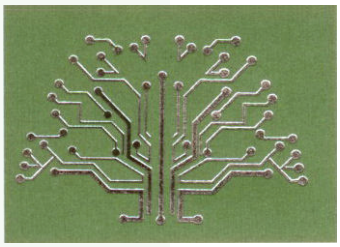

FREEMAN, CRAFT, MCGREGOR GROUP

California Secretary of State Consultant's Report on:

Functional Testing of the ES&S Unity 3.4.1.0 Voting System

Prepared for the California Secretary of State by:

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November 4, 2016

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Election Systems & Software's Unity 3.4.1.0 System Components

The Election Systems & Software (ES&S) Unity 3.4.1.0 Voting System tested consisted of the following major components:

Software Modules**:**

- Audit Manager (AM) version 7.5.2.0
- Election Data Manager (EDM) version 7.8.2.0
- Election Reporting Manager (ERM) version 7.9.0.0
- ES&S Image Manager (ESSIM) version 7.7.2.0
- Hardware Programming Manager (HPM) version 5.9.0.0
- LogMonitor Service version 1.1.0.0
- AutoMARK Information Management System (AIMS) version 1.3.257
- VAT Previewer version 1.3.2907

Hardware Components:

- M100 Precinct Counter HW 1.3/FW 5.4.4.5
- M650 Central Ballot Counter HW 1.2/FW 2.2.2.0
- DS200 Precinct Scanner HW 1.3/FW 1.7.0.0
- DS850 Central Ballot Counter HW 1.0/FW 2.9.0.0
- AutoMARK Voter Assist Terminal (VAT) A100 HW1.0/FW 1.3.2907
- AutoMARK Voter Assist Terminal (VAT) A200 HW1.1,1.3.0&1.3.1/FW 1.3.2907

Scope of Work and Reporting

State certification testing for the Unity 3.4.1.0 System consisted of a series of test events in different locations:

a. System installation and benchmarking, CA SOS office, Sacramento, CA
b. Phase I, Functional Testing, CA SOS office, Sacramento, CA
c. Accessibility Testing, CA SOS office, Sacramento, CA
d. "Red Team" Security Testing, CA SOS office, Sacramento, CA
e. "Red Team" Security Testing, Coherent Cyber office, San Antonio, TX
f. Source Code Review, atsec information security office, Austin, TX
g. Phase II, Functional Testing, CA SOS office, Sacramento, CA
h. Volume Testing, County of Sacramento Voter Registration and Elections Department, Sacramento, CA

This report covers work completed in Phase I and Phase II functional testing. Narratives describing the Accessibility testing, Volume testing and Security testing ("Red Team" and Source Code Review) are prepared as separate reports.

We are not attorneys and do not offer legal advice. We have assisted the California Secretary of State in collecting facts and evidence to reach certification decisions. However, to advise the Secretary of State

(SOS) on the determination of whether the system complies with California's certification requirements would require an interpretation of law. Accordingly we do not provide recommendations or any opinion as to whether the system can be certified.

The work we performed and our findings are strictly limited to the specific serial numbered hardware elements and specific software elements tested during the examination. An inventory of those items is included as Attachment A to this report. The results described in this report should be reliable and repeatable for those specific items. The decision to apply those results to decisions regarding other items is solely at the discretion and risk of the Secretary of State and election officials who purchase the system. Although Attachment A can be used as part of a baseline to reach conclusions regarding the compliance of other items, anyone who wishes to determine the compliance of purchased systems or the compliance of a system in use should conduct appropriate acceptance testing or system validation analysis to support those conclusions.

Description of the System Submitted for Certification

The ES&S Unity 3.4.1.0 (Unity) System is a paper ballot based system. It is a suite of software applications that provides election definition (EDM), ballot layout (ESSIM), voting machine programming (HPM), voting result collection (ERM), consolidated reporting (ERM), access controls and audit logging (AM). The (AIMS) application accepts files from the other modules in Unity to create the election definition for the AutoMARK Voter Assistance Terminal. The applications may be installed on a workstation configured as a full installation of all applications and/or as an ERM only workstation. Either configuration may be installed as a standalone workstation or a client workstation. The software applications can be set up to support one or more of the hardware components described below:

The M100 optical scan tabulator uses Intelligent Mark Recognition, a continuous scan technology, to sense the presence of marks on ballots. This visible light technology allows the ballot to be read in any orientation as it is fed into the machine. It is usually used to tabulate ballots in a polling place, but may also be used as a central count device in small jurisdictions.

The M650 is a high speed, optical scan ballot counter used in central count operations. It is generally used to tabulate mail-in and provisional ballots. It can only read the ballot from one orientation and requires that the ballot be fed in only that direction.

The DS200 is a digital scan tabulator that scans and stores a full-page image of the ballot. During tabulation, the images are processed by proprietary mark recognition software. It is generally used to tabulate ballots in a polling place, but may be used as a central count device in small jurisdictions.

The DS850 is a high-speed digital scan ballot counter that scans and stores ballot images and is used in central count operations. During tabulation, the images are processed by proprietary mark recognition software. This tabulator can out stack write-in ballots and unreadable ballots into separate batches. Ballots may be fed in any orientation. It is used to tabulate mail-in and provisional ballots.

The AutoMARK Voter Assist Terminal (VAT) system accepts ES&S unvoted ballots and, through a DRE style touch screen, allows the voter to select, review, and correct his or her choices before the ballot is actually marked. When the voter has selected the candidates and contests, the AutoMARK marks their choices on the ballot. The ballot is returned to voter who, in turn, carries it to one of the precinct scanners or deposits it into a ballot box for central tallying. The VAT includes alternative interfaces for voters with disabilities, including enhanced visual and audio presentations of the ballots and support for alternative assistive devices such as paddle switches and sip and puff devices. A

voter may also insert a marked ballot and verify that the ballot is marked properly through either a visual screen or an audio ballot playback.

