Applying Visual Management Techniques and Digital Analysis to Post Election Auditing

CASE STUDY AND GRANT FUNDING OUTCOMES

ORANGE COUNTY REGISTRAR OF VOTERS

Introduction

Strict compliance with California state law, as well as regulations instituted by the Secretary of State, is vital to ensuring that election results are accurate and reliable. One such mandate is the One Percent Manual Tally, which is defined by Section 336.5 of the California Elections Code as "the public process of manually tallying votes in one percent of the precincts, selected at random by the elections official, and in one precinct for each race not included in the randomly selected precincts." This manual tally is the final step before certifying an election, and completing this time consuming and labor-intensive process within the 28-day state mandated timeframe can pose significant challenges to elections officials. Recognizing the need to innovate this process, the United States Election Assistance Commission (EAC) announced the availability of grant funding in 2010 through the Voting System Pre-Election Logic and Accuracy and Post-Election Audit Initiative. In 2011, Orange County was awarded a grant of $125,000 in order to increase efficiencies in conducting the post-election audit, as well as improve the accuracy of audit results. This report documents the findings from Orange County's participation in the Voting System Pre-Election Logic and Accuracy and Post-Election Audit Initiative, and the following sections contained herein provide: (1) a description of the One Percent Manual Tally as historically conducted in Orange County; (2) a review of the risk limiting audit process; (3) an overview of the Voting System Pre-Election Logic and Accuracy and Post-Election Audit Initiative; (4) an analysis of the pilot post-election audit program implemented in Orange County; and (5) findings and recommendations gained from participating in the initiative.

In 2003, the Orange County Registrar of Voters purchased the Hart InterCivic electronic voting system, which has produced accurate and certified election results in approximately 30 primary, general, special, and municipal elections since it was first used in Orange County in 2004. Prior to its use in any election, such a voting system must receive federal certification from the EAC, fulfill numerous requirements and regulations established by the Secretary of State and California Elections Code, and be subject to rigorous testing and continual auditing to ensure its accuracy. Pursuant to California state law, the One Percent Manual Tally must be completed as part of the Official Canvass of the Vote when such a voting system is used, and Section 15360 of the Elections Code specifies how the tally is to be conducted by the elections official.[1] It states:

> During the official canvass of every election in which a voting system is used, the official conducting the election shall conduct a public manual tally of the ballots tabulated by those devices, including vote by mail ballots…cast in 1 percent of the precincts chosen at random by the elections official. If 1 percent of the precincts is less than one whole precinct, the tally shall be conducted in one precinct chosen at random by

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[1] The Official Canvass is a complex post-election audit process that involves a number of tasks to account for all ballots that were issued, voted, and not used; it must commence no later than the Thursday following an election and be completed no later than the 28th day after an election. Cal Elec. Code § 15300 et seq. (leginfo.legislature.ca.gov current through 2013-2014 Sess.).

the elections official. In addition to the 1 percent manual tally, the elections official shall, for each race not included in the initial group of precincts, count one additional precinct. The manual tally shall apply only to the race not previously counted.... The official conducting the election shall include a report on the results of the 1 percent manual tally in the certification of the official canvass of the vote. This report shall identify any discrepancies between the machine count and the manual tally and a description of how each of these discrepancies was resolved. In resolving any discrepancy involving a vote recorded by means of a punchcard voting system or by electronic or electromechanical vote tabulating devices, the voter verified paper trail shall govern if there is a discrepancy between it and the electronic record.

In addition to a myriad of state laws, there are also Post-Election Manual Tally standards that were adopted by the Secretary of State in 2007 subsequent to conducting an exhaustive "Top-to-Bottom Review" of each voting system used in the state.[2] The standards adopted to enhance the reliability of election results led to the promulgation of additional requirements to be followed by elections officials in completing the One Percent Manual Tally. For any contest where the margin of victory in the unofficial results is less than one half of one percent (0.5%), the manual tally shall increase to ten percent of randomly selected precincts. Additionally, when variances between the semifinal official canvass results and the manual tally results are discovered, elections officials must document and disclose those variances and take steps to resolve the variances. In Orange County, a countywide election can require over a hundred temporary and full-time employees to hand-count and scrutinize thousands of ballots and Voter Verified Paper Audit Trail (VVPAT) printouts over a period of weeks.

The One Percent Manual Tally at a Glance

The One Percent Manual Tally is the final step in the canvass process before certifying an election, and as it is governed by the California Elections Code §15360, which provides that it is conducted in a similar manner in all counties. Ballots must be hand-counted in at least one percent of precincts selected at random. The number of precincts included in the audit may increase if the initial selection of precincts is less than one whole precinct; further, all contests must be included in the post-election audit, so precincts must be added for each race not included in the initial group of precincts.[3] The audit must be open to the public and include paper ballots, vote-by-mail ballots, and ballots cast electronically on a voting system.

The actual hand counting of ballots is conducted by Tally Boards (Boards). These Boards consist of four staff including one reader, one observer, and two counters. The

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[2] California Secretary of State, *Post-Election Manual Tally Regulations [expired],* http://www.sos.ca.gov/voting-systems/oversight/pemt.htm (accessed Aug. 5, 2013).
[3] Cal Elec. Code § 15360(a) (leginfo.legislature.ca.gov current through 2013-2014 Sess.).

reader calls out each vote in a given contest (ex. "Yes", "No", "Washington", etc…), and the observer confirms that the reader is accurately calling out each vote. The two counters tally the votes called on tally sheets. Counters use two different color pencils that are alternated after a specified number of votes are called. Additionally, both counters will call out "check" after every fifth vote is called. If the counters get out of sync, the reader stops calling votes so the counters can resolve the discrepancy. The counters will announce and mark the last number tallied, line out the rest of the tally box, and write the total in the right-hand column of the tally sheet. The Board conducts the tally blind, in that they do not know the expected result of the count. Thus, a supervisor must verify that results match the original tally before a Board can proceed to another contest.

Confirming manual tally results with the electronic tally can take a considerable amount of time. In the November 2012 General Election, over one million votes were cast in Orange County. Completing the One Percent Manual Tally required 20 Boards, staffed by nearly 100 permanent and temporary employees, hand-counting thousands of ballots around the clock in order to certify the election in 15 days.[4] Ballots were examined multiple times in order to audit almost 500 contests. Hundreds of hours were spent hand-counting votes. In addition, Tally Board Members were required to stand in long lines waiting to report the results of each contest and receive verification of the results and authorization to proceed. If the hand-counted totals match the voting system results, the Board is permitted to begin the next contest. If the totals do not match, the Board must try to resolve or justify any discrepancies and record their findings on the Tally Sheet. Once the Tally Sheet is accurately completed, all Tally Board Members initial the bottom of the sheet to acknowledge and certify the results.

Voting System Pre-Election Logic & Accuracy Testing and Post-Election Audit Initiative

Established by the Help America Vote Act in 2002, the EAC is an independent, bipartisan commission responsible for collecting and disseminating information about election administration issues. The agency's core mission is "developing guidance to meet the Help America Vote Act (HAVA) requirements, adopting voluntary voting system guidelines, serving as a national clearinghouse of information on election administration and finalizing human capital and records management handbooks."[5] In 2010, the EAC announced the availability of grant funding for the purpose of improving the efficiency and accuracy of voting system pre-election logic and accuracy (L&A) testing and post-election audits. Through the Voting System Pre-Election Logic and Accuracy Testing and Post-Election Audit Initiative, the EAC sought to increase insight into "innovative, high quality processes, tools, and effective practices that are cost-

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[4] Pursuant to California Elections Code §15372, an elections official is provided 28 days to certify and report election results. In the 2012 General Election, the Orange County Registrar of Voters certified results 13 days before the state mandated deadline.
[5] U.S. Election Assistance Commission, *2012 Activities Report: VOTE*, p. 2 (Washington D.C., 2012) http://www.eac.gov/assets/1/Documents/FY-2012-EAC-Activities-Report-Website-Scanned.pdf.

effective and evidence-based, for performing voting system pre-election L&A testing and post-election audits by jurisdictions of varying sizes, locations and equipment configurations."[6]

The focus of the EAC on improving the processes involved in identifying and resolving errors and malfunctions is wise, as almost every state in the country utilizes some form of electronic voting system. Inaccurate election results can result from problems with a system's hardware or software, as well as human error in the hand-counting of ballots and tabulation of results. Protecting the integrity of the election process, which is the cornerstone of our democracy, requires effective auditing to confirm the accuracy of voting system operations and election results. In the Grant Notice the EAC identified a number of benefits of L&A testing and post-election auditing, some of which include: preventing the deployment of malfunctioning equipment, finding accidental or intentional error, deterring fraud, detecting configuration errors in ballot layouts or equipment, and promoting public confidence in elections. In an effort to promote best practices for conducting high-quality and cost-effective L&A testing and post-election audits, in 2011 the EAC awarded $1,463,074 to 12 state and local government agencies that included five states, six counties, and one city.[7] Initiative funding was divided between L&A testing and post-election audits and desired outcomes included tool kits, guides, best practices, and research findings and recommendations.

