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Test Report for EAC 2005 VVSG 1.0 Certification Testing MicroVote EMS 4.4 Voting System

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1.0 INTRODUCTION

The purpose of this Test Report is to document the procedures that Pro V&V, Inc. followed to perform certification testing during a system modification campaign for the MicroVote EMS 4.4 Voting System to the requirements set forth for voting systems in the U.S. Election Assistance Commission (EAC) 2005 Voluntary Voting System Guidelines (VVSG), Version 1.0. Certification testing of EMS 4.4 was performed to ensure the applicable requirements of the EAC VVSG 1.0 and the EAC Testing and Certification Program Manual, Version 2.0 were met. Additionally, all EAC Request for Interpretations (RFI) and Notices of Clarification (NOC) relevant to the system under test were incorporated in the test campaign.

Prior to submitting the voting system for testing, MicroVote submitted an application package to the EAC for certification of the EMS 4.4 Voting System. The application was accepted by the EAC and the project was assigned the unique Project Number of MVTEMS44.

The EMS 4.4 EAC-approved test plan, which is available for viewing on the EAC's website at www.eac.gov, was utilized as the guiding document during test performance. Since test plan approval, and as testing progressed, minor system modifications, such as revised system documentation, were incorporated. This test report reflects all of the testing completed and details the final versions of all technical documentation and system components and supersedes the approved test plan.

Unless otherwise annotated, all testing was conducted at the Pro V&V test facility located in Huntsville, AL, by personnel verified by Pro V&V to be qualified to perform the test.

1.1 Description and Overview of EAC Certified System Being Modified

EMS 4.4 is a modification to a previously certified system and has not yet been fielded. The EMS 4.4 software functionality is divided by activity, based on each stage of the election. These activities are further divided into five modes, all building on each other to complete the election process: Administration, Election Setup, Ballot Setup, Programming & Printing, and Vote Tabulation. These modes combined, working together capture:

- Creating and maintaining default preferences and settings for a specific jurisdiction.
- Creating and maintaining preferences and settings for an election.
- Creating and maintaining security clearances for all users of EMS.
- Creating primary, general or both types of elections or municipal elections.
- Creating offices and filing candidates.
- Creating and maintaining all objects appearing on the ballot.
- Printing ballots.
- Programming voting devices.

- Printing reports of election data.
- Tallying election results.
- Generating reports of election results for state reporting systems, media displays, or printing.
- Creating and restoring backup files of election databases for archival purposes

The Administration mode is the system setup stage. This mode includes: Preferences, Political Parties, Vote Types, Precincts, Ballot Text, Ballot Graphics, Equipment, Equipment Assignment, and Security. Election Setup Reports reflecting each form are also available.

The Election Setup, Ballot Setup, and Programming & Printing modes are all pre-election activities. The Election Setup includes entering offices, filing candidates, creating secondary vote lockouts. In Ballot Setup, users create and edit ballots, build activations, and assign precincts. Programming & Printing includes programming voting machines and Smart Cards, previewing and printing ballots, and assigning voting panels to locations.

Phonetics, text-to-speech, option is built into EMS. All pronunciation of words, names or phrases can be altered for better listening comprehension. Reports are available for Election and Ballot setup for further election setup auditing.

EMS 4.4 includes support for an optional Voter Verifiable Printed Audit Trail (VVPAT) printer to be attached to the MicroVote Infinity voting panel. The EMS user can set the number of allowed voter voids (1-5) during the voting session and optional QR code printed on each ballot which contains ballot header information and ballot selections.

The Vote Tabulation mode is the final mode during which all tabulations and final results are produced. Election Night Reporting mode reports reflect the results as they are tabulated.

The EMS software supports the MicroVote Infinity voting panel with optional VVPAT printer attached. This panel is a direct recording electronic (DRE) device, and is connected to EMS via a serial port. Data/Vote tabulations exchange between the EMS and the Infinity machine is done directly through the serial port or via a Smart Card programmed for each election. OMR Ballot Cards, sometimes referred to as Absentee Cards, are optically scanned by a Chatsworth ACP 2200 reader.

Several COTS hardware items and software are used with the EMS software. EMS is designed to be used with Microsoft Windows 10 Pro X86/X64, and is installed on a Dell computer desktop and/or laptop. The database software is SQL Server 2017 Express. There is a COTS DOUBLETALK LT text-to-speech converter box attached to the Infinity machine. There are also COTS Smart Cards and Smart Card readers/writers. All OMR/Absentee ballot cards are optically scanned by the ACP 2200 reader.

1.1.1 Baseline Certified System

The EAC Certified System that is the baseline for the submitted modification is described in the following subsections. All information presented was derived from the previous Certification Test Report, the EAC Certificate of Conformance and/or the System Overview.

The EAC-certified system that is the baseline system for this modification is the EMS 4.2 Voting System. The tables below describe the certified equipment and firmware versions. Detailed descriptions of the EMS 4.2 test campaign are contained in Pro V&V Report No. TR-01-01-MVT-2016-01.01, Rev. C, which is available for viewing on the EAC’s website at www.eac.gov.

Table 1-1. EMS 4.2 System Components

EMS 4.2 SYSTEM SOFTWARE	
Firmware/Software	Version
<i>Proprietary</i>	
Election Management Software (EMS)	4.2
<i>COTS</i>	
Microsoft Windows 10 Professional	1709
Microsoft Visual Studio 2017 Professional	15.5
ComponentOne Ultimate 2014	1
EMS 4.2 SYSTEM HARDWARE	
Component	Serial Number
<i>Proprietary</i>	
Infinity Voting Panel (VP-1 Rev: D05) w/Power Supply	11588
Infinity Voting Panel (VP-1 Rev: C) w/Power Supply	04689
<i>COTS</i>	
Dell OptiPlex 3020 w/Power Cord, Keyboard, & Mouse	BSNNK52
Dell OptiPlex 3020 w/Power Cord, Keyboard, & Mouse	FVNNK52
Dell Latitude EMS Computer (Model E5440 or E5570)	---
Dell 15" Monitor (E153FPb)	CN-0D5421-46633-4B8-0GVU T
Seiko Instruments Printer (DPU-3445) w/Power Supply	2008922A
EMS Download Cable	CC06789-06
USB Smart Card Reader (PC USB TR PIV) w/Stand (HWP109380 B)	113101316600170
DoubleTalk LT w/Radio Shack Headphones	[MVT-001]
Gearmo USB to RS-232 Converter (FTDI-LED)	USA000106043