The Unity paper ballots have machine-readable identification marks that are used by the scanners and the AutoMARK to identify the ballot style and tally the votes marked on the ballots. Although ballots are tallied using devices that read optical marks, they can be manually counted or reviewed in the case of an audit, a recount or examination by ballot resolution boards.

Overview of System Operation

A flow chart illustrating the system configuration can be found in Attachment B.

The initial election definition is created in EDM. This is the entry point for defining a new election. EDM stores precinct, office and candidate information. It can import data from candidate qualification and voter registration systems. The definition created within EDM contains no information regarding ballot formats, but creates a ballot definition file (.bdf) that will be imported for use in the ESSIM applications.

ESSIM is a desktop publishing application used to design and print ES&S paper ballots. It uses the information created by EDM to create and display ballot artwork. Its edit capabilities allow users to modify text formatting, the size and positioning of information labels and voting positions for candidates and questions. Alternative language translations may also be loaded and linked to the election definition in ESSIM. The application allows ballots to be printed directly (appropriate for small numbers of ballots) or will create Portable Document Files (.pdf) for use by printing services. It creates an interface file (.ifc) that will be imported into the HPM and AIMS applications.

HPM imports the .ifc file produced by ESSIM and provides the election definition and ballot layout information for programming the ballot scanners in the ERM module.

ERM supports the accumulation and combination of ballot results from all ES&S tabulators. It generates a variety of printed and electronic reports. It can display election results on monitors or send results directly to media outlets. It allows report formats to be customized.

The AutoMARK Information Management System (AIMS) application imports the .ifc file to create the election definition that is programmed in the AutoMARK VAT. AIMS has the capability to edit the imported election definition to make corrections and adjustments so VAT will recognize, display and mark the voter's choices in the correct positions.

Federal Certification

The United States Election Assistance Commission, Certification Number ESSUnity3410 was issued April 4, 2014. The system is a modification to two previously certified systems: Unity 3.2.1.0 certified on March 29, 2011, under Certification Number ESSUnity3210, and Unity 3.4.0.0. certified on October 31, 2012, under Certification Number ESSUnity3400. Unity 3.4.1.0 provides upgrades to the following components of Unity 3.4.0.0:

Election Data Manager (EDM)
ES&S Ballot Image Manager (ESSIM)
Hardware Programming Manager (HPM)
Election Reporting Manager (ERM)
DS200 Scanner
DS850 Scanner

Approach to Testing

Prior to functional testing, the operating system was installed and benchmarks were established. The Secretary of State of California's test procedures require that the hard drives of computers used in testing are completely wiped and a fresh installation of the operating system is completed. Following the vendor's documentation, the system software and all required supporting utilities were installed from trusted installation media. This work was completed on February 5, 2016.

Functional testing was a joint effort shared by consultants, SOS staff and vendor staff. The Freeman, Craft, McGregor Group (FCMG) and SOS jointly managed the test. ES&S provided technical support and witnessed the test. Personnel included:

FCMG:
- Steve Freeman
- Paul Craft
- Kate McGregor

SOS
- Todd Ross
- Bruce McDannold

ES&S
- Brooke Thernes
- Jeff Rodencal

Functional testing is typically divided into two phases. Phase I includes the steps necessary to install the system, develop test elections, provide ES&S with the data required to print test ballots and to prepare equipment for Red Team Penetration Testing. This work was completed on May 6, 2016. Phase II exercises the system by following the California Use Procedures to stage an election, documents the test results, and prepares benchmark data for future forensic validation of the system by the California Secretary of State. This work was completed on June 18, 2016.

Test elections used for functional testing included a Primary election, a General election, and a Recall election. Prior to FCMG's engagement to assist the SOS with functional testing, the SOS and ES&S decided to use election definitions for the Primary election and the General election from past California elections held in large counties. The elections selected were a Primary election from Sacramento County and a General election from Contra Costa County. The Sacramento County election definition was provided by ES&S, just as it would be provided to a county that was contracting with ES&S for election definition services. The election definition for Contra Costa County was developed using delimited files of candidate, contest and precinct data, as they would be generated in an election office and used by the county to create its own election definition. The election definition for the recall election was coded from scratch during testing.

Scope Limitation

The use of the two large county election definitions limited the scope of the test. At the outset, the intent was to use the Sacramento election to test the second tier of ballot rotations, which are based on County Supervisor districts. However, Sacramento County has five State Assembly districts. Under the rules for ballot rotations, when a county has five or more Assembly districts, the Assembly districts are used for all rotations and the second tier of rotations, based upon Supervisor districts, does not exist. As a result, the second tier of rotations could not be exercised. This was discussed with SOS staff and, since the two-tier

rotation is a function that previous versions of the system have handled successfully, and the change logs for the system did not indicate a change to this function, the scope limitation was deemed a low risk and was accepted.

Phase I Testing

Phase I testing began on May 2, 2016.

Firmware Upgrades

The firmware from the trusted build was installed on the hardware components following the method described in the California Use Procedures.

The firmware was successfully installed on the M100 and DS850.

The prod.release.img, rather than the update.img, file, was initially used to install firmware on the DS200. Errors were encountered because the prod.release.img file is designed for installations on newly manufactured machines rather than upgrades to previously installed firmware. When the correct file was used, firmware was successfully installed on five machines, but the sixth machine displayed errors. It appeared to be adversely affected by the previous attempt to load the incorrect file. ES&S personnel provided alternative procedures to update the machine's internal compact flash card with the prod.release.img file. The Use Procedures were amended to include this alternative procedure in case an initial firmware update turns out to be unsuccessful.

The installation on the M650 was complicated because the machine had been previously upgraded with the new firmware and the machine is designed to prevent identical firmware from being loaded onto it. For the purpose of testing, the firmware first had to be downgraded to an earlier version. Once the downgrade was accomplished, the firmware was successfully installed according to the Use Procedures.

A combination of errors in the Use Procedures and user errors complicated the firmware upgrade for the AutoMARK. ES&S was able to diagnose the problems and the firmware upgrade was ultimately successful. However, at the conclusion of Phase I testing, causes of the failure had not been determined. It was agreed that ES&S would provide documentation on the issue that would be reviewed and tested during Phase II testing.