Orange County Registrar of Voters Post-Election Audit Pilot Program

On May 23, 2011, the Orange County Registrar of Voters was notified by the EAC that it was one of 12 grant recipients. As a local government entity with a voting population of more than 1.5 million voters, the EAC awarded Orange County grant funding in the amount of $125,000. The grant would span a period of 24 months, from May 2011 through April 2013, and funds would be used to increase efficiencies in conducting post-election audits by reducing the number of employees and the amount of time needed to conduct such audits. The desired goals of the Post-Election Audit Program (Audit Program) were twofold: (1) to decrease overall costs associated with completing the post-election audit and the election canvass as a whole, and (2) to increase the accuracy of audit results, while reducing time consuming errors.

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[6] 2010 Pre-Election Logic and Accuracy/Post Election Audit Initiative Grant Notice, http://www.eac.gov/assets/1/Documents/L&A%20Post%20Election%20Audit%20NOFA%20FINAL1.pdf (accessed Aug. 5, 2013).
[7] FY 2011 Pre-Election Logic and Accuracy Testing & Post-Election Audit Initiative Grant Recipients include: California Secretary of State; Orange County Registrar of Voters; County of Humboldt; County of Santa Cruz; Colorado Department of State; State of Connecticut, Secretary of State; Office of Cook County Clerk; State of Indiana, Secretary of State; City of Takoma Park, MD; County of Boone, MO; New York State Board of Elections; and Cuyahoga County Board of Elections, OH. U.S. Election Assistance Commission, *Fiscal Year 2011 Interim Annual Performance Report*, p. 14 (February 13, 2012).

The initial phase of the Program was conducted in 2011. A Post-Election Audit Committee (Committee) comprised of key staff members was convened to identify new post-election audit procedures, training techniques, data collection and management processes, opportunities to test the new Program, and performance metrics. To discover best practices, data collected included, but was not limited to, the quantity of ballots audited by a four-person board in a period of time, the number of contests completed, and the number of employees required to complete the canvass. Ballots involved in the Audit Program included both vote-by-mail and electronic ballots. During this phase, the Committee also analyzed the capabilities of the voting system used by Orange County (Hart InterCivic) to identify potential modifications and enhancements to the system in order to expedite the post-election audit process through the use of technology.

Prior to receiving notification of the grant award from the EAC, Orange County had already volunteered to participate in a Post-Election Risk-Limiting Audit Pilot Program (RLA Pilot). The California Secretary of State received a grant from the EAC to conduct a post-election audit pilot program during 2011 and 2012 to test risk-limiting audit models. By partnering with 20 counties, including Orange County, and Professor Philip B. Stark from the University of California, Berkeley, the Secretary of State conducted 10 audits following elections in 2011 and 2012.[8] By leveraging this partnership, Orange County was provided the opportunity to gain increased understanding of post-election audits, as well as afforded two opportunities to pilot the Audit Program. Specifically, a 2011 Special Election in San Clemente and the 2012 Primary Election would be used as live tests of new technology integrated into the post-election audit process.

The Risk-Limiting Audit Pilot Program (RLA Pilot)

In 2011, The EAC awarded the SOS $230,000 in HAVA grant funds to conduct a post election audit pilot program to test risk-limiting audits in up to 20 California counties through 2012.[9] The Post-Election Risk-Limiting Audit Pilot Program 2011-2012 Semi-Annual Progress Report to the EAC, prepared by the Secretary of State for the reporting period closing November 30, 2011[10], describes the purpose of the RLA Pilot and the process of conducting a risk-limiting audit. Risk-limiting audits are based on modern statistical principles and conducted at the "ballot level." Thus, individual ballots from the entire voting jurisdiction are subject to the random draw of the audit. The number of

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[8] Counties that participated in the RLA Program include: Alameda, Alpine, Colusa, El Dorado, Humboldt, Madera, Marin, Merced, Monterey, Napa, Orange, Sacramento, San Luis Obispo, Santa Cruz, Stanislaus, Sutter, Ventura, Yolo, and Yuba. California Secretary of State Debra Bowen, *Post-Election Risk-Limiting Audit Pilot Program 2011-2013*, http://www.sos.ca.gov/voting-systems/oversight/risk-limiting-pilot.htm (accessed Aug. 14, 2013).
[9] In 2010, AB 2023 was approved by the California Legislature and signed by the Governor, which authorized the SOS to conduct a post election audit pilot program in California counties. http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200920100AB2023&search_keywords= (accessed Aug. 16, 2013).
[10] All Post Election Risk-Limiting Audit Pilot Program Reports prepared by the SOS for the period of 2011 to 2013 can be found on the SOS website at http://www.sos.ca.gov/voting-systems/oversight/risk-limiting-pilot.htm.

ballots reviewed is based on the margin of victory and escalates when significant discrepancies between the hand tally and voting system count are identified. Instead of auditing ballots across an entire voting jurisdiction, California's One Percent Manual Tally involves counting larger quantities of ballots but only from specific, randomly selected precincts.

Post-election audits are essential to ensuring that voting systems accurately tally results and verifying that an election's outcome is not the result of fraud, tampering, or error. The benefit of risk-limiting audits is that they can precisely determine "how much auditing is necessary to confirm election results with a high confidence." Despite the fact that risk-limiting audits can lead to a full hand count of ballots, they have the potential to be to much more efficient and effective than the current One Percent Manual Tally because the number of ballots to be hand counted is dependent on a number of factors. For example, the narrower the margin of victory, the larger the initial sample of ballots to be hand counted. If the initial sample yields no errors or insignificant errors between the voting system result and interpretation of the vote by a human, the audit can stop. However, discovery of significant errors would escalate the audit, leading to a full hand count of ballots. There is not just one model for conducting risk-limiting audits, and Professor Philip B. Stark has pioneered the development of multiple methods for conducting such audits. Professor Stark, from the University of California, Berkeley, participated as lead researcher in the RLA Pilot, and has written and co-written a number of publications on the subject. For a more detailed analysis of risk-limiting audits, the reader is referred to the article entitled, "A Gentle Introduction to Risk-limiting Audits."[11]

In addition to Professor Stark, the Secretary of State engaged an advisory panel to conduct the RLA Pilot, and the pilot program team successfully conducted risk-limiting audits in eight counties prior to the end of 2011.[12] The first pilot conducted was in Orange County on March 14, 2011 following a Special Election in the City of San Clemente on March 8, 2011. In that election there was a single measure on the ballot that resulted in 17,823 ballots being cast, with 42.8% voting Yes and 57.2% voting No as displayed in Chart 1 on the following page.

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[11] Lindeman, M. and P.B. Stark, *A Gentle Introduction to Risk-Limiting Audits,* IEEE Security and Privacy, 10, 42–49 (2012), http://statistics.berkeley.edu/~stark/Preprints/gentle12.pdf. Professor Stark additionally participated in the Risk-Limiting Audits Working Group, which was comprised of election officials, researchers, and advocates, that documented a thorough analysis of risk-limiting audit methods in the white paper, *Risk-Limiting Post-Election Audits: Why and How* (October 2012) http://www.stat.berkeley.edu/~stark/Preprints/RLAwhitepaper12.pdf.

[12] California Secretary of State Debra Bowen, *supra* n. 6, http://www.sos.ca.gov/voting-systems/oversight/risk-limiting-pilot.htm (accessed Aug. 14, 2013).

Chart 1. The number of votes cast for and against Measure A in the San Clemente Special Election on March 8, 2011
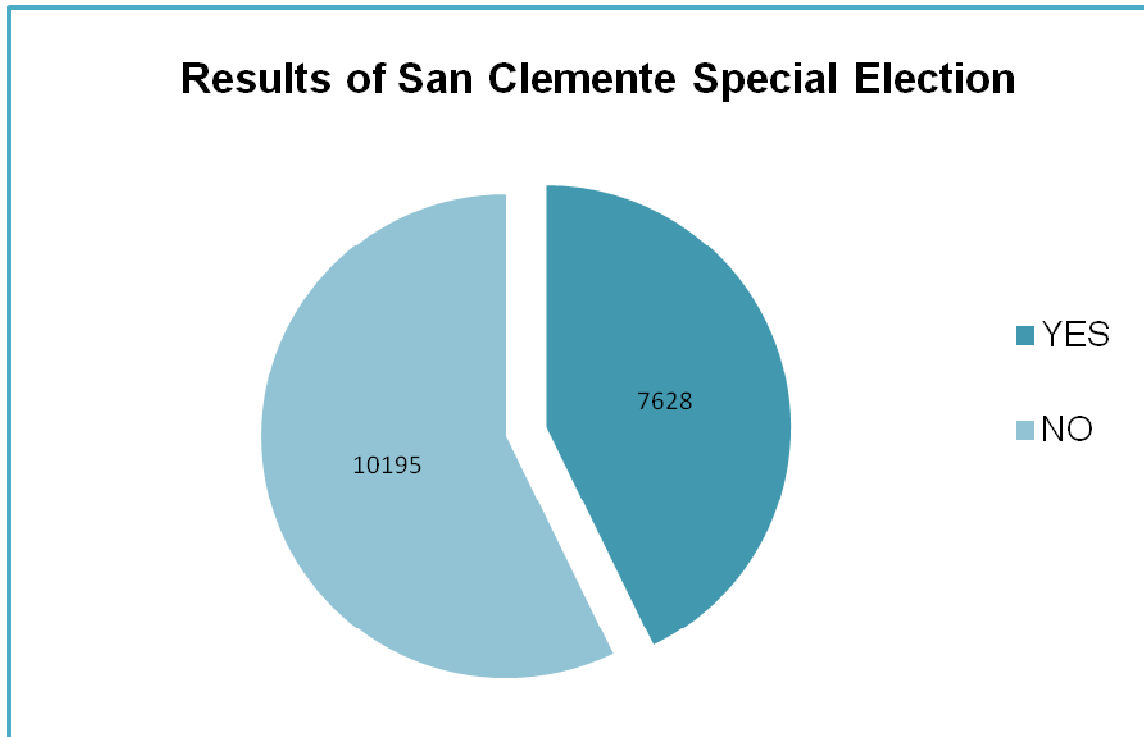
The initial sample size of the post-election audit involved 467 ballots, of which 446 were cast on Hart eSlate direct recording electronic (DRE) voting machines and 21 were cast on paper. The ballots cast on eSlate machines were audited at the DRE level, meaning that VVPATs from 12 randomly selected eSlate DRE machines were hand counted by auditors. Paper ballots were audited at the ballot level by being fed into the Hart system, which generated a cast vote record (CVR) for each paper ballot.[13] See Chart 2 on the following page for a comparison of the total number of ballots audited against the total number of ballots cast in the election.