1.2 References

- Election Assistance Commission 2005 Voluntary Voting System Guidelines (VVSG) Version 1.0, Volume I, “Voting System Performance Guidelines”
- Election Assistance Commission 2005 Voluntary Voting System Guidelines (VVSG) Version 1.0, Volume II, “National Certification Testing Guidelines”
- Election Assistance Commission Testing and Certification Program Manual, Version 2.0
- Election Assistance Commission Voting System Test Laboratory Program Manual, Version 2.0
- National Voluntary Laboratory Accreditation Program NIST Handbook 150-2016, “NVLAP Procedures and General Requirements (NIST Handbook 150-2016)”, dated July 2016
- National Voluntary Laboratory Accreditation Program NIST Handbook 150-22, 2008 Edition, “Voting System Testing (NIST Handbook 150-22)”, dated May 2008
- United States 107th Congress Help America Vote Act (HAVA) of 2002 (Public Law 107-252), dated October 2002
- Pro V&V, Inc. Quality Assurance Manual, Revision 7.0
- Election Assistance Commission “Approval of Voting System Testing Application Package” letter dated November 14, 2019
- EAC Requests for Interpretation (RFI) (listed on www.eac.gov)
- EAC Notices of Clarification (NOC) (listed on www.eac.gov)
- MicroVote EMS 4.3 Technical Data Package (*A listing of the EMS 4.3 documents submitted for this test campaign is listed in Section 4.6 of this Test Plan*)
- MicroVote TDP Section 2.13 System Change Notes, Election Management System, Version 1.18, dated 11/07/2019

1.3 Terms and Abbreviations

This subsection lists terms and abbreviations relevant to the hardware, the software, or this Test Plan.

“COTS” – Commercial Off-The-Shelf

“DRE” – Direct Record Electronic

“EAC” – United States Election Assistance Commission

“EMS” – Election Management System

“FCA” – Functional Configuration Audit

- “HAVA” – Help America Vote Act
- “NIST” – National Institute of Standards and Technology
- “NOC” – Notice of Clarification
- “NVLAP” – National Voluntary Laboratory Accreditation Program
- “PCA” – Physical Configuration Audit
- “QA” – Quality Assurance
- “RFI” – Request for Interpretation
- “TDP” – Technical Data Package
- “VSTL” – Voting System Test Laboratory
- “VVPAT” – Voter Verifiable Paper Audit Trail
- “VVSG” – Voluntary Voting System Guidelines

2.0 CERTIFICATION TEST BACKGROUND

EMS 4.4 is a modification of a previously certified system (EMS 4.2). Pro V&V performed an evaluation of results from the previous test campaign to determine the scope of testing required for certification of the EMS 4.4. Based on this evaluation, Pro V&V determined that testing from the previous test campaign would establish the baseline and that the focus of this test campaign would be on the documented system updates.

No prior non-VSTL testing of the EMS 4.4 modifications were considered for this test campaign.

2.1 Revision History

The table below details the version history of the EMS 4.2 System:

Table 2-1. EMS 4.2 System Revision History

System Version	Certification Type	Baseline System	Certification Number
EMS 4.0	New System	--- (Original System)---	MVTEMS4
EMS 4.0B	Modification	EMS 4.0	MVTEMS40B
EMS 4.1	Modification	EMS 4.0B	MVTEMS41
EMS 4.2	Modification	EMS 4.1	MVTEMS42
EMS 4.4	Modification	EMS 4.2	MVTEMS44*

*Upon grant of certification by the EAC

2.2 Scope of Testing

The scope of testing was limited to the modifications made to the previously certified EMS 4.2 Voting System. Prior to test initiation, Pro V&V performed an evaluation of the results from the previous test campaign along with the changes made to the system to determine the scope of testing required for certification of the EMS 4.4. Based on this evaluation, Pro V&V determined that testing from the previous test campaigns would establish the baseline and that the focus of this test campaign would be on the system updates.

It was determined the following tasks would be required to verify compliance of the modifications:

- Technical Data Package (TDP) Review

A limited TDP Review was performed to ensure that all submitted modifications were accurately documented and that the documents met the requirements of the EAC 2005 VVSG.

- Physical Configuration Audit (PCA), including Security Testing

A PCA was performed to compare the voting system submitted for certification testing to the manufacturer's technical documentation.

- Source Code Review, Compliance Build, Trusted Build, and Build Document Review

A source code review was performed based on the source code changes made since the previous system was certified. To perform the source code review, Pro V&V reviewed the submitted source code to the EAC VVSG 1.0 and the manufacturer-submitted coding standards. Prior to initiating the software review, Pro V&V verified that the submitted documentation was sufficient to enable: (1) a review of the source code and (2) Pro V&V to design and conduct tests at every level of the software structure to verify that design specifications and performance guidelines are met.

- System Level Testing

System Level Testing included the FCA, Accuracy, and System Integration tests. The FCA for this test campaign included an assessment of the submitted modifications and tests designed to verify that the modifications were implemented as intended and did not adversely affect system performance. The System Integration tests were performed to ensure the EMS 4.4 with VVPAT functions as a complete system. The Accuracy Test was performed to ensure the EMS 4.4 with VVPAT correctly captured, stored, consolidated, and reported the specific ballot selections, and absence of selections, for each ballot position.

- EMS And System Functional Regression Testing

Regression testing was conducted on the EMS to establish assurance that the modifications had no adverse impact on the compliance, integrity, or performance of the system.

- Hardware Testing (Operational/Non-Operational Environmental and Electrical)

The addition of the Infinity Revision E, UPS, and VVPAT resulted in the full suite of environmental and electrical hardware testing being performed to verify the VVPAT met the hardware test requirements set forth in the EAC 2005 VVSG 1.0.

- Usability and Accessibility Testing

Usability and accessibility tests were performed to evaluate the system to the requirements set forth in the EAC 2005 VVSG 1.0.

- Security Review

Physical security testing was performed to evaluate the security posture of the system that may have been affected by the changes implemented in this modification.