Firmware Validation

Following the firmware upgrades the plan was to follow ES&S validation procedures to create benchmarks for future validations. ES&S decided to withdrew their original validation procedures and present revised procedures during Phase II testing so this activity was deferred until that time.

Primary Election

The Sacramento County, June 5, 2012, Presidential Primary election definition was used for this test. This election included one thousand forty-one precincts, seven partisan ballots, and a No Party Affiliation (NPA) ballot. ES&S prepared and provided the completed election definition as they would for a county with whom they contracted to provide election services. For the purpose of this test, the SOS requested that five precincts be selected that met the following criteria:

- One precinct that is entirely vote-by-mail (with no corresponding physical precinct)
- Two precincts that have identical ballot styles
- Two precincts that are located in the same Congressional district but different Assembly districts
- Two precincts with the same local contests (county or municipal) but different Supervisorial districts
- At least one of the numbered precincts must be among the 5% assigned the highest precinct numbers and one must be among the 10% assigned the lowest precinct numbers.

ES&S provided copies of the folders and data files for the Sacramento Primary election to populate the EDM and electdata folders in the test system. Instructions were provided in the Unity EMS Programming Guide revised in May, 2016. The appropriate folders were copied into the county and election databases and the results were checked for errors. The instructions in the EMS Programming Guide were followed to review samples of ballot proofs and verify that database tables were properly setup and linked. AIMS was populated by restoring the files from a backup up file rather than a direct copy of the predefined files to the AIMS directory.

The Primary election was checked by capturing proofs of the ballot styles and other tools in EDM/ESSIM and copied to the EMS and ERM standalone workstations for later use. In order to select the options for ballot counting groups and reporting, ERM was not configured until ballot counting commenced in Phase II of the functional test.

With the assistance of ES&S, precincts P11400, P13102, P21728, P22740, and P89240 were selected.

A marking pattern and the corresponding expected results were created for the test decks. ES&S used the marking pattern to produce the test decks for Phase II testing. Elections programming media was produced for the tabulators and AutoMARKs.

General Election

The definition for the Contra Costa County, November 6, 2012, General election was used for this portion of the test. This election included eight hundred thirty-four precincts. The SOS requested that five precincts be selected using the same criteria as the Primary.

The Contra Costa County General election was installed on the EMS Client/Server. The installation used an election database from a prior election that provided district, precinct and office files. A new election was created by importing delimited text files of ballot instructions and candidates. When a candidate text file is imported from the preceding primary election, the winners are not automatically promoted from the Primary into the General election definition. The list of candidates must be reviewed and candidates not in the General election must be deleted. Additional contests or questions that are not part of the imported files may be copied and pasted from other document or text files, then edited in ESSIM.

Once the ballot definitions were proofed, the General election was copied to the EMS and ERM standalone workstations for use in testing.

In order to select the options for ballot groups and reporting, ERM was not configured until ballot counting began.

With the assistance of ES&S, precincts 1, 5, 7, 234, and 828 were selected. Ballots were developed in ESSIM and Unity data was imported into AIMS and HPM. Election programming media was produced for use on the tabulators and AutoMARKs.

A marking pattern and the corresponding expected results were created for the test decks. ES&S used the marking pattern to produce the test decks for Phase II testing.

Recall Election

The test election is modeled after the October 7, 2003, California Gubernatorial Recall election. The election had one hundred thirty-five candidates with ballot positions and a write-in. The purpose of using this election is two-fold. First, it tests the system's ability to handle a contest with one hundred thirty-five candidates. It is also used to test the hardware's ability to read marginal marks and the consistency of the point at which marginal marks are not read. Although the limitation is not mentioned in system documentation, it was not possible to create an election with more than ninety-nine candidates. This was referred to ES&S for research and to be further addressed in Phase II. A ballot containing more than 99 candidates is not necessary to test for marginal mark consistency so the ballots printed for this test were based on the election definition containing ninety-nine candidates.

Preparation for Red Team Testing

Prior to Phase I testing, a server and three workstations were prepared for the Red Team by cloning the machines built for the functional tests. During Phase I testing, copies of the Primary and General election definitions were copied from the functional test machines and installed onto the Red Team machines. Media for the hardware was created and installed. The machines were prepared up to the point of opening the polls, then sealed in accordance with the Use Procedures. Ballots from the Primary election were set aside for the Red Team's use.

Phase II Testing

Phase II testing began on June 13, 2016.

AutoMARK Firmware Upgrade and Validation

At the beginning of Phase II testing, ES&S withdrew the procedures originally prescribed for firmware upgrades on the AutoMARK, and presented revised procedures. The initial procedures only upgraded files that needed to be changed. Older files would not be overwritten if the content did not change between versions. This introduced the possibility that the firmware loaded on an upgraded machine could return hash values that would differ from those returned from a machine with a new installation of the same firmware. This could adversely affect the SOS's ability to validate the firmware on machines that had been upgraded. The new procedure included steps to wipe the software already residing on the device and install a clean version of the trusted build. The new procedure was followed and new versions of the firmware were successfully installed. The procedure was added to Revision 5.0 of the California Use Procedures, released June 22, 2016.

The AutoMARK hashes its own firmware. When the procedures provided by ES&S were followed, the AutoMARKs produced hash values that were documented in printed reports and screen photographs. These artifacts were provided to the SOS to use in their system validation program. The source code was reexamined and the hashing routines within that code were verified.

DS850 and DS200 Firmware Validation

In order to validate the firmware, the jurisdiction must have access to a benchmark copy of that firmware, file listings and the hash value of each file. To validate a system, a script that generates file listings and the hash values of each file is run. The listings and hashes from that run are compared to the benchmark copy. An identical match of file names and hashes indicates that the system being examined is identical to the system used to create the benchmarks. If the benchmarks come from a certified device and the hash values of the system examined match, then the system under examination is validated.