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[13] Paper ballots audited included both vote-by-mail ballots and polling place ballots cast on paper.

Chart 2. The total number of ballots cast and audited in the 2011 San Clemente Special Election
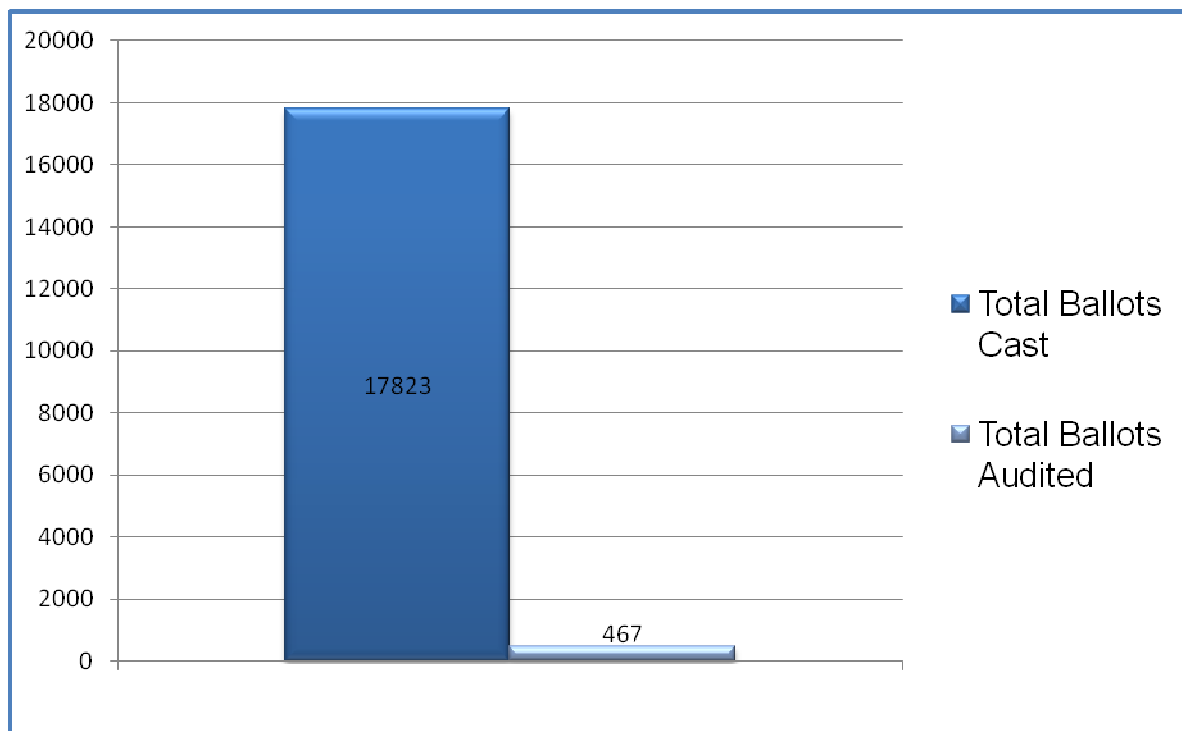
The result of the post-election audit yielded no errors. Thus, the hand tally of the 467 ballots audited perfectly matched that of the machine tally. However, while accuracy was high, so was the hand-counting burden for the audit. As pointed out by the Secretary of State in the Semi-Annual Progress Report to the EAC for the reporting period closing November 30, 2011, approximately 2.5% of all ballots cast in the Special Election were hand counted because votes cast electronically had to be audited at the DRE machine level. However, if the entire audit were conducted at the ballot level, it would have necessitated hand counting approximately 33 ballots, or just 0.10% of all ballots cast. The primary obstacle to conducting the entire audit at the individual ballot level was a limitation of the eSlate DRE machines. Auditing individual ballots cast electronically would require the DRE machines to produce CVRs that could be associated with each VVPAT. As the Hart eSlates did not have this capability, all ballots cast on the randomly selected machines had to be hand counted.

Of the 12 remaining risk-limiting audit pilots scheduled for 2012, only two were successfully completed following the June Presidential Primary Election; pilots were cancelled in six counties and postponed in four, including Orange County.[14] During the

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[14] California Secretary of State Debra Bowen, *Post-Election Risk-Limiting Audit Pilot Program 2011-2013, Semi-Annual Progress Report to the Election Assistance Commission Reporting Period Close: May 31,*

RLA Pilot it was discovered that the inability of Orange County's voting system to export CVRs associated with corresponding physical ballots was not the exception, but the rule for voting systems in use in California. Since this prohibited conducting risk-limiting audits at the individual ballot level, the pilot project team conducted a number of post-election audits by implementing a method of parallel scanning and tallying the votes. This method, described in detail by the Secretary of State, involved a second tally of the ballots using commercial-off-the shelf scanners and open source tally software.[15] Ballots were scanned and either marked or kept in a specific order so that each physical ballot would be paired with its scanned image. By making individual ballots auditable, efficiency is increased, as hand counting at the ballot level can be a significantly smaller workload than auditing vote subtotals of entire precincts. However, four counties, including Orange, conducting this scanning and tallying method of auditing were forced to postpone their audits due to problems with the tally software. While three of the postponed pilots were rescheduled for completion in 2013, the Orange County pilot was terminated in July 2012 due to a recount. The recount left Orange County's ballots out of the order from which they were scanned, thereby making it impossible to conduct a parallel scan and tally of all ballots.

Post-Election Audit Program Revise

Despite the fact that the second post-election audit was unable to be completed, Orange County's participation in the RLA Pilot yielded valuable insight into post-election audit methods and technologies.   The experience of encountering difficulties with the tally software, as well as the limited capabilities of the Hart eSlate machines, necessitated that Orange County re-evaluate the original proposal for the Post-Election Audit Program. Consequently, the Committee reconvened at the end of 2012 in order to conduct a reassessment of the Program, obtain input from stakeholders, identify hardware and software needs, and define data and reporting requirements. By February of 2013 the Committee reworked the original proposal, while still incorporating technology into the One Percent Manual Tally in order to increase the efficiency and accuracy of the process.

The revised Audit Program would allow Orange County to move to a digital platform through the use of hand-held devices and large video monitors to compile and display the data from the One Percent Manual Tally. Currently, staff conducting the post-election audit must manually record and report the data. The process is labor-intensive and time consuming, and it is not atypical for significant bottlenecks in the workflow process to result from staff having to wait in long lines to report results. The goal of entering data into hand-held devices is to increase efficiency by allowing staff to collect an increased amount of data without having to manually record the data and stand in

2013, http://www.sos.ca.gov/voting-systems/oversight/risk-pilot/progress-report-062813.pdf (accessed Aug. 19, 2013). Pilots were cancelled in the following counties: Alpine, Colusa, El Dorado, Sacramento, Sutter, and Yuba. Pilots were postponed and rescheduled in Marin, Santa Cruz, and Yolo after the SOS received a no-cost extension of the RLA Program.

[15] *Id.*

line to report and verify its accuracy. Further, utilizing the hand-held devices to collect and record data may also enhance accuracy by reducing the incidence of human error in the audit process. The hand-held device selected by Orange County for the Program is Motorola's MC65 Rugged Mobile Computer, which is pictured in Appendix A.

In addition to being inefficient, the One Percent Manual Tally process as currently conducted makes it difficult to impossible to monitor the audit's progress as it is underway. To bring clarity and transparency to the process, graphic video monitors would be used to display data in order to monitor the audit's progress in real time. It is anticipated that visually displaying data in this manner will yield several benefits. It would permit staff conducting the audit to monitor their progress in comparison to others, while enabling the Registrar of Voters to determine the most effective allocation of resources. The video monitors would also increase efficiency by allowing decision-makers to identify bottlenecks as they occur and immediately make any needed adjustments to the process, such as increasing or decreasing staff.

Further, the monitors would have the additional benefit of making the audit process more transparent to public observers who would be able to view the status of the audit and hopefully gain a better understanding of the overall process. Data collected and analyzed in real time would be transmitted wirelessly from each counting station to a visual management system developed by the Orange County Registrar of Voters. By visually displaying this data, the progress made by each Board, in addition to contest and precinct completion rates, would be presented in a clear unambiguous manner to interested members of the public.