2.2.1 Modification Overview

The submitted modifications for the EMS 4.4 test campaign included modifications to the baseline EMS 4.2 system. These modifications consisted of various enhancements and updates to add support and improve voting functions, replacements of end-of-life components, adding alternate components (Infinity Revision E and UPS), and adding support for optional VVPAT (Voter Verifiable Paper Audit Trail) thermal roll-to-roll printer within an election.

2.2.1.1 Detailed List of Changes

Descriptions of the submitted modifications are described below:

Enhancements

1. E-01-(EMS/Infinity) – Added support for optional VVPAT (Voter Verifiable Paper Audit Trail) thermal roll-to-roll printer within an election.
2. E-01-(EMS) – Added support for polling locations.
3. E-02-(EMS) – Added support for equipment tracking.
4. E-03-(Infinity) – Added timing mark for VVPAT barcode.
5. E-04-(Infinity) – Allow Infinity programming through VVPAT port.
6. E-05-(Infinity) – Added date/time stamp printing to VVPAT for testing.
7. E-06-(EMS) – Added auto precinct detect for OMR card reading.
8. E-07-(EMS) – Added search box to lookup windows.
9. E-08-(EMS) – Reporting viewed in full screen window.
10. E-09-(EMS) – Allow independent candidate filings past vote limit.

11. E-10-(EMS) – Autodetect of COM port for panel programming, vote extraction and OMR scanning.
12. E-11-(EMS) – Added popup window to reports when report is blank.
13. E-12-(EMS) – Suppressed straight party results with no votes (used for de-linking contests from straight party selector on Infinity panel).
14. E-13-(Infinity) – Changed “Ready” mode to “Locked” mode on Infinity.

Addition of Alternate Components

1. A-01-(EMS) – Infinity Revision E with color display and optional VVPAT printer.
2. A-02-(EMS) – Dell Latitude 3500 Laptop Computer.
3. A-03-(Infinity) – MV1500AVR Minuteman UPS.

Replacement of End-Of-Life Components

1. R-01-(EMS) – Replaced Advanced Installer 14.8 with Advanced Installer 16.4.1.
2. R-02-(EMS) – Replaced SQL Server 2016 Express with SQL Server 2017 Express

2.2.2 System Overview

The MicroVote EMS 4.4 Voting System is comprised of the following components: EMS Software Version 4.4, Infinity Panel Rev. E, Infinity Panel Rev. D, and optional VVPAT, as described in Section 1.1 of this report. The materials identified by the manufacturer as materials deliverable to the end user for the EMS 4.4 system are identified below

Table 2-2. EMS 4.4 System Deliverables

Material	Version	Description
EMS Software	4.4	Election Management Software
Infinity Panel	Rev E	DRE precinct count/accessible voting station
Infinity Panel	Rev D	DRE precinct count/accessible voting station
VVPAT	Rev A	Voter Verifiable Paper Audit Trail

2.2.2.1 System Diagram

The system overview of the EMS 4.4 voting system is depicted in Figure 1-1.