The benchmark hashes for the firmware may be taken from a machine subsequent to installing a trusted build of that firmware. It may also be acquired from a trusted source. The validation process follows validation procedures provided by ES&S and it runs ES&S proprietary scripts on a laptop or workstation using an Ubuntu operating system.

The scripts were examined to identify the program used to generate the hash values and to verify that the scripts are only text based and contain no binary elements. The program called to generate the hash values is a hashing utility that is part of the Coreutils package in Ubuntu. The script files are well documented internally and contain no binary elements.

At the beginning of Phase II testing, ES&S presented new procedures to hash the system. These procedures were followed with the assistance of ES&S. The trusted build of the firmware was installed on the machines in Phase I and benchmark hashes were created. Following the procedures for running the validation scripts confirmed that the hashes matched. During this process a number of errors were encountered in the procedure documentation. The document was revised during the week. At the end of the week after the test elections had concluded, the newly revised procedures were tested without the assistance of ES&S and it was confirmed that the hashes matched the benchmarks. During this process, more errors were found in the procedure documentation. ES&S was apprised of these errors and asked to correct the documentation. On July 8, 2016, following the conclusion of Phase II testing, ES&S submitted revised procedures to SOS. SOS staff used these revisions to independently validate the hardware and reported that they found no further errors in the documentation.

Temporary files are created when a system is hashed, so a successful match of the firmware will usually generate the message, “Two card images (from card partition files) DIFFER!” Since the wording of this message is less than assuring, an independent comparison of the hash benchmark and the hashing output was conducted using UltraCompare software. This comparison confirmed that all hash values were identical.

M650 Firmware Validation

The process used to validate the M650 is similar to, but slightly more complex than, the DS850 and DS200. As with those machines, new procedures were presented and reviewed at the beginning of Phase II testing. A representative from ES&S used the new procedures to create the benchmark hash values and ran through the validation process. SOS staff used the revised procedures dated July 8, 2016, and successfully validated hardware with no reported documentation errors.

M100 Firmware Validation

The procedures provided by ES&S at the beginning of Phase II testing were followed to validate the firmware on an M100. The file names in the documentation did not match the files found on the equipment so ES&S provided additional assistance. The routine only creates screen displays; no report or other files are created. It is important that users capture screen shots of the output. SOS staff used the

July 8, 2016, revised document to successfully validate the hardware and reported no errors in the documentation.

Workstation and Server Validation

At the beginning and end of Phase II testing, the workstations and server were hashed using FCMG batch files and a commercial-off-the-shelf (COTS) hashing utility. The hash results were compared to benchmark hashes taken at the conclusion of system installation. The systems were successful validated at the beginning and end of Phase II testing. Hash analysis shows that there were no unauthorized modifications to the computers used in the certification test from the time the system was installed to the conclusion of functional testing. The hash files produced at the conclusion of functional testing on June 18, 2016, also provide reliable benchmarks for the system that was tested.

Primary Election

The Primary election test was performed on the EMS Client workstation networked to the EMS Server. The EMS Server contains no ES&S software and only serves as shared data storage for one or more networked EMS workstations. The first step was to load election definition media on one DS850, three DS200s, one M650, three M100s and four AutoMARKs. The original test plan included the ERM standalone workstation in the system configuration. However, during preparation for the Logic and Accuracy test, the machine would not run ERM. Upon closer examination, it turned out that hardening procedures used on the workstation were inconsistent with the version ES&S provided for the functional test. The hard drive was wiped and the system was rebuilt. As a result, the machine could not be used for approximately a day and a half. Rather than delaying the test until the machine could be rebuilt, the decision was made to exercise the ERM standalone in the General election. To ensure this error did not recur, the hardening on the other machines was audited and found in compliance before proceeding with the test.

Logic and Accuracy (L&A) testing was conducted in accordance with California Use Procedures. California requires that L&A tests be conducted in election mode so the test mode was not exercised. Zero reports were printed on all devices. Ballots were run. L&A results were printed and verified against expected results.

Ballots were voted on the AutoMARKs and hand marked ballots were added to the test decks and expected results.

After the L&A was completed, the ballots for the test election were run. The results from each of the scanners were printed and the data was loaded into ERM on the EMS Client workstation. The results reports were printed. When the results were audited they were found to be identical to expected results.

During the Primary election, a number of documented bug fixes and enhancements were verified. These will be discussed in the “Findings” section of this report.

General Election

The General election was conducted on the EMS and ERM standalone workstations. The workstations are not connected to each other or a network. Results uploaded from scanners to the ERM workstation are transferred to the EMS workstation on a USB drive.

The election definition was loaded on one DS850, three DS200s, one M650, three M100s and four AutoMARKs. As with the Primary election, an L&A test was conducted in accordance with California Use

Procedures. Zero reports were printed for all devices and ballots were run. L&A results were printed and verified against expected results.

Ballots were voted on the AutoMARKs and hand marked ballots were added to the test decks and expected results.

Following the L&A, the test election was run. Results were printed from all scanners. The scanner data was loaded into ERM on the EMS and ERM standalone workstations and results reports were printed. The results were audited and there was a slight variation from the expected results in two of the precincts. The ballots were hand counted and the hand count confirmed the machine count. The expected results were adjusted. During tabulation a small number of ballots were damaged and removed from the deck. Duplicates of the damaged ballots were created and added to the deck. The deviation from the expected results was caused by duplication errors.

As with the Primary election test, a number of documented bug fixes and enhancements were verified. These will be discussed in the "Findings" section of this report.

Recall Election

After the Phase I test was concluded, ES&S researched the system's inability to create a ballot with more than ninety-nine candidates. The anomaly occurred because the election was defined using "relative positions". Relative positions are numbers in a two-digit field. The use of this two digit field means there are only ninety-nine relative position numbers available and each candidate must be assigned a unique relative position number. Relative position numbers are used when candidate ballot positions need to be in an order other than the order in which the candidates are entered into the system. If candidates are entered in the order that they will appear on the ballot, or in the sequence that will appear in rotations, then there is no need to use the relative position numbers. ES&S demonstrated the ability to create a ballot with more than ninety-nine candidates.