Displaying critical information visually in the work place is not a new management technique, as visual management evolved on factory floors decades ago. The principles of visual management have been applied to various business settings and are used to facilitate understanding of workflow and the current status of processes and/or procedures.[16] Visual management has been found to be an effective method of communicating critical information, such as key performance indicators and disruption of workflow, to staff and stakeholders in order to improve performance. Four key performance indicators were selected for the Audit Program and they include: (1) contest status, (2) precinct status, (3) board status, and (4) time to complete contests by each board. These four performance measures, which are pictured in Appendix B, would be continuously displayed on large video monitors both inside the Registrar of Voters office and the adjoining warehouse throughout the Audit Program that was piloted in a 2013 Special Election.

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[16] Ad Esse Consulting Ltd., *Visual Management: Seeing Clearly*, http://www.ad-esse.com/resources/documents/articles/visual_man.pdf (accessed Aug. 20, 2013).

Figure 1. Orange County Post-Election Audit Program: Goals, Objectives & Strategies

GOAL	OBJECTIVES	STRATEGIES
Increase the efficiency, accuracy & transparency of the One Percent Manual Tally by incorporating technology into the process	Decrease # of staff needed to complete the post-election audit	Use hand-held devices to eliminate time spent by Tally Boards waiting to verify accuracy of the manual tally against the electronic tally
	Increase the accuracy of audit results while reducing time consuming errors	Use hand-held devices to allow Tally Boards to electronically record results of hand-count throughout the audit so as to reduce incidence of human error
	Decrease time required to certify election results	Display progress of audit on large video monitors where the audit is taking place to enable staff to quickly identify and address bottlenecks and workflow disruptions in real time
	Increase understanding of the post-election audit process	Display progress of audit on large video monitors in the Registrar of Voters office to enable both staff and the public to observe the progress of the audit

Test: Cypress Special Election

On June 25, 2013, a Special Election was held in the City of Cypress. On the ballot was a single measure that would amend the Specific and General Plans, as well as the Cypress Zoning Map. The election involved 16 precincts, and on June 26, 2013 precinct number 10613 was randomly selected by computer program for the post-election audit. Audited paper and electronic ballots totaled 303. After an initial training on the hand-held device, which consisted of a PowerPoint presentation and hands-on overview lasting approximately 30 minutes, the audit was successfully completed in approximately 30 minutes. The process of conducting the post-election audit is described below in detail.

Post-Election Audit Program

Step 1: Start a Precinct

Prior to counting any ballots, it was necessary to first start a *precinct* by entering specific data into the hand-held device:
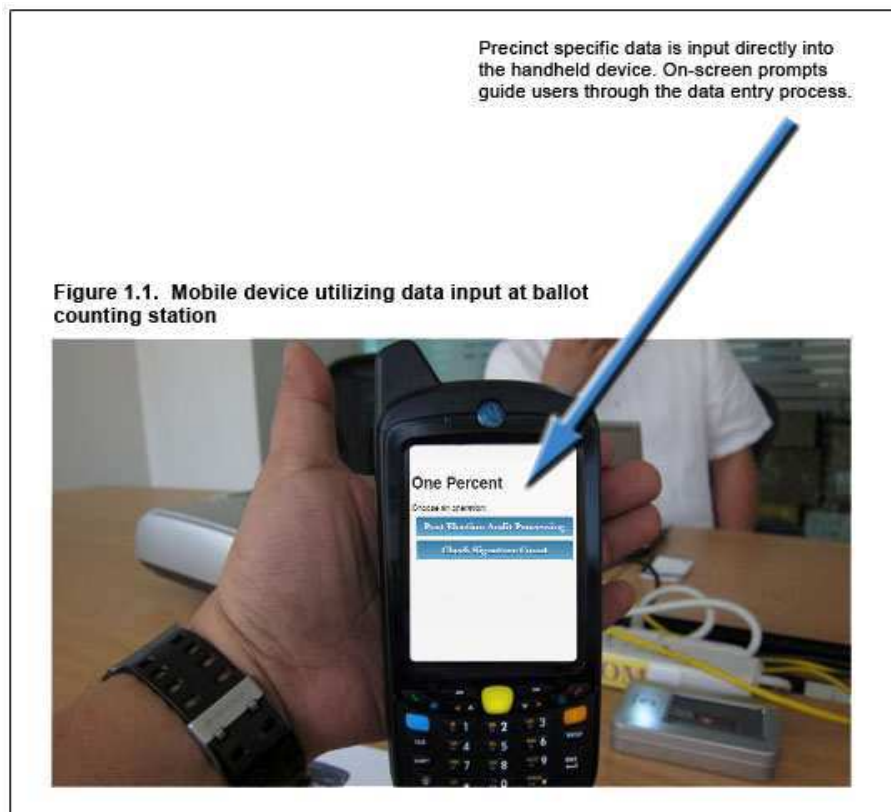
- o Board # (there was only one board used for this post-election audit)

- o "Post Election Audit" selected from menu

- Start Precinct (precinct # can be typed or scanned in using a bar code)

- Database 2 selected from menu to be used for paper ballot count

Step 2: Hand Count Total Ballots

After entering the preliminary information into the device, ballots were counted in stacks of 25 and the total was entered into the device. The counts entered into the device by staff after conducting a hand count are compared to data imported into the device from election results reports. The initial total for paper ballots entered was 107; this was incorrect. There was a second stack of paper ballots inadvertently left out of the first counting. When the incorrect number was entered into the device, it reported that the results did not match and instructed staff to recount the ballots. After recounting all the paper ballots, staff entered 226 into the device and was informed that the count was correct.   Figure 1.1 on the following page provides a display of the hand-held device and highlights the screen prompts that facilitate the entry of data.

Figure 1.1. Display of Motorola MC65 Rugged Mobile Computer

Precinct specific data is input directly into the handheld device. On-screen prompts guide users through the data entry process.

Figure 1.1. Mobile device utilizing data input at ballot counting station

One Percent

Step 3: Start a Contest

Once a precinct has been started, additional information is then entered for the purpose of starting a *contest*:

- o Type precinct # or scan barcode into the device

- o Select City of Cypress from the menu

- o Select Database 2 (for paper ballot count)

Step 4: Hand Count Paper Votes in a Single Contest

With the necessary data entered into the device, the Audit Program process was very similar to the traditional One Percent Manual Tally process.

- o Board make-up consisted of 4 staff:
  - ▪ 1 Observer
  - ▪ 1 Caller
  - ▪ 2 Counters

- o Paper ballots were organized in 9 stacks of 25 plus one additional ballot

- o The caller announced the Yes or No vote for each ballot, one stack at a time

- o The observer operated as a check to ensure that each vote was correctly called

- o Two counters tracked the vote counts using a tally sheet and two different colored pencils, alternating colors with each stack of 25 ballots once the caller announced "end of stack, change pencils"

At the conclusion of the count, the number of Yes and No votes were respectively entered into the device. There were 103 Yes votes entered and 123 No votes. After each total was entered, the hand-held device reported that the counts were accurate. If the totals had not matched, staff would have been notified that the results did not match and instructed to recount the ballots, as was the case when the initial count of the total number of ballots was entered incorrectly. However, if the ballots had been recounted and entered incorrectly a second time, the device would have prompted staff to seek assistance.

Step 5: Start a Precinct

Subsequent to completing the tally of paper ballots, staff audited ballots cast electronically by hand-counting VVPATs. The first step in conducting a hand-count of VVPATs was identical to that for tallying paper ballots. The precinct was started by entering the data listed above in Step 1 into the device, with the exception that Database 3, not 2, was selected for the VVPAT count.

Step 6: Hand Count Electronic Votes in a Single Contest

Votes were cast electronically on eight eSlate DRE machines. Each roll of tape was examined for provisional votes, which were marked with a sticker so they would not be included in the count. Additionally, rejected ballots were marked with stickers so that only accepted ballots were counted. The total number of VVPATs counted and entered into the hand-held device was 77, and the count was verified as accurate by the device.

Step 7: Start a Contest

The data entered into the device to start a contest was the same as that listed above in Step 3; however, Database 3 was selected instead of 2 for the VVPAT count.

Step 8: Hand Count VVPATs in a Single Contest

As with hand-counting paper ballots, the Audit Program process for tallying VVPATs was almost identical to the traditional One Percent Manual Tally process.

- o Board make-up consisted of 4 staff:
    - 1 Roller & Observer
    - 1 Caller
    - 2 Counters

- o One staff rolled the tape and observed to ensure each yes or no vote was correctly called

- o The caller announced each Yes or No vote

- o The counters tracked the vote counts using a tally sheet and two different colored pencils that were alternated with each new roll of tape

The results of the VVPAT count were 17 Yes and 60 No votes. These counts were verified as accurate upon their entry into the hand-held device.

While the process of conducting the hand-count was very similar to the traditional method of conducting the One Percent Manual Tally, there were a couple of notable differences. By using the device, there were many points in time when staff did not have to stop the count to report results to supervising staff in order to verify the

accuracy of the count and be allowed to proceed.   Such points in time during the Audit Program included: (1) reporting and verifying the accuracy of the initial count of 107 total paper ballots; (2) reporting and verifying the accuracy of the second count of 226 total paper ballots; (3) reporting and verifying the accuracy of Yes votes on paper; (4) reporting and verifying the accuracy of No votes on paper; (5) reporting and verifying the accuracy of the total count of VVPATs; (6) reporting and verifying the accuracy of Yes votes cast electronically; and (7) reporting and verifying the accuracy of No votes cast electronically.

Admittedly, in the case of a small Special Election such as Cypress the traditional method would likely not have involved a significant amount of time. However, in a statewide election when there may be up to 20 Boards hand-counting ballots and waiting in line to report results, the time saved through the use of this technology would be substantial.