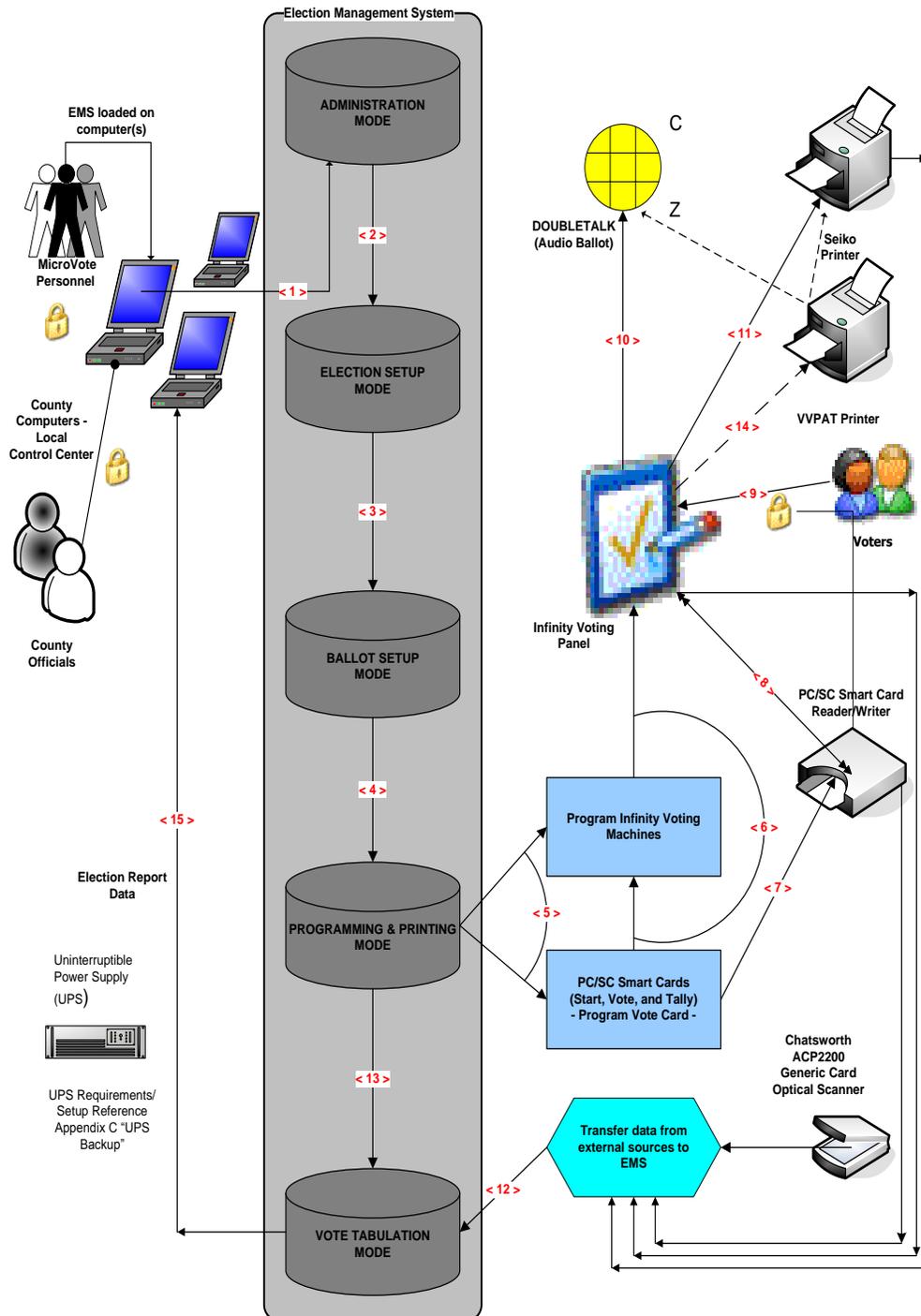


Figure 1-1. EMS 4.4 System Overview

2.2.2.2 Supported Functionality

There were no changes made to the supported functionality of the voting system. The supported functionality for the submitted voting system remains unchanged from the previously certified version. During testing, EMS 4.4 was verified to voting variations listed below:

- General Election
- Closed Primary
- Open Primary
- Partisan/Non-Partisan Offices
- Write-In Voting
- Primary Presidential Delegation Nominations
- Split Precincts
- Vote for N of M
- Provisional/Challenged Ballots
- Straight Party Voting
- Cross-party Endorsement

2.2.2.3 Supported Languages

The following languages are supported by EMS 4.4:

- English
- Spanish
- optional third language, including pictographic

Support for each stated languages was verified. Both English and Spanish language ballots were cast during the performance of functional testing. Additionally, one character based language (Chinese) was tested during System Integration Testing.

Testing of the Chinese language was accomplished through the creation and execution of both a primary and general election verifying the translations could be used by Chinese minority language voters. The translations themselves were taken from an online translator (Google Translate). The translations were then copied and pasted into the qualified EMS ballot text fields using Windows Notepad. In order for the Infinity Panel to recognize the Chinese characters, a number of special reserved ballot text objects were activated, as covered in *MicroVote TDP Appendix B: Third Language Support of the EMS User Manual*.

2.2.2.4 System Limits

The system limits that were verified to be supported by EMS 4.4 are provided in the table below.

Table 2-3. EMS 4.4 System Limitations

Characteristic	Limiting Component	Evaluated	Manufacturer Calculated		
			EMS	Infinity	ACP 2200
Maximum Ballot Positions	Ballot Design Form	300	600	600	402
Maximum Precincts in Election	Precinct Number	600	9,999	9,999	9,999
Maximum Contests in Election	Contests in Ballot Style * Ballot Styles/Election	100	300,000	2,999,700	2,009,799
Maximum Candidates/ Counters in Election	Precinct Counters * Total Precincts	300	5,989,401	5,989,401	4,019,598
Maximum Candidates/ Counters in Precinct	Ballot Design Form	300	599	599	402
Maximum Candidates/ Counters in Activation	Ballot Design Form	300	599	599	402
Maximum Ballot Styles in Election	Ballot Style Number	300	1000	9999	1000
Maximum Contests in a Ballot Style	Ballot Design Form	100	300	300	201
Maximum Candidates in a Contest	Ballot Design Form	300	599	599	401
Maximum Count for any Precinct Element	Transact-SQL Bigint	600	<i>Note 1</i>	65,000	<i>Note 1</i>
Maximum Ballot Styles in a Precinct	Precinct Style Assignment Form	1	1	1	1
Maximum Activations per Ballot Style	Build Activations Form	25	99	30	99
Maximum Activations per Election	Act/Ballot Style * Ballot Style/Elec	1500	99,000	299,970	299,970
Maximum Number of Parties	Party Code Combinations	10	50,653	598	400
Maximum Vote For in Contest	Office Vote Limit	60	99	64	99

Note 1: 9,223,372,036,854,770,000

2.2.3 VVSG

The EMS 4.4 Voting System was evaluated against the relevant requirements contained in the EAC 2005 VVSG, Volumes I and II.

2.2.4 RFIs

There are no RFIs released by the EAC as of the date of this Test Report that pertained to this test campaign that were not in effect at the time of the baseline system certification.

2.2.5 NOCs

There are no NOCs released by the EAC as of the date of this Test Report that pertained to this test campaign that were not in effect at the time of the baseline system certification.

3.0 TEST FINDINGS AND RECOMMENDATIONS

EMS 4.4 was evaluated against the relevant requirements contained in the EAC 2005 VVSG, Volumes I and II. The focus of this test campaign was on the modifications to the voting system configuration that included upgrades to the components of the baselined system. All requirements that were excluded from the previous test campaign (EMS 4.2), with the exception of Volume I, Section 7.9 (Voter Verifiable Paper Audit Trail Requirements), were also deemed not applicable to this test campaign due to the submitted modifications not impacting the specific requirements.

The summary findings and recommendations for each area of testing are provided in the following sections.

3.1 Summary Findings and Recommendation

Summary findings for the System Level Testing (System Integration Testing, Accuracy, and FCA), PCA, Hardware Testing, Usability and Accessibility Review, Security Review, and Source Code Review are detailed in the relevant sections of this report. In addition to these areas of testing, a TDP Review was performed, as described below.

Technical Documentation Package (TDP) Review

In order to determine compliance of the modified TDP documents with the EAC VVSG 1.0, a limited TDP review was conducted. This review focused on TDP documents that have been modified since the certification of the baseline system. The review consisted of a compliance review to verify that each regulatory, state, or manufacturer-stated requirement had been met based on the context of each requirement.

Results of the review of each document were entered on the TDP Review Checklist and reported to the manufacturer for disposition of any anomalies. This process was ongoing until all anomalies were resolved. Any revised documents during the TDP review process were compared with the previous document revision to determine changes made, and the document was re-reviewed to determine whether subject requirements had been met. A listing of all documents contained in the EMS 4.4 TDP is provided in Table 3-1.

