

U.S. Election Assistance Commission

Formal Investigation Report

Election Systems and Software Unity 3.2.0.0

EAC Certification Number: ESSUNITY3200

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Voting System Testing and Certification Division

1201 New York Ave, NW, Suite 300

Washington, DC 20005

www.eac.gov

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Executive Summary

Overview

This Formal Investigation Report summarizes the Scope, Analysis, Findings and Recommendations of the EAC investigation into the Election Systems & Software (ES&S) DS200 Precinct Count Optical Scanner in the Unity 3.2.0.0 EAC certified voting system. The EAC acknowledges and appreciates the level of cooperation received from ES&S during the course of this investigation.

The investigation was initiated by the EAC as a result of information contained in an article in The Cleveland Plain Dealer published on April 14, 2010, about a freeze/shutdown issue experienced in Cuyahoga County, Ohio during pre-election testing.

Although participation in the EAC certification program is voluntary for States, adherence to the program's procedural requirements is mandatory for all participating voting system manufacturers.

Substantiated Anomalies

The EAC deems three of the four allegations of anomalies described in this investigation to be substantiated. The substantiated anomalies are:

- Intermittent screen freezes, system lockups and shutdowns that prevent the voting system from operating in the manner in which it was designed.
- Failure to log all normal and abnormal voting system events.
- Skewing of the ballot resulting in a negative effect on system accuracy.

The cure to these anomalies proposed by ES&S in the form of the modified Unity 3.2.0.0 Rev. 2 voting system, does not correct all anomalies cited in this investigation. These anomalies remain in the EAC Certified Unity 3.2.0.0 voting system in use today. In addition, the ES&S proposed fixes created additional anomalies discovered in the EAC certified Unity 3.2.1.0 voting system.

Recommendations

Based on this finding, the EAC recommends the following:

1. That the EAC issue a Notice of Non-Compliance for the substantiated allegations in the EAC certified Unity 3.2.0.0 system. The Notice will inform the Manufacturer of the next steps in the process, including the Manufacturer's opportunity to cure non-compliance and have an opportunity to be heard prior to any final decision on decertification.

2. That a Manufacturer Site Audit be conducted by the EAC to evaluate the developmental testing and quality assurance practices of ES&S. The EAC has concerns about the Quality Assurance practices of the manufacturer based on the recurrence of certain anomalies and the fact that fixes provided for certain anomalies created additional issues with the DS200.

The Process

Because of the potential adverse impact on voting system manufacturers, election officials and the public, the EAC process for possible decertification actions is complex. The investigation process is initiated when the EAC receives information that a voting system may not be in compliance with the applicable voting system standard or procedural requirements of the EAC certification program. Upon receipt of such information, the EAC initiates an Informal Inquiry to determine the credibility of the information. If the information is credible and suggests the system is non-compliant, a Formal Investigation is initiated. If the results of the Formal Investigation demonstrate non-compliance, the Manufacturer is provided a Notice of Non-Compliance. Before a final decision on decertification is made, the Manufacturer will have the opportunity to remedy any defects identified in the voting system and present any additional information for consideration by the EAC.

1. Introduction

This report summarizes the Scope, Analysis, Findings and Recommendations of the Formal Investigation into the Election Systems & Software (ES&S) DS200 Precinct Count Optical Scanner in the Unity 3.2.0.0 EAC certified voting system.

The *Cleveland Plain Dealer* (“[Appendix B - Cleveland Plain Dealer](#)”) published an article on April 14, 2010, about a freeze/shutdown issue experienced in Cuyahoga County, OH, during pre-election logic & accuracy testing. The EAC followed up with Cuyahoga County and ES&S about the anomaly. ES&S provided the EAC with a “DS200 Lockup Analysis” (“[Appendix Q - DS200 Lockup Analysis](#)”) on June 28, 2010. The EAC analyzed this report and responded with further questions. The EAC contacted all known jurisdictions using Unity 3.2.0.0 and the DS200 to gather information about their experiences with the system.

On October 15, 2010, the Testing and Certification Program Director submitted a “Recommendation to Refer for Formal Inquiry,” (“[Appendix F - Recommendation to Refer for Formal Inquiry](#)”) and submitted an addendum (“[Appendix G - Addendum Recommendation to Refer for Formal Inquiry](#)”) to that recommendation in December 2010. On February 25, 2011, the EAC Executive Director, issued an “Authorization for Formal Investigation” (“[Appendix J - Authorization for Formal Investigation](#)”)¹. The investigation focused on these anomalies: freeze/shutdown, ballot skew, failure to log and vote miscount. The EAC issued a “Notice of Formal Investigation” (“[Appendix R - Notice of Formal Investigation](#)”) to ES&S on March 1, 2011.

As noted in the diagram below, there have been a number of modifications to the EAC certified Unity 3.2.0.0 system. Most of these modifications attempt to address the anomalies reported in this investigation or were discovered during testing of the cure for the anomalies listed in this investigation. Testing for the Unity 3.2.0.0 cure was conducted during the Unity 3.2.1.0 test campaign. The DS200 in 3.2.1.0 shares a large amount of source code with Unity 3.2.0.0, which means that anomalies found in Unity 3.2.1.0 may be present in the Unity 3.2.0.0 certified DS200.