Another noteworthy, but underutilized, benefit resulted from the addition of the large video monitors to the Audit Program. The large video displays clearly and effectively communicated information about the progress of the post-election audit to the entire staff. However, the full benefit of the displays were likely not realized during the Audit Program as there was only one Board required to complete the One Percent Manual Tally. It is expected that the use of video displays will be more impactful in larger elections that necessitate a large number of Boards operating at once. This is due to the crucial role the monitors will play in identifying workflow bottlenecks in real time, thereby permitting staff to address issues with greater alacrity. In the Audit Program, the video monitors, pictured in Appendix B, were used to effectively report the status of four key performance indicators. By visually displaying the below-described four key performance indicators in real time, the post-election audit workflow is made clear to all, including staff, management, and observers, thereby increasing understanding of the process and facilitating the prompt identification of issues that may impede the process.

The Board Status display shows the progress of each Board by showing the total number of contests completed. This display can help identify when a given Board(s) is having difficulty completing contests in comparison to the other Boards involved in the audit, thereby aiding in the prompt identification of issues that may necessitate additional assistance or a reallocation of staff to prevent a significant disruption to workflow. The second display reports the time taken by each Board to complete a contest. While there was only one Board conducting the post-election audit for the Cypress Special Election, in a large statewide election this display can effectively communicate to all staff how every Board is performing by providing a visual comparison of the amount of time needed for all Boards to complete individual contests. As with the Board Status display, this can aid in identifying bottlenecks in real time so that problems can be addressed sooner and delays can be minimized. The third indicator displayed is Precinct Status, which depicts the progress made in all precincts audited by reporting the number of precincts completed, in progress, and not started. The fourth and final indicator presented on the monitors is Contest Status, which shows

the rate of completion for each contest by reporting the number completed, in progress, and not started, much in the same way as Precinct Status data is presented.

Findings

Certifying the Cypress Special Election required manually tallying 303 votes cast in one contest. Paper ballots made up approximately 75% of the ballots that were hand-counted, while votes cast electronically, or VVPATs, were 25% of the post-election audit as shown in Chart 3 below.

Chart 3. Type of ballots cast in One Percent Manual Tally for the 2013 Cypress Special Election

Number of Ballots Cast by Type

- Electronic: 77
- Paper: 226
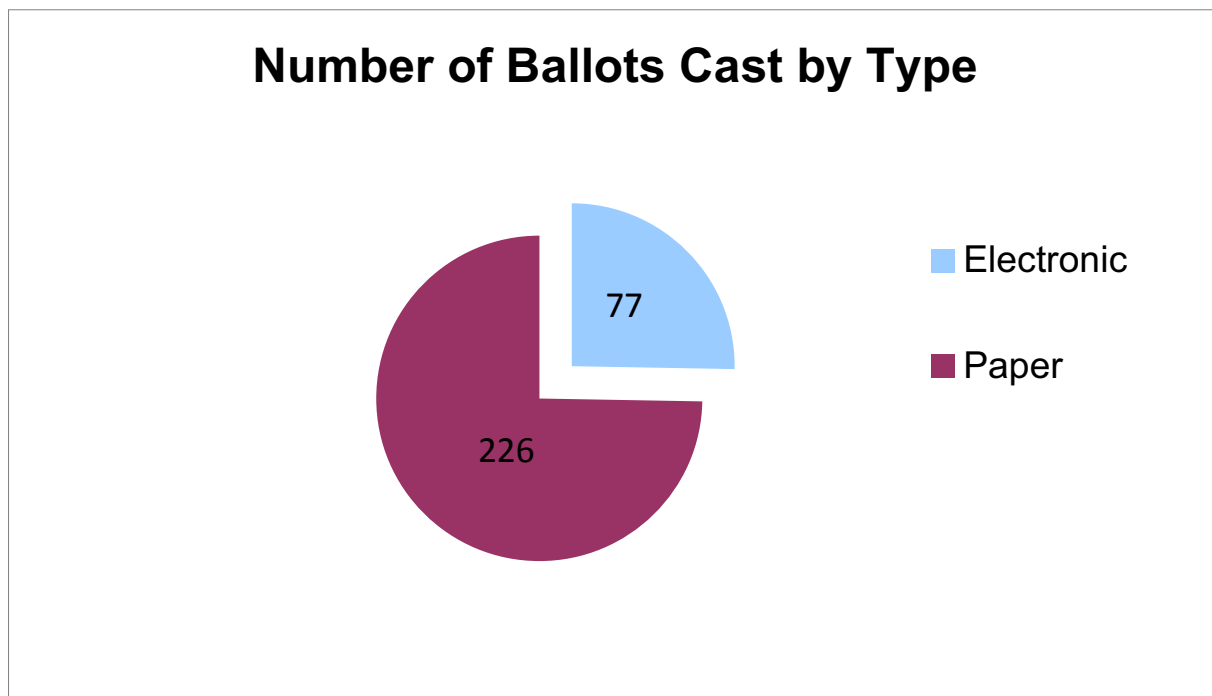
The time required to complete the One Percent Manual Tally, as described in above-listed Steps 1 through 8, was approximately 30 minutes. While this appears to indicate that using the hand-held devices permitted the hand-counting of an average of 10 votes per minute, the average time to manually tally votes varied depending on whether they were cast on paper or electronically. The amount of time required to hand-count votes cast on paper ballots was nearly identical to that needed to count votes cast electronically; or in other words, it took approximately 15 minutes to count 226 paper ballots and another 15 minutes to count 77 VVPATs. Thus, 15.07 paper votes were counted per minute in contrast to 5.13 VVPATs counted per minute as shown in Chart 4

on the following page. The time differential between hand-counting paper ballots and VVPATs is significant but not unexpected due to the additional steps that are taken in the latter case to identify provisional and rejected ballots, as well as the time required to roll the VVPAT tape throughout the hand-counting process.

Chart 4. Number of ballots counted per minute in the 2013 Cypress Special Election

Ballots Counted Per Minute by Type

[Bar chart showing VVPAT at 5.13 and Paper at 15.07 ballots counted per minute]
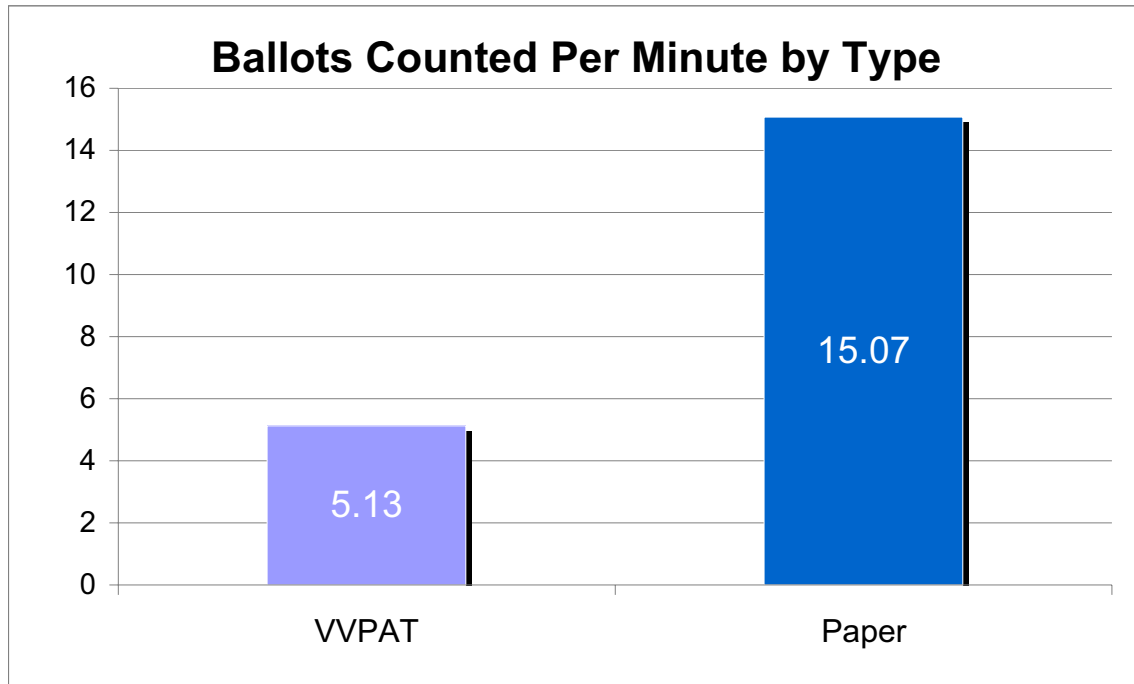
A comparison of the results of the Audit Program to the time required to conduct the One Percent Manual Tally in a statewide election is imperfect due to varying conditions and circumstances. In the Cypress Special Election, 6,884 ballots were cast across 16 precincts necessitating a manual tally of 303 ballots. In contrast, 1.13 million ballots were cast in 1,977 precincts across Orange County in the 2012 General Election. Nearly 50 precincts were involved, in whole or in part, in the One Percent Manual Tally, which necessitated hand-counting approximately 30,884 ballots covering nearly 500 contests.   Five precincts from the 2012 General Election were identified to serve as a basis of comparison against the Audit Program, as they were also audited for a single contest.[17] While a small sample size, these precincts were identified to help control for variances that may result from additional factors involved in auditing precincts with multiple contests.   It is noteworthy that there is considerable variation in the amount of

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[17]   The five precincts identified from the 2012 General Election to be used as a basis for comparison against data collected from the Audit Program include: 14044 (Garden Grove), 17260 (La Habra), 38602 (Laguna Hills), 52604 (Costa Mesa), and 75602 (Villa Park).

time required to manually tally votes when solely examining the precincts audited in the 2012 election, even after controlling for ballot type. The comparison of 2012 General Election data to 2013 Audit Program data from the Cypress Special Election reveals an increase in the number of ballots counted per minute; however, the magnitude differs according to ballot type.