The marginal mark consistency test was conducted using a ballot containing ninety-nine candidates and the election was defined as a vote for eighty contest. One ballot, containing a wide variety of marks, was created. A copy of this ballot appears in Attachment C. The ballot was fed through each model of scanner ten times.

Central scanners are designed to reject unclear marks so election officials can review the ballot, make decisions about the voter's intent and duplicate the ballot. The M650 refused to tabulate a ballot with unclear marks but did not indicate which marks were not recognized. The DS850 would not tabulate a ballot with unclear marks, but it produced a report indicating how many unclear marks it detected on the ballot. The number of marks it found to be unclear on each of ten ballot passes was reasonably consistent and ranged from six to eleven out of eighty marks.

The precinct scanners produced tabulated totals that clearly showed which marks were always read, which were always not and which were marginal. Both the M100 and the DS200 were consistent. The marks that were inconsistently read were expected to be inconsistently read. The DS200 found slightly more marks to be readable and slightly more marginal marks consistently read.

AutoMARK Functionality

In each of the elections, ballots voted on AutoMARK unitss were added to the test decks. These ballots included contests near the corners of the ballots, where the machine is most likely to , mark outside of the target area if the ballot is skewed. The expected results for the elections were adjusted to include votes marked on these ballots. All marks produced on the ballots by the AutoMARK matched the voter's

input and were read by the scanners. A ballot that was not part of the election was inserted in an AutoMARK. A pop up warning appeared and persisted until the ballot was ejected. It was verified that, in high contrast mode, any contest that is under voted flashes in the summary screen. Names entered in write-in contests are limited to twenty nine characters and are printed on the ballot in a single line without wrapping.

Exercise of AutoMARK Accessibility Functions

An AutoMARK VAT with the test Primary election already installed was set up with speakers rather than headphones so the operator and observers could listen to the audio output.

In order determine whether ballots are presented to the voter in a consistent manner, two ballots were voted using the audio mode with the video turned on. The information displayed on the screen was compared to the information provided in the audio stream and found to be the same. A third ballot was voted using only the audio mode with video option turned off.

One ballot was voted using the Yes/No paddle switch interface. The audio instructions are specific to the control panel found on the AutoMARK and not for use with the paddle switch. The button used for "Select" and "Yes" selects contests, candidates and the items in the scroll/navigation bar at the bottom of the screen. The button used for "Scroll" and "No" scrolls through the contests, candidates and the navigation bar at the bottom of the screen. When a contest is fully voted, the script instructs the voter to press the right arrow key to go to the next contest. However, when the paddle switch is used to go to the next contest, the voter needs to press the No button on the left side of the paddle. Navigation through the ballot is not intuitive, but it is possible to navigate and vote the ballot. Absent instruction, the voter may be left to figure out the process through trial and error.

One ballot was voted using the sip and puff interface switch. The operation is essentially the same as for the paddle switch, with a puff being equivalent to the "Select" and "Yes" button and a sip being equivalent to the "Scroll" and "NO" button.

The audio ballot and video ballot modes are able to work both separately and simultaneously. During simultaneous operation, the audio ballot notifies the voter that the video ballot is enabled. Although unlikely, it is possible for a voter to turn the video ballot off and lower the volume of the audio ballot to the point that they would be unable to continue voting or recover from their error.

The instructions given by the machine are adequate for a voter to be able to independently operate the AutoMARK if the voter is using the touchscreen or buttons on the control panel. The instructions do not include how to operate the paddle switch and sip and puff devices. Although these devices are used infrequently, supplemental instructions should be provided to voters who use them.

The AutoMARK presents the voter with the races that he or she is eligible to vote, the candidates available in each race and how many candidates may be selected in each race.

The voter can determine whether their inputs have selected the candidates or responses to questions they intended to select and can review the selections they have made. Prior to casting the ballot, the voter can change any selection previously made and confirm the new selection.

The system notifies the voter when they have failed to vote in a race or have failed to vote the number of total number candidates allowed in any race and requires the voter to confirm their intent to under vote before casting the ballot. The system prevents the voter from over voting any race.

A voter using the AutoMARK can write in a candidate name in contests that allow write-in candidates. However, if a voter uses the paddle or sip and puff interfaces, this may prove to be difficult. These

devices allow the voter to proceed through the alphabet, space, backspace, cancel and OK buttons, but these actions are in a continuous string and operate in only one direction. For example, entering "ZEBRA" using one of these devices requires three trips through the alphabet, one to get to Z, then back to the beginning to get to E, in order to get back to B the voter must run through the remainder of the alphabet and buttons. From the B they can proceed down to R, but must go through the remainder of the string to get back to A. This results in a total of 115 button presses or sip and puff actions.

The voter is able to review their write-in input, edit the input, and confirm that the edits meet their intent.

There is a clear, identifiable action that the voter takes to "cast" the ballot. The system clearly instructs the voter through this process. Once the ballot is cast, the system confirms that the action occurred and that the process of voting is complete.

The system provides wheelchair accessibility and the voting booth meets or exceeds the required 30" wide and 19" deep. Inside the voting booth, voter operable controls will rest with a minimum height of 36" above the finished floor with a minimum knee clearance of 27" above the floor. The AutoMARK also may be used on top of a table.

The system was successfully operated using only one hand, as well as a closed fist. The force required to operate these controls was light and required no pinching or twisting of the wrist. The closed fist approach worked best with the first finger joint knuckles. It was difficult with the finger base knuckles. It was easy with the paddle switches.

The AutoMARK allows a voter who has already marked their ballot, either by hand or by using the AutoMARK, to review their ballot and the results of the review can be displayed on the screen or read by the system audio. To exercise this function, a ballot was marked with a variety conditions including an over vote, an over vote with a write-in, a properly voted race with a candidate selection, a properly voted write-in with the candidate name, a marked write-in with no name and a write in name with no mark, and under voted contests. The results were as expected. The system correctly identified the voted contests without regard to the write-in text. However, if the voter leaves an under voted contest on the ballot, the system will not allow them to vote the under voted race. It instructs them to contact an election official for a new ballot. This leaves the voter with the option to either spoil a ballot or use a pen to correct the under vote.