Table 3-1: EMS 4.4 TDP Documents

Section	Description	Version
---	Technical Data Package (TDP) TABLE OF CONTENTS Election Management System	1.1
2.1	SCOPE Election Management System	1.2
2.2	SYSTEM OVERVIEW Election Management System	1.16
2.3	SYSTEM FUNCTIONALITY DESCRIPTION Election Management System	1.3
2.4	SYSTEM HARDWARE SPECIFICATION Election Management System	1.4
2.5	SOFTWARE DESIGN AND SPECIFICATION Election Management System	2.11
2.6	SYSTEM SECURITY SPECIFICATION Election Management System	1.10
2.7	SYSTEM TEST AND VERIFICATION SPECIFICATION Election Management System	1.3
2.8	SYSTEM OPERATION PROCEDURES Election Management System	1.3
2.9	SYSTEM MAINTENACE PROCEDURES Election Management System	1.4
2.10	PERSONNEL DEPOYMENT AND TRAINING REQUIREMENTS Election Management System	1.1
2.11	CONFIGURATION MANAGEMENT PLAN Election Management System	1.7
2.12	QUALITY ASSURANCE PROGRAM Election Management System	1.4
2.13	SYSTEM CHANGE NOTES Election Management System	1.18
---	Appendices TABLE OF CONTENTS Election Management System	1.9

3.1.1 Source Code Review

Pro V&V reviewed the submitted source code to the EAC VVSG 1.0 and the manufacturer-submitted coding standards. Prior to initiating the software review, Pro V&V verified that the submitted documentation was sufficient to enable: (1) a review of the source code and (2) Pro V&V to design and conduct tests at every level of the software structure to verify that design specifications and performance guidelines are met.

A combination of Automated Source Code Review and Manual Source Code Review methods were used to review the changes in the source code from the previously certified EMS 4.2 voting system. In addition, 10% of the source code comments will be manually reviewed.

Summary Findings

- Automated Source Code Review: The Automated Source Code Review was performed during the EMS 4.4 Compliance and Trusted Builds. No source code issues were found during the Automated Source Code review.
- Manual Source Code Review: The Manual Source Code review was performed on 10% of the comments for compliance to VVSG Volume Section 5.2.7. No source code issues were found during the Manual Source Code review.
- Compliance Build: The compliance build was performed following the compliance review. Once the compliance review was performed and the source was deemed stable enough to proceed with testing, the source code and all additional packages were compiled into a Compliance Build.
- Trusted Build: The trusted build consisted of inspecting customer submitted source code, COTS, and third-party software products and combining them to create the executable code. This inspection followed the documented process from the “United States Election Assistance Commission Voting System Test Laboratory Program Manual” Section 5.5 – 5.7. Performance of the trusted build includes the build documentation review. The Trusted Build was performed following the completion of the Functional Configuration Audit.

3.1.2 Physical Configuration Audit (PCA)

The Physical Configuration Audit (PCA) compares the voting system components submitted for qualification to the manufacturer’s technical documentation, and shall include the following activities:

- Establish a configuration baseline of software and hardware to be tested; confirm whether manufacturer’s documentation is sufficient for the user to install, validate, operate, and maintain the voting system
- Verify software conforms to the manufacturer’s specifications; inspect all records of manufacturer’s release control system; if changes have been made to the baseline version, verify manufacturer’s engineering and test data are for the software version submitted for certification
- If the hardware is non-COTS, Pro V&V shall review drawings, specifications, technical data, and test data associated with system hardware to establish system hardware baseline associated with software baseline
- Review manufacturer’s documents of user acceptance test procedures and data against system’s functional specifications; resolve any discrepancy or inadequacy in manufacturer’s plan or data prior to beginning system integration functional and performance tests

- Subsequent changes to baseline software configuration made during testing, as well as system hardware changes that may produce a change in software operation are subject to re-examination

Summary Findings

During execution of the test procedure, the components of the EMS 4.4 system were documented by component name, model, serial number, major component, and any other relevant information needed to identify the component. For COTS equipment, every effort was made to verify that the COTS equipment had not been modified for use. Additionally, each technical document submitted in the TDP was recorded by document name, description, document number, revision number, and date of release. At the conclusion of the test campaign, test personnel verified that any changes made to the software, hardware, or documentation during the test process were fully and properly documented.

3.1.3 System Level Testing

System Level Testing was implemented to evaluate the complete system. System Level Testing for this campaign included the evaluations of the following test areas: FCA, Accuracy Testing, Volume and Stress, and System Integration Testing. This testing included all proprietary components and COTS components (software, hardware, and peripherals) in a configuration of the system's intended use.

For software system tests, the tests were designed according to the stated design objective without consideration of its functional specification. The system level hardware and software test cases were prepared independently to assess the response of the hardware and software to a range of conditions. Pro V&V reviewed the manufacturer's program analysis, documentation, and module test case design and evaluate the test cases for each module with respect to flow control parameters and entry/exit data. As test cases were utilized throughout the test campaign, they were designed based on the manufacturer's design specifications and the relevant technical requirements set forth by the VVSG. Test cases were examined based on the following aspects of the voting system: Hardware qualitative examination design, Hardware environmental test case design, Software module test case design and data, Software functional test case design, and System level test case design.

Test cases provided information regarding the sequence of actions to be performed for the execution of a test, the requirements being met, the test objective, test configuration, equipment needed, special requirements, assumptions, and pass/fail criteria. Once the test cases were finalized, they were validated and published for use in the test campaign. The validation of the test case was accomplished by technical review and approval. This validation included the following: confirmation of adequate test coverage of the requirement being tested; confirmation that test case results were not ambiguous and gave objective pass/fail criteria; and confirmation that any automated test suites would produce valid results

Pro V&V defined the expected result for each test and the ACCEPT/REJECT criteria for certification. If the system performed as expected, the results were accepted. If the system did not perform as expected, an analysis was performed to determine the cause.

If needed, the test was repeated in an attempt to reproduce the results. If the failure could not be reproduced and the expected results were not met, the system was determined to have failed the test. If the results could not be reproduced, the test continued. All errors encountered were documented and tracked through resolution.

