining multiple component records into a combined result.

5. Developing voter information, training materials, and branding

By Center for Civic Design

Center for Civic Design (CCD) and Oxide Design spent the months ahead of the Franklin County general election preparing communication materials for the various stakeholders involved, principally the County Clerk's election staff, poll workers, and the voters themselves. They conducted pre-election usability testing to better understand whether the language being used to describe ElectionGuard could be clearer; developed materials for the County Clerk's office to send to voters and for them to understand the ElectionGuard process; and designed polling place badges, t-shirts, and even capes to build more cohesion among the ElectionGuard pilot team and clarify their presence at the polling site.

Usability testing

In October 2022, CCD tested some of the language used to explain ElectionGuard and its functions with people in the greater St. Louis area.

All 23 participants in the testing had a positive reaction to the purpose of ElectionGuard. Some specific findings were as follows:

- Participants who have not voted (aged 18-25) commented that they would feel better about voting if they knew their vote was protected. They said things like "I would vote if I knew this was at my voting place."
- Potential and current voters wanted a greater sense of transparency and ease when voting, from feeling safer, to being able to "see your vote in the system."
- Some were curious to learn who the entities were behind creating ElectionGuard. Only 1 participant explicitly mentioned wariness a connection to Big Tech companies.

In testing a variety of basic sentences, some important concepts emerged:

- The ability to take action on your own to check, confirm, or verify
- The importance of independent verification
- The ability to test the system first

The one-liner about ElectionGuard that resonated most with voters was "With ElectionGuard, you know your vote counted, and have independent verification that the elections results are correct."

Training material development

In preparation for Election Day, CCD drafted a letter to send to voters in the district, signed by the County Clerk along with an information sheet about ElectionGuard to give them a sense of what to expect. In addition, the local newspaper, the *Preston Citizen*, ran a front-page story about the pilot.

These educational materials proved to be incredibly beneficial, as over half of the voters interviewed on Election Day remembered seeing or hearing something about ElectionGuard in advance. Even if they had not read them carefully, they were generally prepared for something new happening in the polling place.

Figure 5: The handout, showing a confirmation code tucked in the inside pocket.

CCD also created a handout for voters to hold their confirmation code and take with them after voting. This had some design challenges, as it needed a pocket-sized format and, if it was not compelling in its design, voters would simply toss out the handout before leaving the polling place.

We also wanted something that would be easy for poll workers to manage. By putting the "I Voted" sticker on the handout, they only had to give each voter one item.

The text focused on actions for the voter:

- Marking and casting a ballot with ElectionGuard
- Confirming that their ballot was counted
- Running a Ballot Check
- And a short list of answers to anticipated questions

The final design was a single piece of paper, assembled by hand into a quarter-page booklet with a pocket for the ticket with the confirmation code, which successful: almost none ended up in the trash.

Branding

The goal for the visual branding was simplicity and consistency, so that ElectionGuard materials were easy to identify, even in a chaotic polling place or elections office.

All of the materials used the same font, colors, and logos, making them easy to identify.

CCD worked with the existing logo, incorporating it into the pilot materials. Commemorative items and polling place materials included badges, pins, capes, and t-shirt.

After some experimentation and consultation with Idaho and Franklin County, they decided to avoid using language that suggested that the election was a "pilot" because it suggested that the ballots were not real ballots being cast in a real election.

Figure 6: A name badge for the ElectionGuard on-site team, using the colors and logo

6. Major learnings and impact in a real-world election

By Center for Civic Design

Following the Idaho Election, there were a number of learnings that the ElectionGuard team hopes to carry forward in future elections. This section describes both the key takeaways from the Idaho pilot, as well as the impact that ElectionGuard had on the voters who participated.

Major Learnings

Simple, clear, minimal information is better than technical explanations of what ElectionGuard is:

- The shorter the content, the better it worked to give voters a basic understanding of the value of ElectionGuard.
- When poll workers focused on how similar ElectionGuard is to "regular voting" and how easy it is, fewer voters opted out than when they explained the entire process.
- Half the voters we talked to remembered seeing a letter or news story before the election.
- The small format of the polling place handout helped make it seem unintimidating.

Voters thought positively of Franklin County for being the first to host the pilot:

- We talked 65 of the 111 voters who used ElectionGuard and 44 who had opted out.
- They were happy to have the chance to participate in something new.
- They were proud that their county was chosen, seeing it as an honor and showing that even small counties can be leaders.