When the AutoMARK finishes marking a ballot, it ejects it. The voter removes the ballot from the AutoMARK and inserts it in a precinct counter. Upon ejection, the ballot is held in the throat of the machine with a fair amount of tension. A considerable amount of hand strength is required to remove the ballot and it is most easily removed by using both hands and gripping it on each side. Voters with limited hand strength or the use of only one hand may require assistance to remove their ballot rather than independently removing their ballot and completing the process of voting.

Ballot Scanner Functionality

The M100, DS200 and DS850 scanners performed as expected. Ballots were successfully fed in all four orientations: face up, upside down, backward and forward. A small number of misfed ballots and jams occurred. These generally happened when the operators feeding the ballots inserted a ballot before the previous ballot had finished being scanned.

Although the ballots were successfully tabulated on the M650 scanner, difficulties were experienced during its operation. It is a complicated machine to operate. It requires a trained and experienced operator. In order to feed the ballots, the operator must apply slight thumb pressure to the ballots in the infeed tray. It is very sensitive to the amount of pressure. When a misfeed or jam occurs, the machine produces ambiguous error messages. The only way to determine whether to rescan a ballot is to count

the number of cards in the output hopper and compare the count to the number of cards counted on the display to determine if all cards in the hopper have been counted.

If a ballot is accidentally scanned twice, the only remedies are to either "flush" the precinct or clear the machine of all tabulated ballots. According to documentation provided by ES&S, flushing a precinct requires a "flushing header card". ES&S did not provide such a card and the documentation did not indicate how to make one. When this occurred during testing, both the precinct being counted and a prior precinct had to be cleared, then both precincts recounted. According to ES&S staff, use of the flushing header card is discouraged and the best practice is to write the results to a zip disk at the completion of each precinct so results from ballots in previously scanned precincts will not be lost if the machine needs to be cleared.

The M650 only handles ballots in one orientation. The ballots must be loaded in the input hopper face up, with the top of the ballot to the left and the notched corner in the corner of the input hopper. The ballots had a tendency to curl. This caused ballots to hit the top edge of the scanner mouth, resulting in numerous jams and rapid ballot fatigue.

Final Results Reporting Capability

The system can accommodate provisional and late processed absentee ballots by either adding to previously tabulated totals or setting up separate reporting groups for the additional ballots.

Certified write-in candidates are not handled by the voting system and were not included in the election definition. After canvasing, write-ins must be hand counted and manually entered into the statement of votes cast.

Findings

During Phase I testing the instructions needed to prepare election definitions existed in the system documentation but the sequence of steps and workflow were unclear. The procedures assumed knowledge of the file structures and experience editing the complete election definition on the part of the operator. It is difficult for a novice operator to use the system and, in particular, to import data files. Version 2.3 of the Programming Guide was created to correct this issue but it was received from ES&S on June 15, 2016, after the conclusion of Phase I testing and has not been validated.

The report printing option on EDM for Adobe PDF generates an error message that Crystal-Reports is missing and occasionally aborts the EDM application. The .pdf files must be produced through the use of a command to export to a PDF rather than printing the report. It is unclear whether this Adobe PDF report option should be removed from the system or whether the missing files can, and need to be, installed.

According to ES&S staff, when ballots are produced in multiple languages with a unique ballot for each language, the languages will have different sized text blocks. This can change the spacing of the ovals in the ballot layout. The user creating the ballots must check and, if necessary, adjust the spacing so the voting ovals are in the correct position. Although the procedures provide instructions for adjusting/floating the spacing of the contest, this step should be required when the ballot is created and proofed.

Within the test, the ES&S Unity 3.4.1.0 Voting System ran the test Primary and General elections without any tabulation errors. A number of documentation errors were found and referred to ES&S for revision.

When the AutoMARK is used to review a previously marked ballot containing a write-in vote, it will verify that the write-in was selected but does not verify the text of the write-in.

The functional test included testing a number of documented bug fixes and enhancements for which the SOS requested verification. These include:

Review of the resolution of the "Chinese Character Anomaly", in which certain Chinese characters are translated with an ANSI value of 254. This is read by the system as an end of line marker, causing the text that includes the character to be truncated.

- ES&S provided the SOS with updated documentation on supporting Chinese on ballots. The test Primary election included properly rendered Chinese text and ES&S produced a ballot showing proper rendering of the thirty-seven characters that were subject to the anomaly.

Review the resolution of the "Code Channel Eleven Anomaly", in which a ballot containing a type eleven code is skewed in the scanner, misread, and, instead of generating a "Type Code Error" and identified as an unreadable ballot, is interpreted to be a ballot header card, causing the ballot not to be counted. This causes any subsequent ballots in the same precinct to be rejected and interrupts the process. This anomaly only occurs when precinct header cards and Type Code eleven are used.

- The workaround for this is simply to avoid use of Type Code eleven when header cards are used. ES&S provided analysis and procedures resolving this anomaly.

Verify that an enhancement that prevents users from selecting both the Straight Party Early Cast Mode and the Contest Under Vote Warning Flags under Merge Preferences does not exist in the California system configuration.

- There is no option for selecting Straight Party in the California system configuration.

Verify an enhancement to Audit Manager that logs the names of all users who are created, edited or deleted.

- Users were created, edited and deleted. The log reflected the actions.

Verify an enhancement to Audit Manager that logs the names of individuals who access the audit manager application.

- No event logs entries were found for access or activities within the Audit Manager Application.

On a long contest, requiring the use of the "More" button cast a write-in vote and observe that the AutoMARK returns to where it left off, rather than at the top of the contest.

- Verified. This was regression testing of an issue resolved in earlier versions of the system.

Verify that a procedure previously used to access the AutoMARK operating system during power up no longer works.

- Verified. This was regression testing of an issue resolved in earlier versions of the system.

Verify a change that prevents over voting a vote for two contest on an AutoMARK.