Charts 5 and 6 below compare data pertaining to votes cast electronically in the 2013 Program Audit against that from the five precincts audited in the 2012 General Election. Charts 7 and 8 display the same data points as they pertain to paper ballots cast.

Chart 5. The number of electronic ballots counted per minute in the Cypress Special Election and 5 precincts in the 2012 General Election
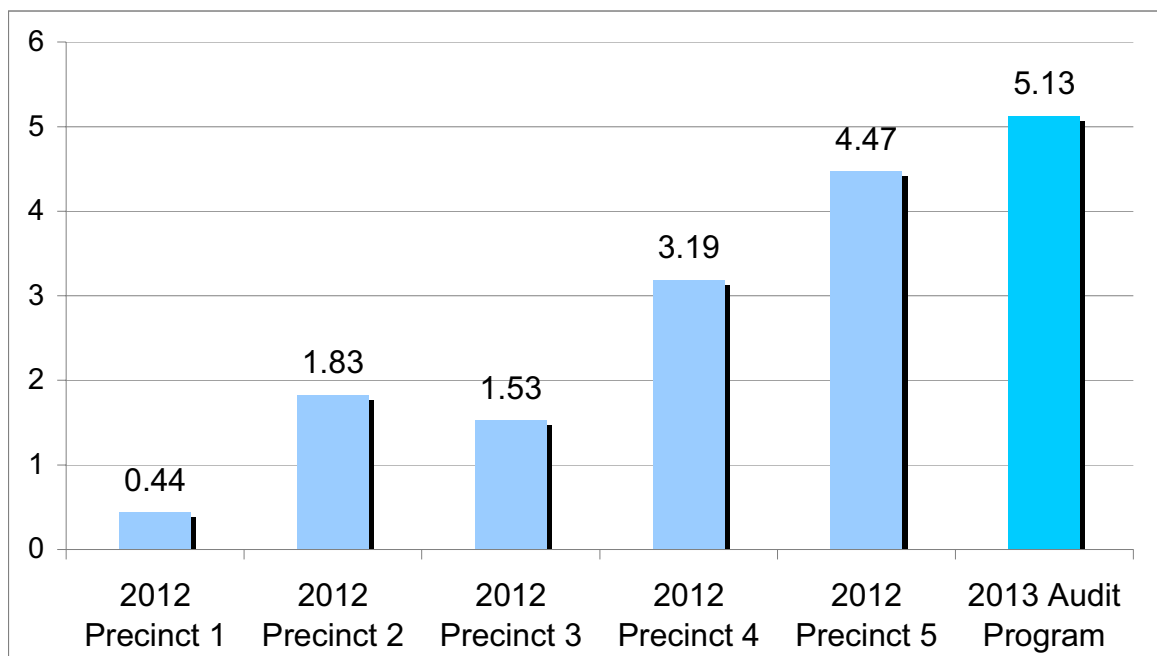

Chart 5 above reveals that the number of VVPATs hand-counted per minute varies significantly among the five precincts from the 2012 election with the rate of hand-counting VVPATs slightly increasing from the largest number 4.47 hand-counted per minute in 2012 by Precinct 5 to 5.13 tallied per minute in the 2013 Audit Program. It is important to note that the rate of manually tallying ballots does not appear to correspond to the quantity of ballots audited in a given precinct. This is evidenced by the fact that the precinct with the lowest number of ballots tallied per minute was not the precinct with the largest number of ballots audited, but instead it was the precinct with the smallest number as shown on the next page in Chart 6.

Chart 6.   Total number of VVPATs audited by precinct as compared to the number of votes hand-counted per minute
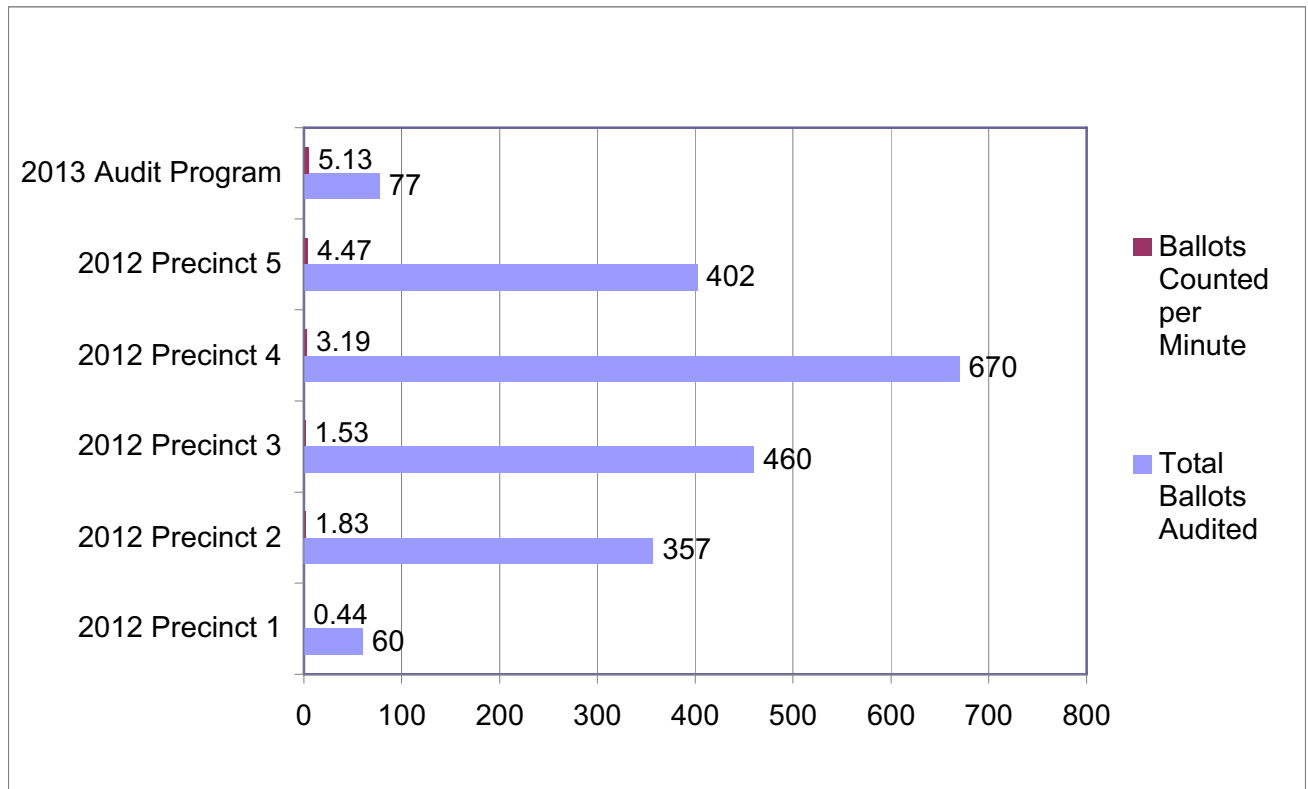
While it may be unsurprising that with the second lowest number of ballots audited, the 2013 Audit Program resulted in the fastest rate of tallying VVPATs per minute, Precinct 5 had the second fastest rate of hand-counting VVPATs despite the fact that the precinct had the third largest number of ballots to be audited. As previously stated, a comparison of the data in Charts 6 and 6 indicates that the number of ballots counted per minute bears no correlation to the total number of ballots audited per precinct.

As in Charts 5 and 6 above, Charts 7 and 8 will show data collected in regard to the number of votes manually tallied per minute and the total number of ballots audited per precinct; however, this data pertains only to votes cast by paper ballot.