ElectionGuard did not disrupt the flow of voters through the polling place:

- In a polling place with a small, steady stream of voters, there was no significant difference in how long voting took.
- Even when voters or poll workers encountered technical problems, if the question can be answered easily or an issue fixed quickly, it is less likely to have a negative impact.

Even voters who opted out understood the goal and benefit of ElectionGuard.

- Voters overwhelmingly saw the main benefit of ElectionGuard as increasing confidence and transparency of elections (see more below).
- Voters were generally comfortable with using new technology, though some said they were "old school" and less eager for change.
- Voters understood how the Confirmation Code is used. Almost all of voters who used ElectionGuard said they planned (73%) or might (23%) might use their Confirmation Code (and most of them were able to show us that they had the code).

Below are some direct quotes from voters who reflected on ElectionGuard's value:

- "Anything that makes the vote more accurate is better."
- "You hear about things like fraud. This would help with that."
- "This is more accurate. Other counties have problems and we don't want that here."
- "You can test the process to validate the election. For non-cheating."

- "Given how our nation is now with rumors or gossip, why not be safe? This tool leaves no space for those rumors."
- "Excited for us to use new technology in helping us move forward and to eliminate possible human error."
- "Great for the confidence."
- "I think this is very forward thinking and a progressive move for Franklin County to be a pilot for ElectionGuard. K[u]dos to those who sought this out, and made it happen 👍."
- "I hope this way of voting can cut down on all the people complain[in]g about our voting system."

Impact of ElectionGuard technology

In addition to getting feedback from voters as they were leaving the polling place, we also sent out a survey following the election to understand ElectionGuard's impact on confidence in the election process. While we were able to talk in person to half the voters, we only received seven completed online surveys. Our assumption is that with so many people taking part in the interviews at the polling place, they felt they had already given feedback and had no more to say. Participants in surveys are often people with strong opinions (positive or negative), so overall we consider this a good indicator of acceptance of ElectionGuard.

Of the individuals who filled out the post-election survey:

- **6** reported being very or somewhat confident that their personal vote counted as intended.
- **All** were either very or somewhat confident in their county's election results. A voter who expressed high confidence in the county's baseline election procedures noted concerns about unnecessary costs for elections but noted that ElectionGuard may be helpful in larger jurisdictions.
- **5** reported less confidence in the elections at the state or national level.
- **2** reported they were not at all confident in ballots being counted as intended at the national level. However, both suggested that ElectionGuard could change that: 1 advocated ElectionGuard be implemented nationwide. The other said that its implementation could be used to prevent human error.

Toward the end of the feedback survey, we asked specifically whether "the options to confirm that your ballot was counted and use BallotCheck to test the accuracy of the system influence your confidence that the votes in Franklin County were counted as voters intended?"

Respondents reported that ElectionGuard "significantly increased" confidence for Franklin County's election for most voters.

- **5** reported a significant increase in election confidence with ElectionGuard.
- **1** was unable to successfully confirm their ballot counted due to printing issues.
- **1** wrote a comment that they were confident in the county's elections, regardless of ElectionGuard's implementation.

Conclusions and recommendations

By Microsoft and endorsed by all participants

The integration of ElectionGuard with Hart InterCivic's Verity scanner significantly improved confidence in the election process and outcome for voters, poll workers, and election guardians in the Preston, Idaho election. This sentiment extended across all voters.

A variety of factors contributed to that perception, from simply the fact of investment in new voting technologies focused on improving confidence to the existence of a method for validating that a ballot was included in the published results.

While ElectionGuard was not the sole new technology introduced --voters previously did not use the Verity precinct scanner, either-- the technologies were complementary. Voters used the Verity review screen to verify their selections, and the Confirmation Code receipt enabled them to check that their ballot was included in the total. In some cases, simply the fact of being able to check was sufficient to instill confidence, whether the voter actually went to the confirmation code lookup site or not.

Many factors contributed to the positive outcome. Investing in usability studies to test how voters respond to terms and descriptions of the technology helped; the existing vernacular of end-to-end verifiable elections is complex and jargon-laden. Prior to working with Franklin County directly, there was also a tendency to refer to the deployments as "pilot" elections; if one is working in a real-world election, it is not a pilot, it is an election. Even something as innocuous as special "My vote counted" stickers was seen as problematic because all votes count irrespective of voting method used.