2. Scope of Formal Investigation

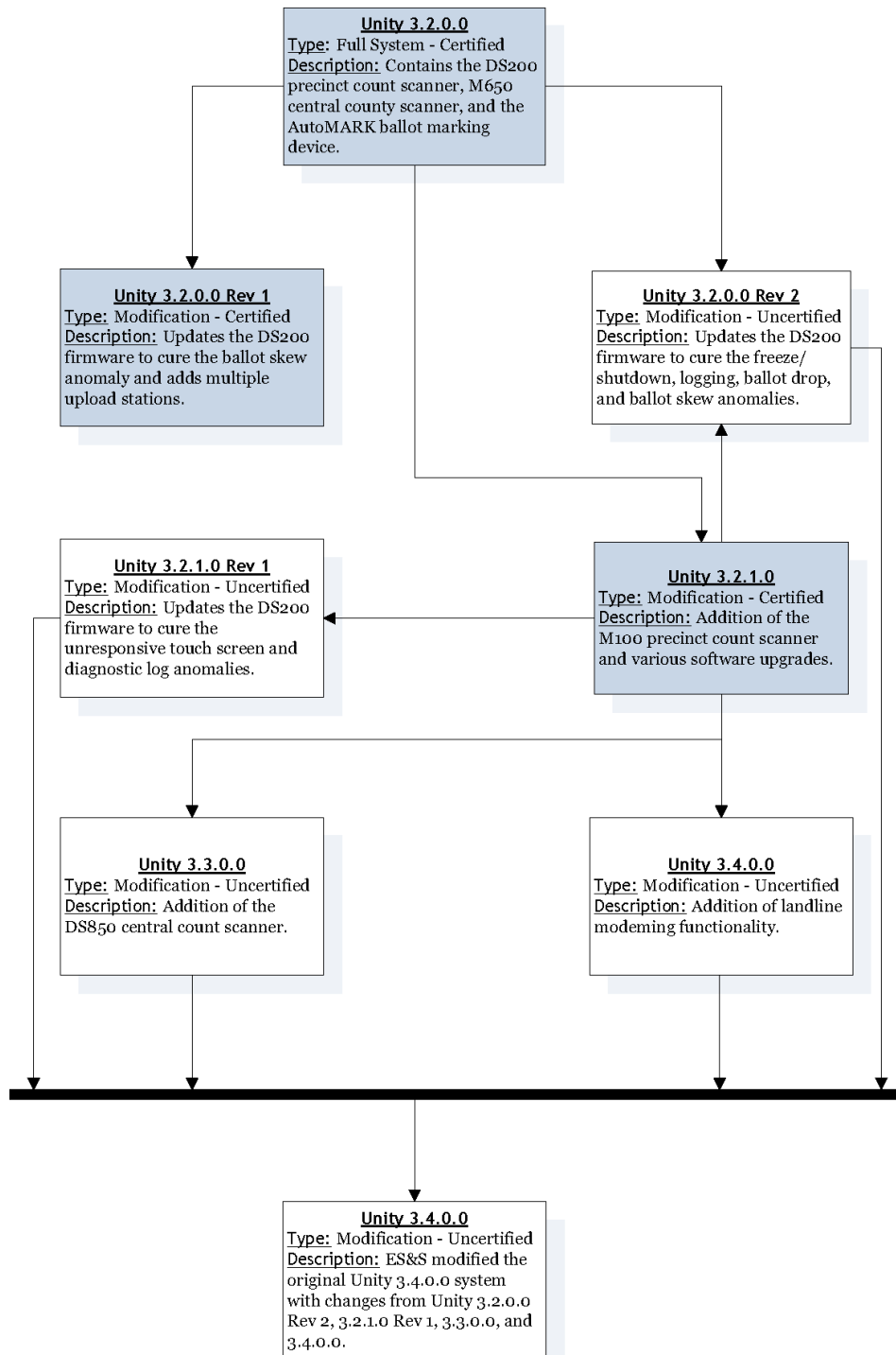
The focus of the Investigation was the ES&S DS200 Precinct Count Optical Scanner (firmware version 1.3.10.0) contained in the ES&S Unity 3.2.0.0 EAC certified voting system. The scope of the Investigation was to determine if the freeze/shutdown anomaly first experienced in Cuyahoga County, Ohio during pre-election logic and accuracy testing in preparation for the May 4, 2010 Primary Election rendered the system non-conformant to the 2002 Voting Systems Standards (VSS). In addition to the freeze/shutdown anomaly, the EAC’s Informal Inquiry revealed additional anomalies with the DS200, including issues related to ballot skew, ballot insertion,

1 EAC Executive Director Thomas Wilkey retired effective November 30, 2011. Under the provisions of HAVA, the EAC General Counsel becomes acting Executive Director until the Commission selects a permanent replacement.

and unlogged errors. Further, the potentially more serious issue noted in the December 20, 2010 addendum which outlined the problem encountered when the DS200 accepted a voted test ballot without recording that ballot on its internal

ES&S Unity 3.2.0.0 Voting System Flowchart:

This flowchart is a graphical representation of the relationships between the Unity 3.2.0.0 voting system and its subsequent modifications described in this Report



counter during testing at iBeta Quality Assurance, was investigated for potential non-compliance with the 2002 VSS.

2.1 Freeze/shutdown

At random intervals, the DS200 initiates the shutdown process whereupon it will complete approximately 90% of the shutdown process and then freeze. The DS200 Unit will not accept ballots in the frozen state.

The Freeze/shutdown issues indicates a system non-conformity to the 2002 VSS Volume 1 Section 2.2.1 & 3.4.3:

2.2.1.b – Provide system functions that are executable only in the intended manner and order, and only under the intended conditions.

3.4.3 – Reliability: The reliability of voting system devices shall be measured as Mean Time Between Failure (MTBF) for the system submitted for testing. MBTF is defined as the value of the ratio of operating time to the number of failures which have occurred in the specified time interval. A typical system operations scenario consist of approx. 45 hours of equipment operation, consisting of 30 hours of equipment set-up and readiness testing and 15 hours of elections operations. For the purpose of demonstrating compliance with this requirement, a failure is defined as any event which results in either the:

- *Loss of one or more functions; or*
- *Degradation of performance such that the device is unable to perform its intended function for longer than 10 seconds*

The MTBF demonstrated during certification testing shall be at least 163 hours.