3.1.3.1 Functional Configuration Audit (FCA)

The FCA targeted the specific functionality claimed by the manufacturer to ensure the product functions as documented. This testing used both positive and negative test data to test the robustness of the system. The FCA encompassed an examination of manufacturer tests, and the conduct of additional tests, to verify that the system hardware and software perform all the functions described in the manufacturer's documentation submitted in the TDP (such as system operations, voter manual, maintenance, and diagnostic testing manuals). It included a test of system operations in the sequence in which they would normally be performed. These system operations and functional capabilities were categorized as follows by the phase of election activity in which they are required:

- Overall System Capabilities: These functional capabilities apply throughout the election process. They include security, accuracy, integrity, system audit ability, election management system, vote tabulation, ballot counters, telecommunications, and data retention.
- Pre-voting Capabilities: These functional capabilities are used to prepare the voting system for voting. They include ballot preparation, the preparation of election-specific software (including firmware), the production of ballots, the installation of ballots and ballot counting software (including firmware), and system and equipment tests.
- Voting System Capabilities: These functional capabilities include all operations conducted at the polling place by voters and officials including the generation of status messages.
- Post-voting Capabilities: These functional capabilities apply after all votes have been cast. They include closing the polling place; obtaining reports by voting machine, polling place, and precinct; obtaining consolidated reports; and obtaining reports of audit trails.
- Maintenance, Transportation and Storage Capabilities: These capabilities are necessary to maintain, transport, and store voting system equipment.

In addition to functioning according to the manufacturer's documentation, tests were conducted to ensure all applicable EAC VVSG 1.0 requirements were met. Regression testing was also conducted on the EMS 4.4 to establish assurance that the modifications had no adverse impact on the compliance, integrity, or performance of the system.

Summary Findings

All functional tests were successfully executed. During execution of the test procedures, it was verified that the EMS 4.4 system successfully completed the FCA by functioning according to the manufacturer's documentation with all actual results obtained during test execution matching the expected results.

3.1.3.2 Accuracy

The Accuracy Test ensured that each component of the voting system could process 1,549,703 consecutive ballot positions correctly within the allowable target error rate. The Accuracy Test is designed to test the ability of the system to “capture, record, store, consolidate and report” specific selections and absences of a selection. The required accuracy is defined as an error rate. This rate is the maximum number of errors allowed while processing a specified volume of data. In an effort to achieve this and to verify the proper functionality of the units under test, the following methods were used to test components of the voting system:

The accuracy requirements for the MicroVote EMS 4.4 were accomplished by the execution of the standard accuracy test utilizing a voting script.

For DRE-based voting systems the system must correctly capture, store, and report the specific ballot selections, and absence of selections, for each ballot position. DRE configurations which include a VVPAT must also correctly print the ballot selections made by the voter. The accuracy requirements for the Infinity Panel were met by loading elections for the ballot length supported by the system onto DRE units, and using the MicroVote vote simulation tool, cast votes on the device using predetermined marking patterns. Accuracy testing was performed on both the Infinity Panel and Infinity Panel with VVPAT connected. Barcodes printed on VVPAT receipts were scanned to ensure that the information included within the barcodes correctly matched vote selections.

For paper-based voting systems, the ballot positions on a paper ballot must be scanned to detect selections for individual candidates and contests and the conversion of those selections detected on the paper ballot converted into digital data. The accuracy requirements for the ACP-2200 was met by the execution of the standard accuracy test utilizing hand-marked ballots of the ballot length supported by the system.

Summary Findings

The ACP-2200 was tested by utilizing hand marked ballots to achieve an accuracy rate greater than 1,549,703 correct ballot positions. The Infinity Panel and VVPAT units were tested by using the MicroVote vote simulation tool to cast a sufficient number of ballots to achieve an accuracy rate greater than 1,549,703 correct ballot positions.

3.1.3.3 Volume & Stress

The Volume & Stress Tests are utilized to investigate the system’s response to conditions that tend to overload the system’s capacity to process, store, and report data.

The test parameters focused on the system’s stated limits and the ballot logic for areas such as the maximum number of active voting positions, maximum number of ballot styles, maximum candidates, maximum contests, and stated limits within the EMS. This test is utilized to ensure the system could achieve the manufacturer’s TDP claims of what the system can support. Testing was performed by exercising an election definition and test cases developed specifically to test for volume and stress conditions of the EMS 4.4 system being tested.

Summary Findings

The EMS 4.4 System successfully passed the Volume & Stress Test. During execution of the test procedure, it was verified that the EMS 4.4 System successfully completed the test with all actual results obtained during test execution matching the expected results.

3.1.3.4 System Integration

The system integration tests were performed to ensure the EMS 4.4 functioned as a complete system. The system integration testing addressed the integration of the hardware and software. This testing focused on the compatibility of the voting system software components and subsystems with one another and with other components of the voting system. During test performance, the system was configured as would be for normal field use.

Summary Findings

During test performance, the system was configured as it would for normal field use. This included connecting all supporting equipment and peripherals including ballot boxes, voting booths (regular and accessible), and any physical security equipment such as locks and ties. Pro V&V personnel properly configured the system by following the procedures detailed in the EMS 4.4 technical documentation. During System Integration testing, three General Elections and three Primary Elections were successfully exercised on the voting system, as described below:

General elections with the following breakdown:

- General Election GEN-01: A basic election held in 4 precincts, one of which is a split precinct. This election contains 19 contests compiled into 4 ballot styles. 5 of the contests are in all 4 ballot styles. The other 15 contests are split between at least 2 of the precincts with a maximum of 4 different contest spread across the 4 precincts.
- General Election GEN-02: A basic election held in 3 precincts. This election contains 15 contests compiled into 3 ballot styles. 10 of the contests are in all 3 ballot styles with the other five split across the 3 precincts.
- General Election GEN-03: A basic election held in two precincts. This election contains eight contests and is compiled into two ballot styles. Four of the contests are in both ballot styles. The other four contests are split between the two precincts. This election is designed to functionally test the handling of multiple ballot styles, support for at least three languages including a character-based language, support for common voting variations, and audio support for two languages (English and Spanish).

Primary elections with the following breakdown:

- Primary Election PRIM-01: Open Primary Election in two precincts. This election contained thirty contests compiled into five ballot styles. Each ballot style contains 6 contests.

- Primary Election PRIM-02: Open Primary Election held in two precincts. This election contained thirteen contests compiled into three ballot styles. One contest is in all three ballot styles; all other contests are independent.
- Primary Election PRIM-03: A basic election held in two precincts. This election contains ten contests and is compiled into two ballot styles. Two of the contests are in both ballot styles. The other eight contests are split between the two parties' ballots. This Primary Election is designed to functionally test the handling of multiple ballot styles, support for at least three languages including a character-based language, support for common voting variations, and audio support for two languages (English and Spanish).