Outreach to voters in advance of the election was also important. Almost all voters came to the polling place aware of the changes taking place, either through the mailing to residents or the advance article in the local paper.

Fundamentally, the requirements of needing to fit within the confines and practices of actual real-world systems and elections drove the most significant innovations in ElectionGuard. Working with partners experienced in the processes and regulations followed by election administrators, as well as needing to be able to articulate the benefits and requirements to actual poll workers and voters, focused the effort on the proper priorities. Participating in the heat of election day activities and questions has already informed significant improvements underway in the next-generation ElectionGuard user experience.

As such, it is our contention that the current lifecycle approach envisioned by the EAC and NIST to evaluate E2E-V algorithms is insufficient to support the innovation and experience truly necessary for widespread adoption of independently verified elections. An algorithm can pass the proposed evaluation process yet fail to perform in an actual device. The first ballot run through the Hart InterCivic Verity scanner during the development phase, for example, took over 4 minutes to process; significant investment in efficient execution was necessary to reduce encryption time to the sub second performance necessary before placing in front of voters.

Similarly, the long lead-time required for certification assumes a stable algorithm over time. Already the next-generation version of ElectionGuard, expected to be released in mid-2023, will adopt many improvements to accommodate more efficient performance, additional voting methods and capabilities such as recount support, and improved mechanisms for verifiers to scrutinize the election record. Innovations such as ranked-choice voting will necessitate different approaches in the tally process, which will need to be recognized in any corresponding spec and associated verifier, even if the core encryption structures don't change. Would that need

to follow its own lifecycle process, or can the different computations and structures be evaluated incrementally. Isn't the proof (or in this case proofs) in the encryption pudding inherently?

In all important respects, demonstration of a successful deployment in the real world is a necessary and arguably sufficient condition for approval and use in other, similar scenarios. This would of necessity include the entire ecosystem deployed in Idaho:

- Integration into the voting systems used by voters, and in a manner that increases and doesn't impede voter participation at the polling place
- Generation of a tally that validates the results produced by those systems and the ballots that contributed
- Publication into at least one and ideally multiple publicly accessible confirmation-code lookup sites
- Verification of the election record by at least one and ideally many independently developed verifiers

To that end, we strongly advocate for explicit recognition of the validity and necessity of an incremental, pilot-based approach based on real-world rather than laboratory demonstrations. The ultimate measure of success of this technology is through the eyes of those that administer elections and the voting public itself.

Appendix 1: Voter research methodology

By Center for Civic Design

The goal of the research was to see if ElectionGuard meets its goals in this pilot—and how it could be improved.

We wanted to learn how voters interact with ElectionGuard while voting, reactions to using it, and how it affects their confidence in elections. Some of the questions we were focused on were:

- Does the presence of ElectionGuard raise confidence in the election both during the voting experience and after the election?
- Does the attention to security encourage more voters to verify their ballot before casting?

More specifically, we focused on answering four main questions:

- What do voters need to know about ElectionGuard to be informed and ready to vote, with a sufficiently accurate understanding of the process.
- How voters interact with ElectionGuard during voting
- Reactions to the voting experience and what voters understand about ElectionGuard after taking part in the pilot.
- Post-election confidence in and attitudes about ElectionGuard

Each part of the research gave us a different perspective on the pilot and data about how it worked. As much as possible, we coordinated wording of questions.

When/where	Questions	Dates
Before the election	**What voters need to know** • Learn how to best communicate what ElectionGuard does and why it is being tried out in this election. • Create training, letters to voters, FAQs and other materials based on the usability testing Usability test the explainers and other materials with voters. • Participants were recruited through intercepts at public locations. • They were asked to read a 1-page explainer and answer questions about what they learned • They were compensated with a small cash payment for their time	**Testing dates:** **October 4-5, 2022** **Location** 5 sites in Greater St. Louis **Participants: 23** 12 Black, 6 White, 5 Other 9 Male, 14 Female 14 aged 18-24, 7 aged 25-65, 2 aged 65+
In the polling place	**How voters interact with ElectionGuard** Observe and document: • Reactions to being asked to participate in the pilot • How long voting takes • How they interact with the scanner, review screen, and Confirmation Code.	**November 8, 2022** at Preston District #4