2.2 Failure to log

Cuyahoga County election officials provided the EAC with DS200 system logs from their May 4 and August 8, 2010 elections. The May 4 election used over 1,000 DS200s; the August 8 election was smaller, providing logs from only 12 machines. Review of these system logs identified an additional issue. The freeze/shutdown event did not result in any record of its occurrence in the system logs. In addition, records of numerous other normal and abnormal events were absent from the system logs.

The failure to log issue indicates a system non-conformity to the 2002 VSS Volume I 2.2.4 Integrity:

Integrity measures ensure the physical stability and function of the vote recording and counting processes.

2.2.4.1 - Common Standards

To ensure system integrity, all systems shall:

- g. Record and report the date and time of normal and abnormal events.*
- i. Detect and record every event, including the occurrence of an error condition that the system cannot overcome, and time-dependent or programmed events that occur without the intervention of the voter or a polling place operator.*

2.3 Ballot Skew²

When a 17” ballot is inserted incorrectly into the unit the lower left and right hand corners of the ballot are not accurately read.

The failure to accurately read all valid votes on a ballot indicates a system non-conformity to the 2002 VSS Volume I 2.2.2.1 Common Standards:

To ensure vote accuracy, all systems shall:

- c. Record each vote precisely as indicated by the voter and be able to produce an accurate report of all votes cast.*

2.4 Vote miscount

The DS200 accepts a voted ballot but does not record the ballot on its internal counter. In addition the marks of the second ballot are not recorded.

The inaccurate vote count indicates a system non-conformity to the 2002 VSS Volume I 2.2.9 Ballot Counter:

For all voting systems, each device that tabulates ballots shall provide a counter that:

- b. Records the number of ballots cast during a particular test cycle or election.*

3. Investigative process

On March 1, 2011, the EAC Executive Director issued a Notice of Formal Investigation for the ES&S Unity 3.2.0.0 voting system. Section 7.4 of the EAC *Voting System Testing and Certification Program Manual* (Manual) outlines the process for conducting a formal investigation.

During the course of the investigation, EAC staff created a record of all relevant documents and information, including: initial reports about the anomalies; ES&S Lockup Analysis and documentation regarding proposed fixes to the system; ES&S Technical Advisories; EAC Product Advisories; and system documentation. The EAC created this record from documents and information received during both the Informal and Formal investigation process.

Section 7.4.5.5.4 of the Manual permits the EAC to develop written requests for information (referred to as interrogatories in the Manual). The EAC developed

² As used in this report. “Ballot Skew” refers to the ballot paper being placed into the scanning feed mechanism of the DS200 not perfectly parallel to the DS200 paper guide.

several sets of interrogatories and sent them (March 30, 2011) to iBeta Quality Assurance (“Appendix S - Interrogatory: iBeta Quality Assurance”); Wyle Laboratories (“Appendix T - Interrogatory: Wyle Laboratories”); Director of Elections, Cuyahoga County, OH (“Appendix U - Interrogatory: Cuyahoga County”); and ES&S (“Appendix V - Interrogatory: ES&S”). The EAC received and reviewed the responses and documentation for these interrogatories. The information gathered through this process is part of the record of this investigation.

On April 15, 2011, ES&S received EAC approval to begin testing a modification, (Unity 3.2.0.0, Rev. 2), to cure the issues cited in the Notice of Formal Investigation. This modification integrated firmware changes, which are part of the certified Unity 3.2.1.0 system, with the Unity 3.2.0.0.

Section 7.4.5.5.2 of the Manual permits the EAC to conduct field audits of EAC certified systems. An EAC Computer Engineer traveled to Cuyahoga County to observe the County’s upgrade to the Unity 3.2.1.0 system. While observing the upgrade installation, the EAC witnessed anomalies similar to those reported in the informal and formal investigation for Unity 3.2.0.0 (“Appendix L - EAC Report on Cuyahoga 3.2.1.0 Upgrade”).

4. Relevant facts & timeline

- On July 21, 2009, ES&S Unity 3.2.0.0 received EAC certification (EAC certification number: ESSUnity3200). This system contained the DS200, M650, and AutoMARK.
- On October 20, 2009, ES&S released Technical Bulletin PRBD2000006 (DS200 Registers Unmarked Ovals as Marks on Skewed 17 and 19 inch Ballots) to certain DS200 users.
- On April 14, 2010, The *Cleveland Plain Dealer* published an article about the freeze/shutdown issue experienced in Cuyahoga County, OH, during Logic & Accuracy Testing.
- On April 19, 2010, ES&S created an initial hardware analysis describing tests run on machines and initial findings on the cause of the freeze/shutdown issue.
- On April 23, 2010, ES&S sent guidance to Cuyahoga County on recommended procedures to handle the freeze/shutdown anomaly on Election Day (May 4, 2010).
- On June 22, 2010, ES&S Unity 3.2.0.0 Rev.1 application for modification of Unity 3.2.0.0 was approved. This modification was intended to fix the ballot skew and allow for multiple upload stations for the DS200.
- On June 25, 2010, the EAC released a Technical Advisory titled “Intermittent Freeze/Shutdowns with EAC Certified ES&S Unity 3.2.0.0 System .”