The EMS 4.4 system successfully passed the System Integration Test. During execution of the test procedure, it was verified that the EMS 4.4 system successfully completed the system level integration tests with all actual results obtained during test execution matching the expected results.

3.1.3.5 EMS and System Functional Regression Testing

EMS and System Functional Regression Testing was performed to ensure the submitted modification did not adversely affect the EMS 4.4 system. Throughout the test campaign, Pro V&V personnel maintained a test log identifying the system and equipment under test and any records of deviations to the test plan along with the rationale for performing the deviations. Pro V&V also utilized an internal bug tracking system to record and track all issues and/or discrepancies noted during the test campaign.

3.1.4 Hardware Testing

The hardware configuration and design for the modification has changed from the baseline system. The Infinity Revision E with color display, optional VVPAT printer, and UPS have been added as part of the EMS 4.4 system. These modifications required the full suite of environmental and electrical hardware testing to be performed to verify the modification met hardware test requirements set forth in the EAC 2005 VVSG 1.0. These tests are listed below:

Electrical Tests:

- Electrical Power Disturbance
- Electromagnetic Radiation
- Electrostatic Disruption
- Electromagnetic Susceptibility
- Electrical Fast Transient
- Lightning Surge
- Conducted RF Immunity
- Magnetic Fields Immunity

- Electrical Supply

Environmental Tests:

- Bench Handling
- Vibration
- Low Temperature
- High Temperature
- Humidity
- Temperature Power Variation

The hardware tests specified in the VVSG are divided into two categories: non-operating and operating. The non-operating tests apply to the elements of the system that are intended for use at poll site locations and are intended to simulate the storage and transport of equipment between the storage facility and the polling location. The Operating tests apply to the entire system, including hardware components that are used as part of the voting system telecommunications capability, and are intended to simulate conditions that the voting system may encounter during operation. Prior to and immediately following each required non-operating and operating test, the system shall be subjected to an operational status check.

Pro V&V utilized third party testing during the performance of hardware testing. Testing was performed at the NTS Longmont facility located in Longmont, Colorado. All testing at the NTS Longmont facility was witnessed on-site by Pro V&V personnel, with the exception of Temperature Power Variation in which Pro V&V qualified staff executed all testing.

Summary Findings

The results for electrical hardware testing are summarized in the table below. Detailed procedures and results are included in the following NTS reports:

- ETR-PR108417 Revision 0 and, presented in Attachment A-1
- ITR-PR108417 Revision 0, presented in Attachment A-2

Table 3-2. Electrical Hardware Test Results

Standard/Method	Description	Criteria	Class/Level	Result
FCC 15.107 ICES-003 VVSG Vol. 1 4.1.2.9	Power Line Conducted Emissions	Normal Operation & No Data Loss	Class B	Pass
FCC 15.109 ICES-003 VVSG Vol. 1 4.1.2.9	Radiated Emissions	Normal Operation & No Data Loss	Class B	Pass
EN61000-4-11 VVSG Vol. 1 4.1.2.5	Electrical Power Disturbance	Normal Operation & No Data Loss	Various	Pass

Table 3-2. Electrical Hardware Test Results (continued)

Standard/Method	Description	Criteria	Class/Level	Result
EN61000-4-4 VVSG Vol. 1 4.1.2.6	Electrical Fast Transient	Normal Operation & No Data Loss	±2kV - Mains	Pass
EN61000-4-5 VVSG Vol. 1 4.1.2.7	Lightning Surge	Normal Operation & No Data Loss	±2kV Line - Line ±2kV Line - Ground	Pass
EN61000-4-2 VVSG Vol. 1 4.1.2.8	Electrostatic Disruption	Normal Operation & No Data Loss	±8kV Contact ±15kV Air	Pass
EN61000-4-3 VVSG Vol. 1 4.1.2.10	Electromagnetic Susceptibility	Normal Operation & No Data Loss	10 V/m, 80 MHz – 1 GHz	Pass
EN61000-4-6 VVSG Vol. 1 4.1.2.11	Conducted RF Immunity	Normal Operation & No Data Loss	10 Vrms, 150 kHz – 80 MHz	Pass
EN61000-4-8 VVSG Vol. 1 4.1.2.12	Magnetic Immunity	Normal Operation & No Data Loss	30 A/m	Pass

The results for environmental hardware testing are summarized in the table below. Detailed procedures and results are included in the following NTS report:

- Test Report TR-PR108417-00 Revision 0, presented in Attachment A-3

Table 3-3. Environmental Hardware Test Results

Standard/Method	Description	Criteria	Result
MIL-STD-810D, 516.3, I-3.8 VVSG Vol. 1 4.1.2.14, VVSG Vol. 2 4.6.2	Shock – Bench Handling	Normal Operation & No Data Loss	Pass
MIL-STD-810D, 514.3, I-3.2.1 VVSG Vol. 1 4.1.2.14, VVSG Vol 2 4.6.3	Vibration - Basic Transportation	Normal Operation & No Data Loss	Pass
MIL-STD-810D, 502.2, II-3 VVSG Vol 1 4.1.2.14, VVSG Vol 2 4.6.4	Low Temperature - Storage	Normal Operation & No Data Loss	Pass
MIL-STD-810D, 501.2, I-3.2 VVSG Vol 1 4.1.2.14, VVSG Vol 2 4.6.5	High Temperature - Storage	Normal Operation & No Data Loss	Pass
MIL-STD-810D, 507.2, I-3.2 VVSG Vol 1 4.1.2.14, VVSG Vol 2 4.6.5	Humidity – Hot/Humid	Normal Operation & No Data Loss	Pass
MIL-STD-810D, 501.2/502.2 VVSG Vol 1 4.1.2.13, 4.3.3, VVSG Vol 2 4.7.1	Reliability, Temp-Power Variation Testing	Normal Operation & No Data Loss	Pass
VVSG Vol. 1 4.1.2.4	Electrical Supply	Normal Operation & No Data Loss	Pass

3.1.5 Usability & Accessibility

Usability & Accessibility testing was performed to evaluate the EMS 4.4 System to the applicable requirements. Testing specifically focused on the modifications implemented since the certification of the baseline system.