	• Any observations of what happens including interactions with poll workers for questions or problems. Metrics for the pilot: • ElectionGuard does not cause longer voting times or lines • Voters are able to vote with no or minimal additional instruction • At least 1% of voters challenge a ballot • At least 75% of voters take their confirmation code	
Outside the polling place	**How voters react to ElectionGuard** Semi-structured interviews with voters as they leave to learn about their understanding of ElectionGuard, and their initial reactions to its value in elections. Metrics for the pilot • Voters will be able to give a sufficiently accurate explanation of what ElectionGuard is. • Voters will, on average, express confidence in using ElectionGuard. • Voters will not report significant usability problems in understanding or using ElectionGuard. • Voters who challenged their ballot will express confidence in that process. • At least half the voters will say they plan to use their confirmation code.	**November 8, 2022** in the entryway to the North Stake Center outside the Preston District #4 polling place **Participants: 109** Ages 2 aged 18-24 | 25 aged 25-34 | 22 aged 35-49. | 6 aged 50-65 | 41 aged 66+ Last time they voted 42 in 2022 primary 47 in 2020 3 2018 or earlier 1 first-time voter
After the election	**How ElectionGuard affects confidence or trust** Invite all voters to complete an online survey about their awareness of the pilot, what they know about ElectionGuard, and their attitudes about trust and confidence in elections. Postcards about the survey mailed to all registered voters in the district Metrics for the pilot: • Whether the presence of ElectionGuard raises confidence in elections, both for people who voted using it and others who may have only heard about it • Whether voters and others understand how ElectionGuard contributes to a secure election with sufficient accuracy (even if not phrased in technical terms)?	**November 9-23, 2022** Online Survey **Participants: 7**

Observations note-taking instructions

Every 15 minutes, note how many people are at the check-in tables

For each voter, note:

- How/when were they asked about participating in the pilot?
- What was their reaction to the invitation to take part in the pilot?
  Confused, Neutral, Positive
- Did they have questions or an extended conversation with the poll workers

For voters choosing ElectionGuard, note:

- Did they get help voting or casting their ballot?
- Did they appear to verify their ballot by scrolling though the review screen
- Did they correct or spoil their ballot
- Did they take their Confirmation Code? What did they do with it?
  Put it in their pocket, Put it in the voter guide, Threw it away
- Anything else unusual that happened.

Exit interview questions

About you

A1 – Did you vote in Preston District 4?

A2 – What was the last time you voted?
2022 primary, 2020, 2018, earlier

A3 – What is your age?

A4 – Did you get a handout like this? [show it and note it they have a Confirmation Code}

A5 – Did you vote using the ElectionGuard scanner or red ballot box

Voting experience

B1 – How was voting for you today?

B2 – How would you explain ElectionGuard in your own words?

B3 – What do you think the benefit of ElectionGuard is?

B4 – Can you tell me what the Confirmation Code is for? Do you plan to use it?

B5 – Did you do a BallotCheck? Tell me about that/

B6 – What do you think of Franklin County and Idaho hosting this pilot of a new election **technology?**

B7 – Anything else you'd like to add?

Online Survey

Tell us about your voting experience

We are collecting feedback from people in Franklin County about voting in the November 8 election. The information we collect will be used to help evaluate the use of a new technology called ElectionGuard.

This questionnaire should take less than 5 minutes to complete. You do not have to answer any question you don't want to. Your feedback is anonymous.

If you do not want to continue, just close this browser window. You can return at any time.

If you have questions, please contact Dr. Martha Kropf at mekropf@uncc.edu or the Franklin County Clerk's office.

Q1 Which of the following statements best describes you?

- I did not vote in the election this November
- I thought about voting this time, but didn't
- I usually vote, but didn't this time
- I tried to vote, but was not allowed to when I tried
- I tried to vote, but it ended up being too much trouble
- I definitely voted in the November General Election

If not "definitely voted", ask why and skip to Q3

Q2 How did you vote in this election?

- I voted in person on Election Day (at the polls)
  I voted in person before Election Day (in-person absentee)
- I voted absentee by mailing or dropping off a ballot
- I don't know

Questions Q3-Q6 answers: Very confident (1) ... Not at all confident (4)

Q3 How confident are you that your vote in the General Election was counted as you intended?

Q4 Think about vote counting throughout Franklin County, and not just your own personal situation. How confident are you that votes in Franklin County were counted as voters intended?

Q5 Now, think about vote counting throughout Idaho. How confident are you that votes in Idaho were counted as voters intended?

Q6 Finally, think about vote counting throughout the country. How confident are you that votes nationwide were counted as voters intended?