Chart 7.   The number of votes cast by paper ballot counted per minute in the Cypress Special Election and 5 precincts in the 2012 General Election
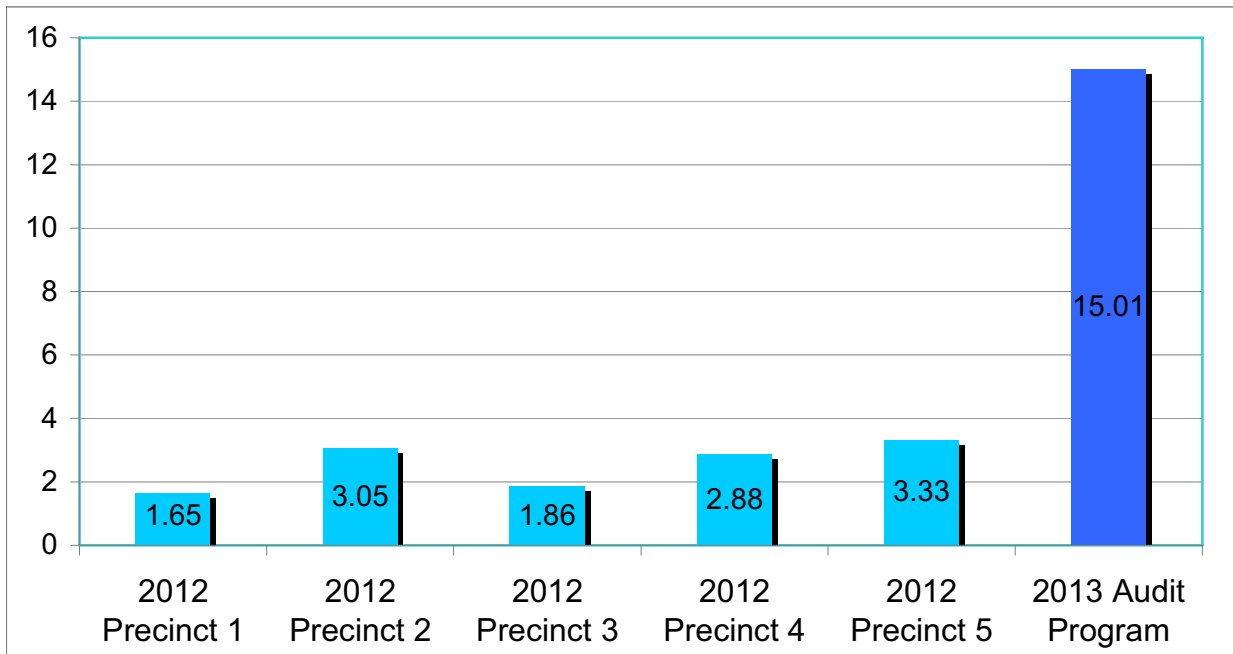
While there is some variation in the rate of hand-counting paper ballots amongst the five precincts from the 2012 General Election, that variation is smaller than when compared to the variation in the rate of manually tallying electronic ballots in those same precincts. Further, the increase in the rate of hand-counting VVPATs from the fastest rate in 2012 to that in the 2013 Audit Program was modest when compared to the dramatic increase in the rate of manually tallying paper ballots from 2012 to 2013, as shown here in Chart 7. However, the data presented on the following page in Chart 8 reveals that, similar to electronic ballots, there does not appear to be any correlation between the quantity of paper ballots audited and the number tallied per minute.

Chart 8. Total number of paper ballots audited by precinct as compared to the number of votes hand-counted per minute
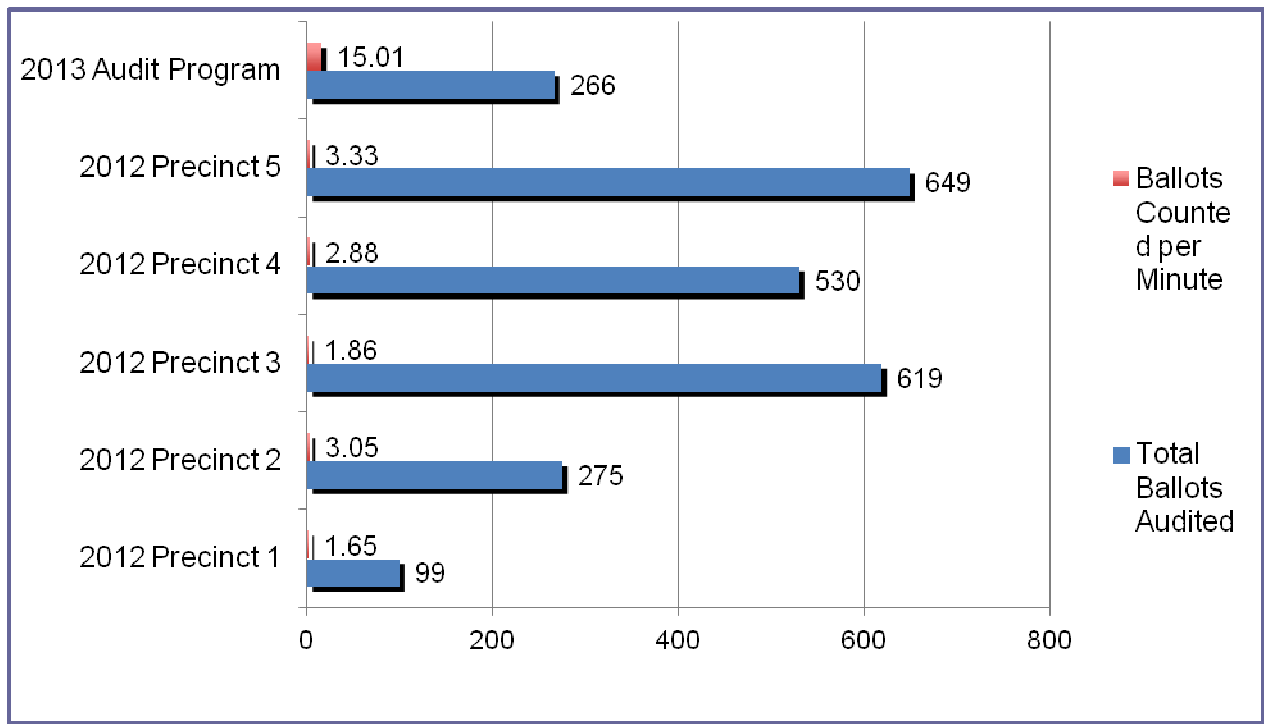
As was the case with electronic ballots, the precinct with the smallest number of paper ballots to audit in 2012 (Precinct 1) was also the precinct with the lowest number of hand-counting votes per minute. While the precinct with the largest number of paper ballots to audit was the second fastest in manually tallying the votes (Precinct 5), the precinct with the second highest number of ballots to audit was also the second slowest at hand-counting votes per minute. Once again, the data does not indicate that there is a relationship between the number of ballots audited in a given contest and the rate at which those ballots will be manually tallied.

Conclusions

Findings

The goal of the Audit Program was to increase the efficiency, accuracy, and transparency of the One Percent Manual Tally through the incorporation of technology into the process. The results of the Audit Program show that the completion of the post-election audit was expedited in the Cypress Special Election, which involved the use of the hand-held devices and video monitors, in comparison to five precincts from the 2012 General Election. The five precincts from the 2012 election were used as a basis of

comparison because, similar to the Cypress Special Election, they were only audited for a single contest. While this eliminated one variable, it was not possible to control for all the potential variations that can arise due to the fact that the circumstances and conditions of every election are different.   Admittedly, the results of the Audit Program are impacted by measures difficult to quantify including, but not limited to, the experience and skills possessed by the staff making up the Boards, human error, and the impacts of fatigue and distraction on the performance of this exacting task. While technology is not the only factor affecting the results of the Audit Program, it is worth reiterating that there was variation in the results across all precincts compared, as the results did not reveal only a variation between 2012 and 2013 data.   For example, there was a much greater discrepancy in the number of electronic ballots counted per minute between Precincts 5 and 1 from the 2012 General Election than there was between Precinct 5 from 2012 and the precinct audited in the 2013 Special Election.

The results from the Audit Program do not show a cluster of similar times and counts from 2012 that are inconsistent with that from the 2013 election, but rather the data reveals a range extending across all precincts regardless of the election cycle. In the case of both paper and electronic ballots, the rate of ballots manually tallied per minute in the 2013 Audit Program exceeded that of all five of the 2012 comparison precincts. So while the technology used in the 2013 Audit Program may not have been the only factor, the data indicates that it did in fact contribute to a more efficient post-election audit.   The results were not unexpected as the hand-held devices reduced the disruptions to the tally process, as staff did not have to stop the hand-count to wait in line to verify the results with a Supervisor. By permitting staff to record data throughout the manual tally process, it is additionally believed that human error was reduced, which thereby reduced the amount of time spent recounting ballots due to inaccurate initial tallies. Further, the full magnitude of the utilized technology's efficacy was likely not realized in the 2013 Audit Program. It is expected that by displaying the four key performance indicators on large video monitors, both transparency and efficiency will be significantly increased due to the utility of the monitors in enabling staff to promptly and proactively address bottlenecks in the audit process. Staff supervising the audit process will no longer have to wait for the Boards to alert them to issues and problems, but they will be able to observe the progress made by all Boards in real time.

Recommendations

While the Cypress Special Election was a small test election, the results of the Audit Program are promising. The Orange County Registrar of Voters office has invested in this technology through the acquisition of 23 hand-held devices and 16 video displays, and foresees that this investment will yield even greater benefits during the 2014 statewide elections. Orange County has long sought out means to innovate the elections process through the use of technology and the implementation of efficient practices and procedures. While a critical check on the reliability and accuracy of voting system, there is much room to improve and streamline the One Percent Manual Tally. The utilization of hand-held devices and video monitors is but one method of increasing the efficiency and accuracy of the post-election audit, but it is by no means the only

method. The experience of participating in the RLA Pilot, though unsuccessful, was insightful, as it revealed the opportunity to improve the process through enhanced voting system capabilities and the potential for utilizing other methodologies for conducting more efficient and accurate post-election audits.   It is hoped that experimentation and innovation in this area will continue in order to identify methods and technologies that will decrease the amount of resources and error involved in the One Percent Manual Tally, while increasing both the public's trust in election results and the transparency of the processes by which those results are certified.