- On June 28, 2010, ES&S provided the EAC with a “DS200 Lockup Analysis.”
- On July 7, 2010, ES&S released Technical Bulletin PRBDS2000008 (DS200(i) Intermittent Freeze and Shutdown).
- On July 9, 2010, ES&S provided the EAC with a USB trace analysis and clarification to questions about the “DS200 Lockup Analysis.”
- On July 22, 2010, The EAC issued an “Initial Decision on Certification” for ES&S Unity 3.2.0.0 Rev. 1 modification. This modification addressed ballot skew and multiple upload station functionality. This modification did not address all known non-conformities.
- On August 2-4, 2010, an EAC Computer Engineer traveled to Cuyahoga County to witness Logic & Accuracy Testing.
- On August 17-20, 2010, Program Director; Program Deputy Director; an EAC Technical Reviewer; visit Orange County, Florida election offices to discuss the DS200.
- On October 8, 2010, The EAC certified ES&S Unity 3.2.0.0 Rev. 1 (Modification).
- On October 15, 2010, EAC Program Director, submitted a “Recommendation to Refer for Formal Inquiry ” to EAC Executive Director.
- On November 2, 2010, an EAC Computer Engineer traveled to Cuyahoga County, OH, to witness Election Day activities.
- On November 30, 2010, iBeta Quality Assurance decided to leave the EAC program, effective December 14, 2010. All testing for Unity 3.2.1.0 was moved to Wyle Laboratories at the request of ES&S. iBeta provided Wyle with a partial test report for Unity 3.2.1.0.
- On December 20, 2010, EAC Program Director submitted an addendum to the “Recommendation to Refer for Formal Inquiry ” to the EAC Executive Director.
- On February 11, 2011, ES&S issued Technical Bulletin PRBDS2000010 (Public Counter Does Not Increment When Ballot is Dropped into Ballot Box).
- On February 17, 2011, ES&S issued Technical Bulletin FYIDS2000019 (DS200 Threshold Settings).
- On February 25, 2011 EAC Executive Director issued an “Authorization for Formal Investigation”. The investigation focused on these anomalies: freeze/ shutdown, ballot skew, failure to log and vote miscount. The EAC issued a “Notice of Formal Investigation” to ES&S on March 1, 2011.
- On March 3, 2011, the EAC released a Technical Advisory titled “Ballot Drop with EAC Certified ES&S Unity 3.2.0.0 and 3.2.0.0 Rev. 1 .”

- On March 29, 2011, the EAC certified ES&S Unity 3.2.1.0 (EAC Certification number: ESSUnity3210).
- On March 30, 2011, the EAC sent interrogatories for the Formal Inquiry to iBeta Quality Assurance, Wyle Laboratories, Cuyahoga County and ES&S. The EAC requested all parties to respond by April 13, 2011. All parties responded to the Interrogatories by April 14, 2011. The interrogatories and responses focused on issue notification, quality assurance testing, configuration management and root cause analysis of reported issues.
- On April 15, 2011, the EAC approved an application for ES&S Unity 3.2.0.0 Rev. 2 (Modification). This modification used firmware from the EAC Certified ES&S Unity 3.2.1.0 system to fix the freeze/shutdown, ballot skew, failure to log, and vote miscount as identified in the “Notice of Formal Investigation.”
- On June 13-15, 2011, an EAC Computer Engineer traveled to Cuyahoga to witness the County’s upgrade to the Unity 3.2.1.0 system. The EAC Engineer reported occurrences of the ballot skew anomaly, as well as several other issues.
- On July 28, 2011, the EAC released a Technical Advisory, titled “DS200 Unresponsive Touchscreen .”
- On July 28, 2011, the EAC released a Technical Advisory titled “Ballot Skew.”
- On July, 28, 2011, ES&S Unity 3.3.0.0 application to modify EAC Certified ES&S Unity 3.2.1.0 by adding the DS850 hardware component was approved.
- On July 29, 2011, the EAC approved an application for ES&S Unity 3.2.1.0 Rev.1 (Modification). This modification fixes the anomaly presented by the diagnostic log, used to analyze the freeze/shutdown issue, in EAC certified Unity 3.2.1.0.
- On July, 29, 2011, ES&S Unity 3.4.0.0 application to modify EAC Certified ES&S Unity 3.2.1.0 by adding landline modeming functionality to the DS200 was approved.
- On August 3, 2011, ES&S issued Technical Bulletin FYIDS2000021 (Mark Reported Missed during a Customer Acceptance Testing Exercise).
- On August 3, 2011, ES&S issued Technical Bulletin PRBDS2000013 (System Log Fills Internal Compact Flash Card Partition in DS200 Versions 1.4.3.11 (Unity 3.2.1.0) or 1.5.2.0 (4.0.0.3 Version 2 [FL])).
- On August 9, 2011, Unity 3.2.0.0 Rev 2. test campaign was suspended after calibration and ballot skew anomalies were found in fielded DS200’s Unity 3.2.1.0 and reported to the EAC (see June 13-25, 2011).
- On October 25, 2011, ES&S expressed their intent to terminate Unity 3.2.0.0 Rev 2., Unity 3.2.1.0 Rev 1., and Unity 3.3.0.0 test campaigns and merge all proposed fixes and modifications into the Unity 3.4.0.0 test campaign.

5. Analysis

5.1 Analysis of freeze/shutdown

On April 15, 2010, the EAC became aware of an issue with the EAC certified DS200 (Unity 3.2.0.0) in Cuyahoga County, OH. The DS200 demonstrated intermittent screen freezes, system lockups and shutdowns. ES&S provided the EAC with a root cause analysis of the freeze/shutdown anomaly. The DS200 System Lockup Analysis (“Appendix Q - DS200 Lockup Analysis”) cited two causes of the freeze/shutdown anomaly.

The first cause cited was a memory management issue. In the DS200 source code there were several instances where proper memory deallocation was not performed. The second contributing factor cited in the report was an X-Windows call, which caused a fatal fault in the system. The following is a summary of the root cause analysis performed by ES&S on the DS200, taken directly from the Lockup Analysis provided to the EAC on June 28, 2010:

“In summary, through analysis of the accumulated data, the investigating engineers have determined that the sequence of events leading up to and causing the shutdowns is as follows:

- *A program (HAL) that uses the x-windows library makes a call to the x-windows server. The specific call listed above is XOpenDisplay().*
- *The x-call fails and this causes the pipe between the client (HAL) and the server to break and the OS raises the SIGPIPE signal.*
- *The client (ES&S code) catches the signal but the x-windows system was designed such that an xclient process must exit (the exit call is contained in the x library code) if it loses contact with the server.*
- *The client (HAL) exits.*
- *The rest of the ES&S code no longer has access to the information it needs and therefore shuts itself down.”*

The excerpt below outlines the proposed changes to fix the anomalies described by ES&S in the Lockup Analysis:

“A vast majority of the changes to the ES&S firmware source code as a result of the investigation fall into 4 main categories.