Q7 The State of Idaho and Franklin County hosted a pilot of a new election technology called ElectionGuard. Voters used it at one polling place. How did you first hear about it?

- I got a letter from the County Clerk
- The newspaper or a radio program
- Someone told me about it
- I heard about it when I voted
- From the card inviting me to give feedback do this survey

- I don't remember exactly where I heard about it
- I'm not sure if I heard about it
- I never heard about it
- Other

Q8 Based on what you heard, what do you think ElectionGuard does?

- [open text entry]

Q9 Did you vote at the Preston #4 district at the North Stake Center (across from West Motors)

If no, skip to Q12

Q10 When you cast your ballot, you may have received a confirmation code to take home with you. Did you use the confirmation code to check to see if your ballot was counted?

- Yes, and I was able to confirm that my ballot counted
- I tried to, but I could not confirm that my ballot counted
- I wanted to, but I lost the code
- I didn't try

Q10A – Why did you decide to use the Confirmation Code to see if your ballot was counted?

- [open text entry]

Q10B How easy or difficult was it to see for yourself whether your ballot counted?

- Every easy, Somewhat easy, Somewhat difficult, Very difficult

Q10C Do you have any other comments on using the Confirmation Code?

- [open text entry]

Q11 ElectionGuard allows you to run a test, called a "BallotCheck". It allows you to set aside a ballot to check that the system recorded it correctly. Did you set aside a ballot?

- Yes
- No
- I didn't realize I could use BallotCheck to test the system

Q11A After the election, how easy was it to check the ballot on the website?

- Extremely difficult > Extremely easy (4 point scale)

Q11B Was your BallotCheck ballot recorded accurately?

- Yes
- No
- I was unable to determine if it was accurate

Q11C How satisfied with the overall experience of doing a BallotCheck

- Extremely satisfied > Extremely dissatisfied (4 point scale)

Q11D Do you have any other comments on your experience with BallotCheck

- [open text entry]

Q12 Which of the following features do you think are important to increasing transparency in elections?

For each statement: Important, Neutral, Not important

- Each voter can confirm that their ballot was counted.
- Making sure any ballot receipts do not reveal how any one person voted.
- Voters cast a paper ballot.
- The ability for independent organizations to verify that the election results are accurate.
- Voters themselves can test that the system is recording votes accurately.

Q13 How do the options to confirm that your ballot was counted and use BallotCheck to test the accuracy of the system influence your confidence that the votes in Franklin County were counted as voters intended?

- The increased my confidence significantly
- They increased my confidence somewhat
- They neither increased nor decreased my confidence
- They decreased my confidence somewhat
- They decreased my confidence significantly
- I don't know

Q13 Is there anything else you would like to tell us about your experience with ElectionGuard or your overall experience voting in this election?

- [open text entry]

Q14 What do you think about Franklin County hosting this pilot of new election technology?

- [open text entry]

Now, we just have a couple more questions about you to help us so we can understand everyone's responses.

Q15 When was the first election you voted in?

- 2021-2022
- 2017-2020
- 2013-2016
- 2000-2012
- Before 2000
- I have never voted
- I don't remember

Q16 How many years have you lived in Franklin County?

- Less than 5 years
- 5- 10 years
- More than 10 years

Q17 What is your gender?

- Female
- Male
- Other

Appendix 2: Pre-election Usability Study Results

By Center for Civic Design

A month before the election (on October 4-5), Center for Civic Design conducted a usability study at five sites in the Greater St. Louis area to test first drafts of the explainers and voter information about ElectionGuard. Locations in the city were picked for diversity and as a counterpoint to the older, whiter demographic of Franklin County. Participants included 12 black, 6 white and 6 Latinx, Southeast Asian or other. There were 14 women and 9 men. Most were young: 14 from 18-24, 4 from 25-34, 3 from 35-65, and 2 over 65.