- This is not applicable to ballots used in California.

Verify support for alternative languages, specifically Spanish and Chinese.

- Verified. All three languages were used on the Primary election ballots including AutoMARK audio and video.

Observe and document how over votes and under votes are tabulated in multiple vote for contests.

- Over votes in a contest count as one over vote. Under votes in a contest count as the number of vote opportunities lost.

Verify procedures to roll primary election winners into a general election definition.

- This function does not exist in the system or use procedures.

Verify a change that properly left justifies audit log entries that begin with numbers.

- Verified in review of audit logs.

Verify correction of an error that prevented proper archiving of the Audit Manager Database.

- Verified by following the procedures for archiving audit logs and, after archiving, opening and reviewing the archived log.

Verify enhancements that allow the M100 to out stack ballots with over votes, where the over vote was caused by selecting the maximum number of candidates and then selecting a write-in.

- This could not be verified. The election definitions were set up to out stack all over voted ballots and did not specify that this particular over vote condition would be singled out to be out stacked while other ballots containing over votes would not.

Verify a change to the M100 audit log to record the event “print audit log” when the audit log is printed while the polls are open.

- Verified by printing an M100 audit log while the polls were open, then reprinting the audit log and observing that the prior print event was logged.

Verify a change to the election data manager where the default behavior of the “do not rotate” checkbox is deselected when transitioning from a completed office configuration to a new office form.

- Verified by observation.

Verify enhancements to the M100 log that will include a log entry for each “ballot accepted” event and for each “power on” event.

- Verified by printing out and inspecting an M100 log and confirming that it contained entries for these events.

Attachment A

Inventory of Components Tested

EMS Server

Vendor	Model	Serial# or Service Tag#
Dell	PowerEdge 1430	C7KNT52
MS	Keyboard/Model 600	65809471993
Dell	Mouse Optical V2.0/Model 1113	CN-09RRC7-48729-54P-009Q
Dell	Monitor/Model # covered	CN-0YDPKC744454BI-AXWB
OMNI	OMNI USB Prof/Model RAT0020710	28432-USB2
COTS Software		
Vendor	Product	Version
Microsoft	Windows Server 2008	R2 Standard 64 -Bit SP1
Symantec	Endpoint Protection	12.1.4013.4013
Symantec	Endpoint Protection Intelligent Updater	64 - Bit

EMS Client

Vendor	Model	Serial# or Service Tag#
Dell	Optiplex 7020 /Model D13M	FTWX052
Dell	Keyboard/KB212B	CN-0D45871581-55K-0455A01
MS	Mouse Optical V2.0/Model 1113	Not Found
Dell	Monitor/Model # covered	CN-0YD2KC744454BI-AXYB
Omni	OMNI USB Prof/Model RAT0020710	28432-USB2
COTS Software		
Vendor	Product	Version
Microsoft	Windows 7 Professional	64-Bit SP1
Symantec	Endpoint Protection	12.1.4013.4013
Symantec	Endpoint Protection Intelligent Updater	64 - Bit
Adobe	Acrobat	9
TwinBridge	Chinese Partner	6.5 Premium Edition
ES&S	RM/COBOL Runtime	12.06
CSM GmbH	Omni Drive USB Professional Driver	3.33
CSM GmbH	PC Card Manager	3.0.5
Unity 3.4.1.0 Software		
ES&S	Log Monitor	1.1.0.0
ES&S	Audit Manager	7.5.2.0
ES&S	VAT Preview	1.3.2907
ES&S	AutoMARK Information Management System (AIMS)	1.3.257
ES&S	Election Data Manager	7.8.2.0
ES&S	Ballot Image Manager	7.7.2.0

ES&S	Hardware Programming Manager	5.9.0.0
ES&S	Election Reporting Manager	7.9.0.0

EMS Standalone

Vendor	Model	Serial# or Service Tag#
Dell	Optiplex 7020/Model D13M	72J6Z62
Dell	Keyboard/KB212-B	CN-0DJ4547158134F-01XX-A00
Logitech	Mouse Optical/ModelUV96	265986003
Dell	Monitor/PN# 07R1K3	CN-0YDPKC744454BI-AXUB

COTS Software

Vendor	Product	Version
Microsoft	Windows 7 Professional	64-Bit SP1
Symantec	Endpoint Protection	12.1.4013.4013
Symantec	Endpoint Protection Intelligent Updater	64 - Bit
Adobe	Acrobat	9
TwinBridge	Chinese Partner	6.5 Premium Edition
ES&S	RM/COBOL Runtime	12.06
CSM GmbH	Omni Drive USB Professional Driver	3.33
CSM GmbH	PC Card Manager	3.0.5

Unity 3.4.1.0 Software

ES&S	Log Monitor	1.1.0.0
ES&S	Audit Manager	7.5.2.0
ES&S	VAT Preview	1.3.2907
ES&S	AutoMARK Information Management System (AIMS)	1.3.257
ES&S	Election Data Manager	7.8.2.0
ES&S	Ballot Image Manager	7.7.2.0
ES&S	Hardware Programming Manager	5.9.0.0
ES&S	Election Reporting Manager	7.9.0.0

ERM Standalone

Vendor	Model	Serial# or Service Tag#
Dell	Optiplex 7020 /D13M	DWWX052
Dell	Keyboard/KB212-B	CN-0DJ45A71581-55K-044LA01
MS	Mouse Optical V2.0/Model 1113	CN-09RRC7-48729-54P-00A5
Dell	Monitor/PN# 07R1K3	CN-07R1K3-74445-54E-182B
OMNI	OMNI USB Prof/Model RAT0020710	11999-USB2
Okidata	8431dn/N22115A	

COTS Software		
Vendor	Product	Version
Microsoft	Windows 7 Professional	64-Bit SP1
Symantec	Endpoint Protection	12.1.4013.4013
Symantec	Endpoint Protection Intelligent Updater	64 - Bit
ES&S	RM/COBOL Runtime	12.06
CSM GmbH	Omni Drive USB Professional Driver	3.33
CSM GmbH	PC Card Manager	3.0.5
Unity 3.4.1.0 Software		
ES&S	Log Monitor	1.1.0.0
ES&S	Election Reporting Manager	7.9.0.0