The largest category is the addition of extensive diagnostic logging. Software engineers changed a function named LogIt to LogErr. The LogErr routine calls the Linux OS system function vsyslog to write entries to a log located in the log directory on the var partition of the CF card. (/var/log) This log file is named “messages” with no suffix. This file is designed to provide diagnostic information in case of a problem. ES&S software engineers felt the need to expand the diagnostics based upon a lesson learned from confronting a lack of helpful data to

use to diagnose the initial problem. It is a “rotating” file that never grows beyond a limited size.

The second category is the removal of all code that accessed the x-windows library in the fashion that exposes the apparent bug in the x-windows library. This deals primarily with queries to determine the screen and backlight state. These changes also involve making sure the backlight no longer turns off after a specified period of time. This avoids the possibility that the backlight will shut off and a user could inadvertently touch the screen on a button (hotspot) when they attempt to “wake up” the display.

The third category is the code to improve memory management problems as detailed earlier in this document. Most of this is making sure data pointers are properly set to null after a free() call.

The last category contains a relatively small amount of code to look for a ballot in the transport upon start up. If a ballot is in the transport, the DS200 will automatically back it out of the machine.”

In response to the Lockup Analysis, an EAC Computer Engineer attempted to verify the conclusions drawn by ES&S. The EAC determined the examination completed by ES&S did not provide a sufficient explanation or analysis of the root cause for the freeze/shutdown anomaly. The EAC based its determination on the fact that the Lockup Analysis did not provide adequate details or descriptions of the investigation conducted by ES&S, and that the test parameters, setup, raw data and results of the testing were insufficient for the EAC to validate the analysis.

ES&S applied their identified fixes for this anomaly to the Unity 3.2.1.0 certification effort then underway at iBeta Quality Assurance. The EAC, using the information provided by ES&S and independent EAC research, issued test expectations to iBeta Quality Assurance (“[Appendix W - Expectations for Freeze Shutdown Testing](#)”). The anomaly did not appear in testing after the ES&S fixes were applied to the system. Upon completion of testing, iBeta Quality Assurance submitted a partial test report for Unity 3.2.1.0 to the EAC. During the EAC review of the test report, iBeta withdrew from the Voting System Test Laboratory program (“[Appendix X - iBeta VSTL Withdrawal Letter](#)”). The EAC granted the ES&S request to move the system to Wyle Laboratories per Section 4.3.1.2 of the EAC *Testing and Certification Program Manual* (“[Appendix Y - Approval to move Unity 3.2.1.0 to Wyle](#)”) on January 11, 2011. Wyle addressed the remaining issues with the Unity 3.2.1.0 system and recommended it for certification. The EAC certified the system on April 4, 2011 (EAC certification # ESSUNITY3210). On April 15, 2011, ES&S submitted a testing application for the Unity 3.2.0.0 Rev. 2 modification for the Unity 3.2.0.0 Rev. 1 system. This submission was to correct the anomalies noted in the Scope of Formal Investigation for the Unity 3.2.0.0 system. The fixes for Unity 3.2.0.0 Rev. 2 modification are from the EAC Certified Unity 3.2.1.0. ES&S chose to place the identical firmware from Unity 3.2.1.0 on the Unity 3.2.0.0 DS200.

In June 2011, an EAC Computer Engineer witnessed the upgrade from Unity 3.2.0.0 to Unity 3.2.1.0 in Cuyahoga County, OH. During testing of the upgrade, the EAC discovered that the DS200 touch screen interface became unresponsive at random times. Cuyahoga County provided this information to ES&S and the EAC requested that ES&S provide a root cause analysis of this latest anomaly. ES&S reported (“[Appendix Z - ES&S Response to Investigation](#)”) that the cause of the screen unresponsiveness was a diagnostic log feature ES&S added during the initial investigation of the freeze/shutdown anomaly (Now referred to as the “Sys.log file”).

In their report, ES&S stated that because the file does not “rotate”, meaning the system did not create a new file to prevent the original file from growing beyond its memory allotment, it grows without bounds. This uncontrolled growth made a section of the internal compact flash (CF) card inaccessible. This inaccessible section of the CF card also contained the calibration settings for the DS200’s touch screen interface. When this section of the CF card became inaccessible, the calibration settings were no longer available to the system and caused the screen to become unresponsive.

5.2 Analysis of failure to log

During the course of the formal investigation, the EAC examined DS200 logs provided by multiple jurisdictions. Using the ES&S Software Design Specification, EAC staff extracted the logs from the election media and analyzed their content in Excel. During analysis, the EAC discovered the Unity 3.2.0.0 DS200’s were not capturing some significant system events. Events not captured in the logs included:

- Casting a vote
- Power on, power off, and
- Certain administrative functions.

ES&S proposed to resolve this anomaly with a modification to the Unity 3.2.1.0 system. The EAC instructed iBeta Quality Assurance to review the system logs for conformance to the 2002 VSS. (“[Appendix W - Expectations for Freeze Shutdown Testing](#)”). The laboratory recommended the Unity 3.2.1.0 system for certification stating that all VSS and VVSG requirements had been met. The EAC certified the system on April 4, 2011. On April 15, 2011, ES&S submitted a testing application for the Unity 3.2.0.0 Rev. 2 modification. This application was to correct the logging anomalies noted in the Scope of Formal Investigation for the Unity 3.2.0.0 system. The fixes for Unity 3.2.0.0 Rev. 2 modification are from the EAC Certified Unity 3.2.1.0 DS200. ES&S choose to place the identical firmware from Unity 3.2.1.0 on the Unity 3.2.0.0 DS200.