Reading one-page explainers

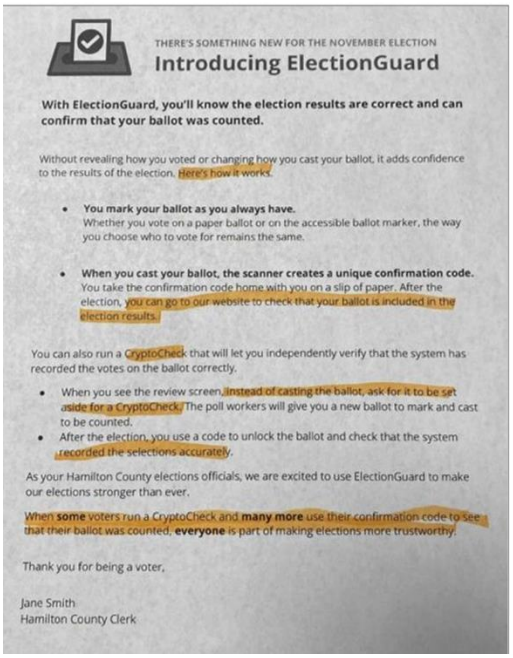
Researchers showed participants a one-page explainer of ElectionGuard asking them to read it, restate what it said, and if they had any questions. Overall, all 23 participants understood the explanation.

Who is behind ElectionGuard? Some were curious to learn who were the entities behind creating ElectionGuard. Only one participant explicitly mentioned wariness of ElectionGuard being connected to Big Tech companies.

Does ElectionGuard add to confidence? Non-voters would gain confidence in the voting process and system if ElectionGuard were present. They commented that they would feel better about voting if they knew their vote was **protected**.

"I would vote if I knew this was at my voting place."

Current voters focused on **transparency** and **ease while voting** From feeling safer, to being able to "see your vote in the system."



THERE'S SOMETHING NEW FOR THE NOVEMBER ELECTION

Introducing ElectionGuard

With ElectionGuard, you'll know the election results are correct and can confirm that your ballot was counted.

Without revealing how you voted or changing how you cast your ballot, it adds confidence to the results of the election. Here's how it works.

- **You mark your ballot as you always have.** Whether you vote on a paper ballot or on the accessible ballot marker, the way you choose who to vote for remains the same.
- **When you cast your ballot, the scanner creates a unique confirmation code.** You take the confirmation code home with you on a slip of paper. After the election, you can go to our website to check that your ballot is included in the election results.

You can also run a CryptoCheck that will let you independently verify that the system has recorded the votes on the ballot correctly.

- When you see the review screen, instead of casting the ballot, ask for it to be set aside for a CryptoCheck. The poll workers will give you a new ballot to mark and cast to be counted.
- After the election, you use a code to unlock the ballot and check that the system recorded the selections accurately.

As your Hamilton County elections officials, we are excited to use ElectionGuard to make our elections stronger than ever.

When **some** voters run a CryptoCheck and **many more** use their confirmation code to see that their ballot was counted, **everyone** is part of making elections more trustworthy.

Thank you for being a voter,

Jane Smith
Hamilton County Clerk

Figure 4. A sample explainer with highlighting identifying areas discussed with the participant.

General election terms could also be confusing. Some had a problem understanding what the "accessible ballot marker" was. A few asked for clarification if it was the electronic way of voting. Others asked questions such as if it as a physical marker – like a sharpie – to if it were some sort of ballot indicator.

Analogies to other election information helped people understand ElectionGuard. They had reactions like "it's like a receipt," or "Oh, Georgia ballots have barcodes on them."

Did they understand the process? It took some time to process the series of actions to be taken when casting and verifying the ballot. Some had only voted through one method, so there were follow-up questions asking to clarify paper vs electronic voting, what happens if the ballot is tallied incorrectly, or where the scanner is located.

They had questions about BallotCheck. After trying several terms, there was significantly less confusion about the term "BallotCheck" for challenging a ballot, but some people were confused when it happens during the voting process. Many people tried to under the experience as part of series of actions taken when casting a ballot. They asked "Is it the same as the review screen?" to simply asking when and where it happens.

People generally understand the purpose and understanding of "confirmation code." One person described it back to us as it being the **"QR code"** Another person expected the slip of paper to have the time of day.

Comparing one-sentence introductions

After discussing two versions of the one pager, researchers showed participants 6 different one-line explanations of ElectionGuard and asked them to rank them in order of their preference. The results are shown in the table below.

The final version used in the letter to voters and the polling place handout combines elements of several, focusing on the sentiments that got the most positive response: agency in the election, independence, and accuracy or correctness.