Usability was defined generally as a measure of the effectiveness, efficiency, and satisfaction achieved by a specified set of users with a given product in the performance of specified tasks. In the context of voting, the primary user is the voter, the product is the voting system, and the task is the correct recording of the voter ballot selections. Additional requirements for task performance are independence and privacy: the voter should normally be able to complete the voting task without assistance from others, and the voter selections should be private. Accessibility evaluates the requirements for accessibility. These requirements are intended to address HAVA 301 (a) (3) (B).

Summary Findings

The EMS 4.4 System successfully met the requirements of the Usability and Accessibility evaluation. During test performance, the EMS 4.4 System was configured as per the MicroVote EMS 4.4 TDP. Any deficiencies encountered during testing were successfully resolved.

3.1.6 Security Review

The objective of the security testing was to evaluate the security posture of the system that may have been affected by the changes implemented in this modification. The evaluation of the system was accomplished by utilizing a combination of documentation review, functional testing, and manual inspection. During the security review, the system was inspected to verify that various controls and measure are in place in order to meet the objectives of the security standards which include: protection of the critical elements of the voting system; establishing and maintaining controls to minimize errors; protection from intentional manipulation, fraud and malicious mischief; identifying fraudulent or erroneous changes to the voting system; and protecting the secrecy in the voting process.

Physical Security testing was performed to verify and validate submitted changes are in compliance to the requirements of the EAC 2005 VVSG. Physical Security was tested by setting up the system as described in the TDP and then examining the effectiveness and comprehensiveness of physical security measures.

Summary Findings

As a result of the Security Review, it was determined that the EMS 4.4 met the VVSG 1.0 security requirements. Any deficiencies encountered during testing were successfully resolved.

3.2 Anomalies and Resolutions

When a result is encountered during test performance that deviates from what is standard or expected, a root cause analysis is performed.

Pro V&V considers it an anomaly if no root cause can be determined. In instances in which a root cause is established, the results are then considered deficiencies. No anomalies occurred during the testing of the EMS 4.4.

3.3 Deficiencies and Resolutions

Any violation of the specified requirement or a result is encountered during testing that deviates from what is standard or expected in which a root cause is established is considered a deficiency. Upon occurrence, deficiencies are logged throughout the test campaign for disposition and resolution. Any deficiencies encountered during testing, along with their resolution, are noted below.

Table 3-4. Noted Deficiencies

ID#	Test Category	Deficiency	Resolution
499	FCA	The audio on the last page of the ballot before casting/reviewing is incorrect. When the button is pressed, the audio that is presented is from a previous contest earlier in the ballot. This only happens with the Infinity Panel without the VVPAT configuration. IP with VVPAT has no issues providing the correct audio on the last page.	Issue resolved with firmware update: 4.40-004 for Rev E & 4.30-018 for Rev D.
500	FCA	If a contest has a large number of candidates in it (i.e. 30+), a selection is made when the Cast Vote button is pressed (in this case Candidate 30). Depending on the Vote For number & number of candidates, multiple selections can be made in one contest with the Cast Vote button.	Issue resolved with firmware update: 4.40-004 for Rev E & 4.30-018 for Rev D.
502	FCA	The Consolidated Tally Report does not display any selections made for Straight Party selections.	Issue resolved with updated EMS (EMS 4.4.6).

4.0 RECOMMENDATION FOR CERTIFICATION

The EMS 4.4, as presented for testing, successfully met the requirements set forth for voting systems in the U.S. Election Assistance Commission (EAC) 2005 Voluntary Voting System Guidelines (VVSG), Version 1.0. Additionally, Pro V&V, Inc. has determined that the EMS 4.4 functioned as a complete system during System Integration Testing. Based on the test findings, Pro V&V recommends the EAC grant the EMS 4.4 identified in Tables 4-1 and 4-2 certification to the EAC VVSG 1.0.

Table 4-1. MicroVote EMS 4.4 Software

Firmware/Software	Version
<i>Proprietary</i>	
EMS	4.4
Infinity Panel Rev. D	4.30
Infinity Panel Rev. E	4.40
<i>COTS</i>	
Microsoft Windows 10 Professional	1909
Microsoft Visual Studio Professional 2017	15.9
ComponentOne Ultimate 2014	1
Advanced Installer	16.4.1
Advanced Installer Extension for Visual Studio 2017	16.5

Table 4-2. MicroVote EMS 4.4 Hardware

Component	Serial Number
<i>Proprietary Hardware</i>	
Infinity Voting Panel (Rev D) w/Power Supply	11588
Infinity Voting Panel (Rev E) w/Power Supply	14009
Infinity Voting Panel (Rev E) w/Power Supply	14010
VVPAT (Rev A) w/Power Supply	001011
VVPAT (Rev A) w/Power Supply	001100
<i>COTS Hardware</i>	
Tripp Lite Portable Surge Protector (TRAVELCUBE)	[MVT-TC-001]
Tripp Lite Portable Surge Protector (TRAVELCUBE)	[MVT-TC-002]
Minuteman UPS (EP1000LCD)	AK11190890004
APC Back-UPS Pro (BN1100M2)	3B1925X63177
APC Back-UPS Pro (BN1100M2)	3B1925X63227
Dell Latitude 5580 Laptop w/Power Supply	51LG8H2
Dell Latitude 5580 Laptop w/Power Supply	5DL1RN2
USB Smart Card Reader (PC USB TR PIV) w/Stand (HWP109380 B)	113101316600170
EMS Download Cable	CC06789-06
EMS Download Cable	[MVT-DC-001]

Table 4-2. MicroVote EMS 4.4 Hardware *(continued)*

Component	Serial Number
USB-RS232 Converter	USA000106043
USB-RS232 Converter	USA000155787
Seiko Instruments Printer (DPU-3445) w/Power Supply	2008922A
DoubleTalk LT	[MVT-DT-001]
Hamilton Buhl (PRM100B)	[MVT-HB-001]
Chatsworth Data (ACP-2200)	CDT021901537
Chatsworth Data (ACP-2200)	CDT121901544
Head Stick	[MVT-HS-001]

ATTACHMENT A

Hardware Test Reports

Provided as separate documents