During installation of the 3.2.1.0 upgrade in Cuyahoga County, OH, election officials provided DS200 system logs to the EAC for examination. EAC staff compared the logged actions to the actual actions of the county testers. (“[Appendix AA - Cuyahoga 3.2.1.0 Upgrade Checklist](#)”). The EAC found that the DS200 event log still did not

record all significant system events. For example, one of the steps that the test performs is to calibrate the touch screen interface. This calibration event is not recorded.

5.3 Analysis of ballot skew

The ballot skew anomaly was discovered during the Unity 3.2.1.0 EAC testing campaign. When a 17” ballot was inserted at an angle, the DS200 did not consistently count the mark properly. The mark registered either as a different selection than intended or did not register at all. ES&S reported to the EAC that ballot skew caused this anomaly. Ballot skew is defined as instances in which the image of the ballot captured by the OS units bowed or out of perfectly straight alignment in some other way. The DS200 uses this image to create evaluation areas where the voting targets, the space a voter marks, should be. This skew caused the mark evaluation area to shift to a different location than the voting target. The DS200 codebase for Unity 3.2.1.0 is similar to the certified Unity 3.2.0.0 software that was under an informal inquiry. The EAC suspected that the anomaly would also be present in the 3.2.0.0 DS200. Due to this possibility, the EAC expanded the scope of the inquiry to include the ballot skewing issue.

ES&S submitted a fix to the skew issue to iBeta Quality Assurance. Along with this fix, ES&S submitted the internal testing that they performed to show that the anomaly was resolved. After iBeta reviewed the testing performed by ES&S, they reported the anomaly as resolved to the EAC. In June 2011, EAC staff witnessed the upgrade from Unity 3.2.0.0 to Unity 3.2.1.0 in Cuyahoga County, OH. During this upgrade and testing, a valid vote (mark) was not counted by one of the DS200s.

The EAC, while at the Cuyahoga testing facility, began an analysis of the ballot images to see if ballot skew was the cause of the anomaly. The EAC documented a noticeable amount of skewing in many of the ballot images recorded on the DS200.

ES&S subsequently submitted information describing how their patented mark recognition software works. Using this information, the EAC performed an analysis on 11”, 14”, 17” and 19” ballots. The EAC found varying degrees of ballot image distortion; with the 17” ballot having the largest degree of skew.

5.4 Analysis of vote miscount

During testing of the Unity 3.2.1.0 system, one of the DS200 units accepted a voted ballot without incrementing the public counter or counting any of the marks. As a result, the laboratory test personnel found two ballots were in the DS200 ballot bin but only one ballot was counted by the DS200.

The DS200 displayed two different messages in rapid succession when this anomaly occurred. The first message informed the voter that votes for more than one party was selected. This is followed by a message advising the voter to either accept or

return the ballot. In normal operation of the system the messages would have required the user to respond before the system would continue. The system did not require response and continued on.

On November 29, 2010 iBeta laboratories submitted a letter (“[Appendix X - iBeta VSTL Withdrawal Letter](#)”) informing the EAC of their intent to resign as a VSTL. Due to the resignation, ES&S moved all testing campaigns to Wyle Laboratories. Wyle Laboratories and ES&S conducted extensive research in order to identify the root cause of the ballot counter anomaly. Wyle traced the anomaly through the voting system’s source code and found that when certain ballot exceptions (i.e., ballot overvote messages) occur while processing a ballot, a function within the scanner can incorrectly make the DS200 believe the submitted ballot is twenty-eight (28) inches long . Therefore, when a standard ballot was fed into the scanner and this error condition occurred the ballot was accepted into the ballot bin without incrementing the counter because the scanner was expecting a longer ballot. ES&S implemented improvements to the Unity 3.2.1.0 DS200 firmware in an attempt to resolve this anomaly.

6. Findings

6.1 Freeze/shutdown

Based on the analysis of the freeze/shutdown issue described in Section 5.1 of this document, the EAC believes that the allegation, as described in the Scope of Investigation (Section 2.1), is **substantiated**. The EAC believes that the fix provided in Unity 3.2.0.0 Rev. 2 (changed to Unity 3.4.0.0. See page 15 of this report) will cure the anomaly.

The addition of the diagnostic log added to improve troubleshooting capabilities introduced a new anomaly noted in the above analysis. The EAC therefore finds that the DS200 is non-compliant with Volume 1 Section 2.2.1.b:

2.2.1.b . Provide system functions that are executable only in the intended manner and order, and only under the intended conditions.

And Volume 1 sections 7.2, 7.4, 7.5, & 7.6 Quality Assurance of the 2002 VSS:

7.2 General Requirements:

The voting system vendor is responsible for designing and implementing a quality assurance program to ensure that the design, workmanship, and performance requirements of this standard are achieved in all delivered systems and components.

At a minimum, this program shall:

a. Include procedures for specifying, procuring, inspecting, accepting, and controlling parts and raw materials of the requisite quality;

- b. Require the documentation of the hardware and software development process;*
- c. Identify and enforce all requirements for:

 - 1) In-process inspection and testing that the manufacturer deems necessary to ensure proper fabrication and assembly of hardware, and*
 - 2) Installation and operation of software (including firmware).**
- d. Include plans and procedures for post-production environmental screening and acceptance test; and*
- e. Include a procedure for maintaining all data and records required to document and verify the quality inspections and tests.*

7.4 Responsibility for Tests

The manufacturer or vendor shall be responsible for:

- a. Performing all quality assurance tests;*
- b. Acquiring and documenting test data; and*
- c. Providing test reports for review by the ITA, and to the purchaser upon request.*

7.5 Parts & Materials Special Tests and Examinations

In order to ensure that voting system parts and materials function properly, vendors shall:

- a. Select parts and materials to be used in voting systems and components according to their suitability for the intended application. Suitability may be determined by similarity of this application to existing standard practice, or by means of special tests;*
- b. Design special tests, if needed, to evaluate the part or material under conditions accurately simulating the actual operating environment; and*
- c. Maintain the resulting test data as part of the quality assurance program documentation.*

7.6 Quality Conformance Inspections

The vendor performs conformance inspections to ensure the overall quality of the voting system and components delivered to the ITA for testing and to the jurisdiction for implementation. To meet the conformance inspection requirements the vendor or manufacturer shall:

- a. Inspect and test each voting system or component to verify that it meets all inspection and test requirements for the system; and*

b. Deliver a record of tests, or a certificate of satisfactory completion, with each system or component.