> **With ElectionGuard you know your vote counted, and have independent verification that the election results are correct.**

# of votes	One-sentence explanation	Comments
13 votes	ElectionGuard lets you confirm that your ballot was counted and provides an independent verification that the election results are correct.	The use of "independent verification" resonated with people: "I like the independent aspect of it"
11 votes	ElectionGuard lets you confirm your votes were counted and is a way to test the system to make sure it records the votes accurately.	Some people said that having a sense of accuracy, dependability, and trustworthiness are baseline emotions one should feel when going through the voting process. "Recorded accurately…it's important to know if your ballot wasn't rigged" "Important to emphasize that the vote is counted." "Likes that this tells me this is accurate and that they could double check." "Makes me think that I matter in this system"
10 votes	ElectionGuard lets you verify yourself that your votes were included in the final results and also test that the voting system is working correctly.	Use of "verify yourself" resonated "I really like the verify for yourself, it might be able to appeal to conspiracy theorists" Two participants liked "working correctly" "I like the positive framing of working correctly." Some people felt a sense of greater agency in the voting process. "This talks about inclusion"

		"Power is back in the individual. Yourself being able to check is really powerful" "You would be more involved with future votes"
9 votes	ElectionGuard lets you confirm that your ballot was counted and that the election results are correct.	People liked the emphasis that the vote was counted "It's a simple explanation that affirms the vote is counted" People also felt this description increases confidence and eases worries. "Leads you to think nothing to worry about"
8 votes	ElectionGuard creates an independent encrypted copy of the election that you can use to check your vote was counted.	The youngest liked the usage of "encrypted" and felt a sense of reassurance: "'Encrypted copy' is a keyword that was helpful for me to see" "Like because you can check the system to verify" Older participants were worried about hacking: "'Encrypted copy' – I'm nervous, who can hack it?"
5 votes	ElectionGuard allows you to confirm that your ballot was counted.	A participant described it as concise - "Short and sweet"
3 votes	With ElectionGuard, you'll know the election results are correct and can confirm that your ballot was counted.	One or two noted the positive framing and how it described the overall purpose of EG.

Endnotes

[i] The EAC Adopts VVSG 2.0 (https://www.eac.gov/march-2021-newsletter)
[ii] Ronald R. Rivest, John P. Wack *On the notion of "software-independence" in voting systems* (https://people.csail.mit.edu/rivest/RivestWack-OnTheNotionOfSoftwareIndependenceInVotingSystems.pdf)
[iii] Election Assistance Commission, Voluntary Voting System Guidelines 2.0, p. 181 (https://www.eac.gov/sites/default/files/TestingCertification/Voluntary_Voting_System_Guidelines_Version_2_0.pdf,)
[iv] https://www.electionguard.vote/
[v] https://en.wikipedia.org/wiki/Software_development_kit
[vi] https://www.microsoft.com/en-us/corporate-responsibility/democracy-forward
[vii] A Robust and Verifiable Cryptographically Secure Election Scheme, Josh Benaloh and Michael J. Fischer, Proceedings of 26th Symposium on Foundations of Computer Science | September 1985
[viii] Josh Benaloh, PhD Thesis Yale University, 1987 *Verifiable Secret-Ballot Elections* (https://www.microsoft.com/en-us/research/publication/verifiable-secret-ballot-elections/)
[ix] Microsoft's voting software is getting its first test in a small Wisconsin town.
[x] Another step-in testing ElectionGuard (https://blogs.microsoft.com/on-the-issues/2020/02/17/wisconsin-electionguard-polls/)
[xi] VotingWorks, Microsoft, and the State of Wisconsin Partner on Election Pilot (https://www.voting.works/news/2020-02-wisconsin-electionguard)
[xii] Post Election Audits – Inyo County Elections (https://elections.inyocounty.us/post-election-audits/)
[xiii] *U.S. House Democrats adopt mobile internet voting for leadership contests*, Reuters (https://www.reuters.com/article/us-usa-congress-tech/u-s-house-democrats-adopt-mobile-internet-voting-for-leadership-contests-idUSKBN28E1C0)
[xiv] *Hart and Microsoft Announce Partnership to Make Elections More Secure, Verifiable* (https://www.hartintercivic.com/hart-and-microsoft-announce-partnership-to-make-elections-more-secure-verifiable/)
[xv] https://www.electionguard.vote/concepts/Verifiability/
[xvi] https://www.enhancedvoting.com/projects/
[xvii] https://electionintegrity.mitre.org/verifier/
[xviii] https://www.infernored.com/work/microsoft-electionguard
[xix] https://blogs.microsoft.com/on-the-issues/2019/07/17/new-cyberthreats-require-new-ways-to-protect-democracy/
[xx] See Wikipedia entry on public key cryptography (https://en.wikipedia.org/wiki/Public-key_cryptography)