Appendix A: Motorola MC65 Rugged Mobile Computer

Appendix B: 4 Key Performance Indicators Displayed on Video Monitors

1. Board Status
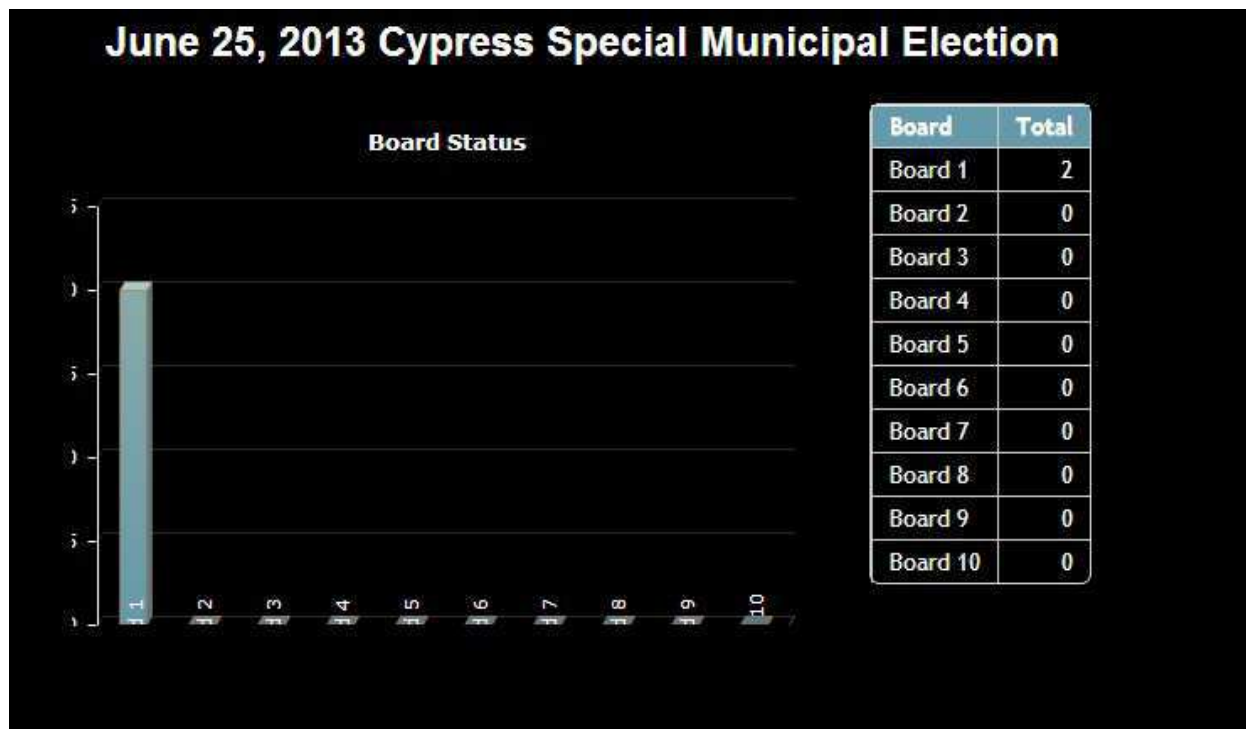
Board Status displays the progress of each Board by showing the total number of contests each has completed. Board 1 was the only Board involved in the One Percent Manual Tally for the City of Cypress Special Election. While there was only one contest on the ballot, the display shows two completed as the paper ballot counts for one and the VVPAT count is the second.

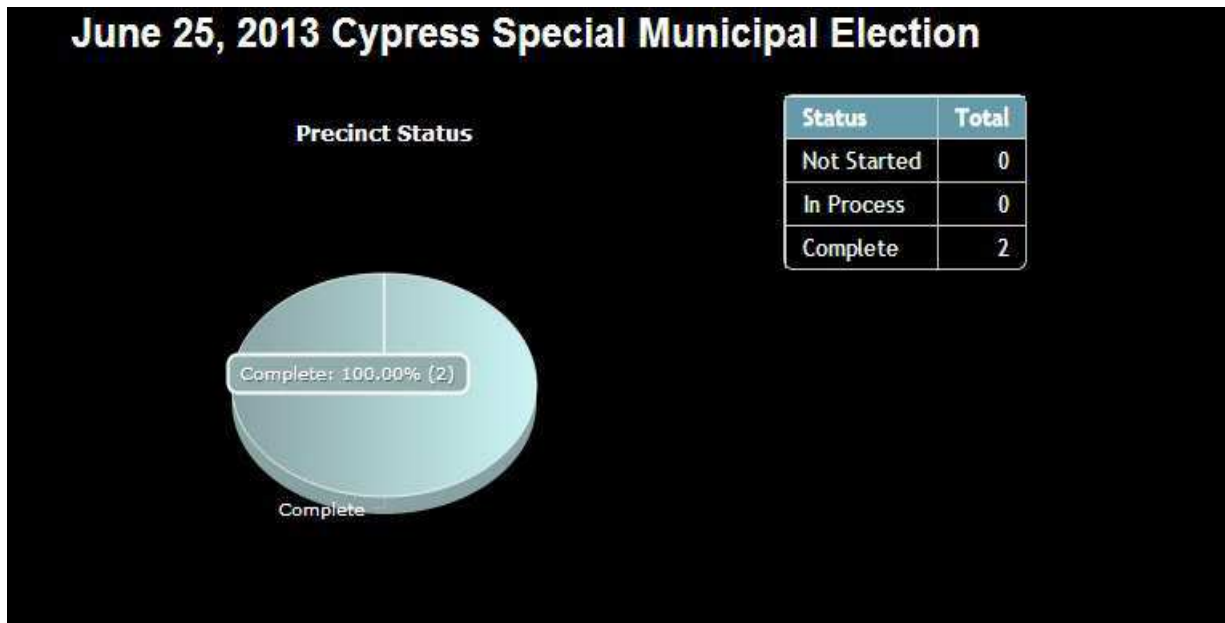**Appendix B: 4 Key Performance Indicators Displayed on Video Monitors**

2. Time to Complete Contest by Board

Board	Time
Board 1	14.508333333333
Board 2	0
Board 3	0
Board 4	0
Board 5	0
Board 6	0
Board 7	0
Board 8	0
Board 9	0
Board 10	0

Time to Complete Contests by Board displays the amount of time in minutes a given Board needed to complete a single contest. Again, in this context a contest does not include both the paper and VVPAT count. Hence, this display shows that it took Board 1 approximately 15 minutes to complete a hand count of paper ballots cast for a single contest; VVPATs for the same contest were timed separately.

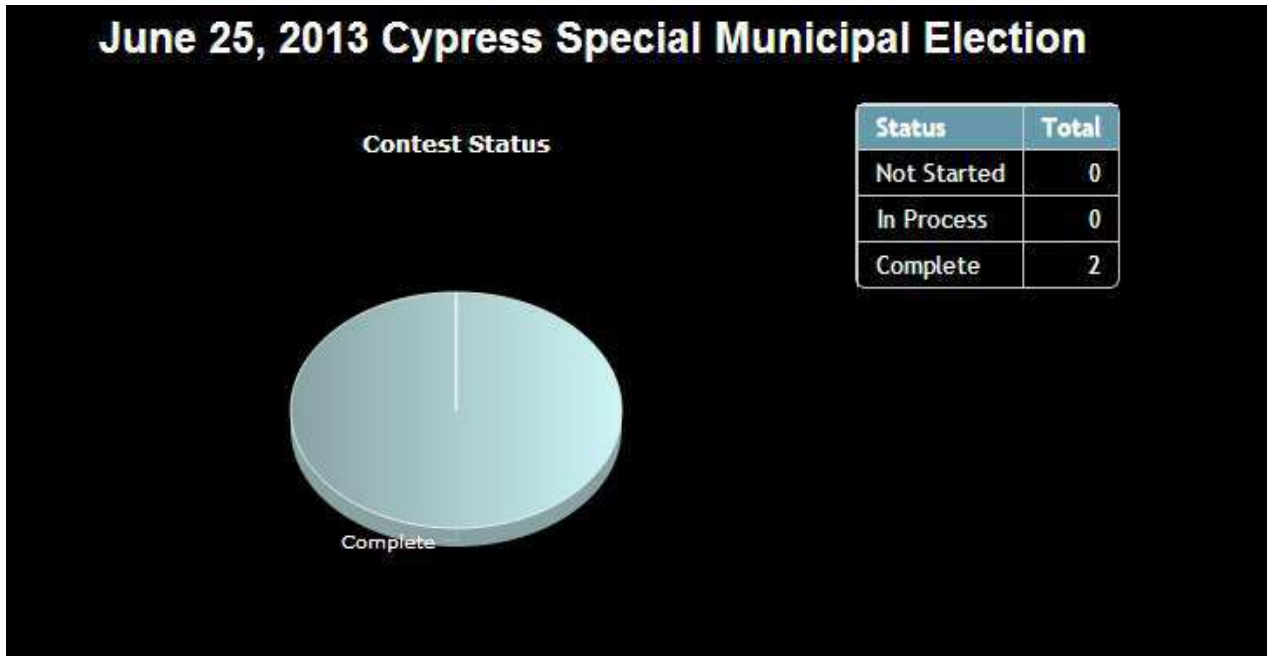**Appendix B: 4 Key Performance Indicators Displayed on Video Monitors**

3. Precinct Status

The Precinct Status display reports the total progress of the post-election audit based on the total number of precincts that have been completed, are in progress, or have not been started.

Appendix B: 4 Key Performance Indicators Displayed on Video Monitors

4.   Contest Status

The Contest Status display reports the total progress of the post-election audit based on the total number of contests that have been completed, are in progress, or have not been started.