6.2 Failure to log

Based on the analysis of the DS200 logs in the Unity 3.2.0.0 described in Section 5.2 of this document, the EAC finds that the allegation that the DS200 is non-compliant with Volume 1 section 2.2.4 of the 2002 Voting System Standards is **substantiated**.

Integrity measures ensure the physical stability and function of the vote recording and counting processes.

2.2.4.1 - Common Standards

To ensure system integrity, all systems shall:

g. Record and report the date and time of normal and abnormal events.

i. Detect and record every event, including the occurrence of an error condition that the system cannot overcome, and time-dependent or programmed events that occur without the intervention of the voter or a polling place operator.

6.3 Ballot skew

Based on the analysis of the DS200 ballot images in the Unity 3.2.0.0 and 3.2.1.0 as described in Section 5.3 of this document, the EAC finds that the allegation that the DS200 is non-compliant with Volume 1 Section 2.2.2.1.c of the 2002 Voting System Standards is **substantiated**.

c. Record each vote precisely as indicated by the voter and be able to produce an accurate report of all votes cast

In addition, during the analysis the EAC discovered that the DS200 is also in non-compliance with Volume 1 Section 3.2.1.a & c Accuracy:

Voting system accuracy addresses the accuracy of data for each of the individual ballot positions that could be selected by a voter, including the positions that are not selected.

For a voting system, accuracy is defined as the ability of the system to capture, record, store, consolidate and report the specific selections and absence of selections, made by the voter for each ballot position without error. Required accuracy is defined in terms of an error rate that for testing purposes represents the maximum number of errors allowed while processing a specified volume of data. This rate is set at a sufficiently stringent level such that the likelihood of voting system errors affecting the outcome of an election is exceptionally remote even in the closest of elections.

The error rate is defined using a convention that recognizes differences in how vote data is processed by different types of voting systems. Paper-based and

DRE systems have different processing steps. Some differences also exist between precinct count and central count systems. Therefore, the acceptable error rate applies separately and distinctly to each of the following functions:

a. For all paper-based systems:

- i. Scanning ballot positions on paper ballots to detect selections for individual candidates and contests;*
- ii. Conversion of selections detected on paper ballots into digital data;*

c. For precinct-count systems (paper-based and DRE):

Consolidation of vote selection data from multiple precinct-based systems to generate jurisdiction-wide vote counts, including storage and reporting of the consolidated vote data; and

For testing purposes, the acceptable error rate is defined using two parameters: the desired error rate to be achieved, and the maximum error rate that should be accepted by the test process.

For each processing function indicated above, the system shall achieve a target error rate of no more than one in 10,000,000 ballot positions, with a maximum acceptable error rate in the test process of one in 500,000 ballot positions.

And Volume 1 sections 7.2, 7.4, 7.5, & 7.6 Quality Assurance of the 2002 Voting System Standard:

7.2 General Requirements:

The voting system vendor is responsible for designing and implementing a quality assurance program to ensure that the design, workmanship, and performance requirements of this standard are achieved in all delivered systems and components.

At a minimum, this program shall:

- a. Include procedures for specifying, procuring, inspecting, accepting, and controlling parts and raw materials of the requisite quality;*
- b. Require the documentation of the hardware and software development process;*
- c. Identify and enforce all requirements for:
 - 1) In-process inspection and testing that the manufacturer deems necessary to ensure proper fabrication and assembly of hardware, and*
 - 2) Installation and operation of software (including firmware).**

- d. Include plans and procedures for post-production environmental screening and acceptance test; and*
- e. Include a procedure for maintaining all data and records required to document and verify the quality inspections and tests.*

7.4 Responsibility for Tests

The manufacturer or vendor shall be responsible for:

- a. Performing all quality assurance tests;*
- b. Acquiring and documenting test data; and*
- c. Providing test reports for review by the ITA, and to the purchaser upon request.*

7.5 Parts & Materials Special Tests and Examinations

In order to ensure that voting system parts and materials function properly, vendors shall:

- a. Select parts and materials to be used in voting systems and components according to their suitability for the intended application. Suitability may be determined by similarity of this application to existing standard practice, or by means of special tests;*
- b. Design special tests, if needed, to evaluate the part or material under conditions accurately simulating the actual operating environment; and*
- c. Maintain the resulting test data as part of the quality assurance program documentation.*

7.6 Quality Conformance Inspections

The vendor performs conformance inspections to ensure the overall quality of the voting system and components delivered to the ITA for testing and to the jurisdiction for implementation. To meet the conformance inspection requirements the vendor or manufacturer shall:

- a. Inspect and test each voting system or component to verify that it meets all inspection and test requirements for the system; and*
- b. Deliver a record of tests, or a certificate of satisfactory completion, with each system or component.*

6.4 Vote miscount

During the course of the investigation ES&S proposed a fix to the DS200. This fix was tested in the Unity 3.2.1.0 test campaign. Based on the testing and subsequent June 11, 2011 field audit, the EAC finds that the allegation described in Section 5.4

of this document that the DS200 is non-compliant with Volume 1 Section 2.1.8.b of the 2002 Voting System Standards is **unsubstantiated**.