AutoMARK (VAT)

Vendor	Model/Hardware Version/Firmware	Serial#
ES&S	Model A100/HW1.0/1.3.2907	AM0106430969
ES&S	Model A200/HW 1.3.0/1.3.2907	AM0206443709
ES&S	Model A200/HW1.1/1.3.2907	AM0206441677
ES&S	Model A200/HW 1.3.1/1.3.2907	AM0208461405

DS200 Ballot Scanner

Vendor	Hardware Version/Firmware Version	Serial#
ES&S	1.3/1.7.0.0	DS0315381010
ES&S	1.3/1.7.0.0	DS0315380813
ES&S	1.3/1.7.0.0	DS0315381002
ES&S	1.3/1.7.0.0	DS03153890937
ES&S	1.3/1.7.0.0	DS0315380974

DS850 Ballot Scanner

Vendor	Hardware Version/Firmware Version	Serial#
ES&S	HW 1.0	DS8509420014
Printers	Model	Serial#
OKI	Microline 420/D22900A	AK44007044E0
OKI	B431dn/N222034	AK37004129A0

M100 Ballot Scanner

Vendor	Hardware Version/Firmware Version	Serial#
ES&S	HW 1.3/FW 5.4.4.5	231229
ES&S	HW 1.3/FW 5.4.4.5	231043

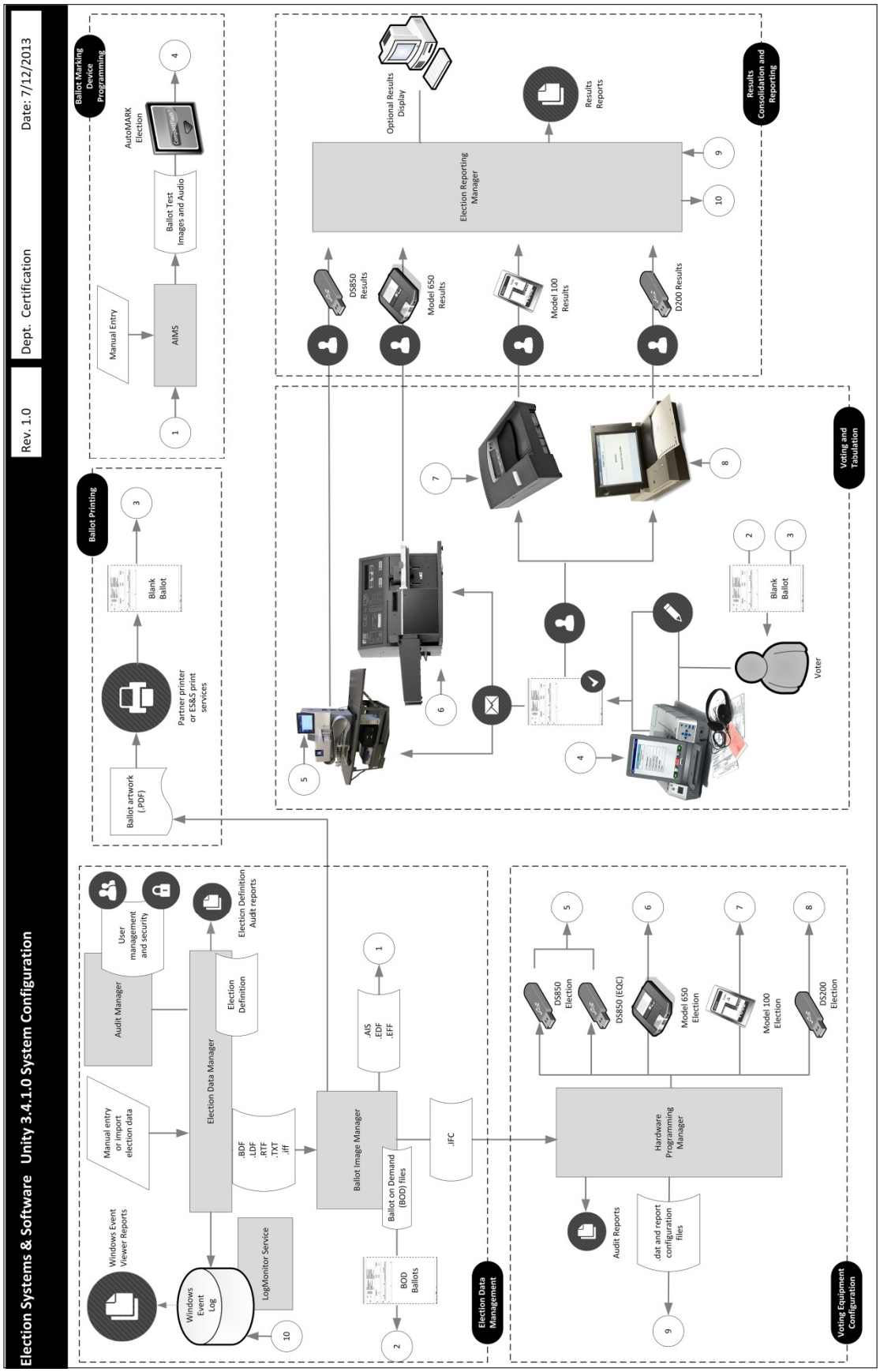
ES&S	HW 1.3/FW 5.4.4.5	230867
ES&S	HW 1.3/FW 5.4.4.5	231339
ES&S	HW 1.3/FW 5.4.4.5	231206
ES&S	HW 1.3/FW 5.4.4.5	230880

Vendor	Hardware Version/Firmware Version	Serial#

M650 Ballot Scanner

Printers	Model	Serial#
ES&S	HW 1.2/FW 2.2.2.0	29037079
Epson	LQ590	FSQ4180256
Epson	LQ590	FSQ4137389

Attachment B



Attachment C

Marginal Marks Ballot