For all voting systems, each piece of voting equipment that tabulates ballots shall provide a counter that:

b. Records the number of ballots cast during a particular test cycle or election.

7. Recommendation

For the reasons noted in findings section of this document, the EAC deems three of the four allegations described in this investigation to be substantiated. The cure presently proposed by ES&S, Unity 3.2.0.0 Rev. 2, as demonstrated in the upgrade in Cuyahoga County does not correct all anomalies cited in this investigation. These anomalies remain in the EAC Certified Unity 3.2.0.0 system in use today. In addition, the proposed fixes created additional anomalies discovered in the Unity 3.2.1.0 system.

Based on the findings discussed above and the fact that the fix proposed in Unity 3.2.0.0 Rev. 2 is entirely based on Unity 3.2.1.0, which demonstrated some of the anomalies that prompted this investigation, the Program Director recommends a Manufacturer Site Audit to evaluate the developmental testing and quality assurance practices of ES&S (See Section 8.5 of the EAC Voting System Testing and Certification Program Manual). The EAC has noted outstanding issues related to the Quality Assurance practices of the manufacturer, based on the recurrence of certain anomalies and the fact that fixes provided for certain anomalies created additional anomalies with the DS200. The EAC intends to conduct a Manufacturer Site Audit to review policies, procedures and practices related to Quality Assurance and Configuration Management, to ensure that the Manufacturer meets EAC standards.

On November 9, 2011, the EAC received an application modification from ES&S requesting to combine the scope of testing for Unity 3.2.0.0 Rev 2, Unity 3.2.1.0 Rev 1, and Unity 3.3.0.0 into the revised ES&S Unity 3.4.0.0 test campaign. ES&S requested that all test activities cease on the three above mentioned test campaigns and noted that separate letters withdrawing these systems from certification testing would be submitted separately to the EAC. On November 17, 2011 the EAC accepted this modified application for the ES&S Unity 3.4.0.0 test campaign.

In addition, the Program Director recommends that the EAC issue a Notice of Non-Compliance (See Sections 7.6-7.7.3 of the Manual) for the substantiated allegations in the EAC certified Unity 3.2.0.0 system. The Notice of Non-Compliance will be sent to the Manufacturer regarding the substantiated allegations. The Notice will inform the Manufacturer of the next steps in the process, including the Manufacturer's opportunity to cure non-compliance and have an opportunity to be heard, based on Sections 7.6-7.7.3 of the Manual.

Per Section 7.2 of the Manual, voting systems certified by the EAC may be decertified if they are shown not to meet an applicable voting system standard or standards. Systems may only be decertified after the completion of an Informal Inquiry and Formal Investigation.

Decertification is the process the EAC uses to revoke a certification granted for a voting system. It serves to ensure that program requirements are followed and that certified voting systems fielded for use maintain the same level of quality as those presented for testing.

Decision Authority Signoff

I have reviewed this Formal Investigation Report and concur with the recommendations outlined in Section Seven (7) of the Report.



Mark Robbins, General Counsel and Acting Executive Director

United States Election Assistance Commission

12/20/11

Date

Appendix A - ES&S Technical Bulletin PRBD2000006



DS200 Registers Unmarked Ovals as Marks on Skewed 17 and 19 Inch Ballots

Technical Bulletin	PRBDS2000006
Date	October 20, 2009
Product Name	DS200
Firmware Versions	1.3.8.0 and 1.3.10.0
Distribution	Internal and External

Problem:

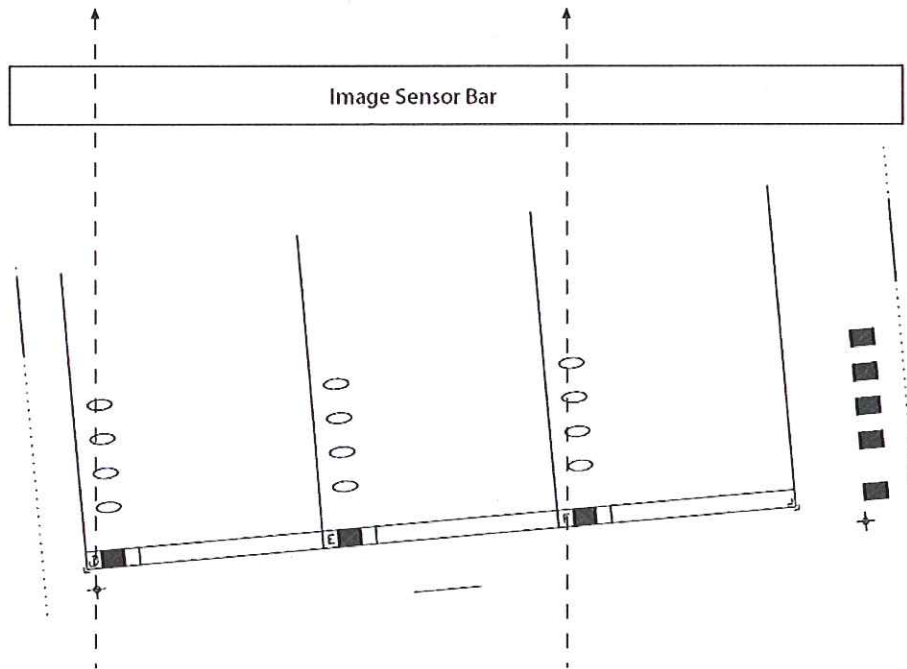
Due to an issue in the skew correction routines in Versions 1.3.8.0 and 1.3.10.0 of the DS200 scanner firmware, users with this firmware must employ the specifications defined below when designing and printing 17" and 19" ballots. This issue does **NOT** apply to 11" or 14" ballots. If these specifications are not followed on Versions 1.3.8.0 and 1.3.10.0 with 17" and 19" ballots, it is possible that specific unmarked ovals on skewed ballots will register as marks. Following the ballot specifications will prevent this from occurring.

Note: The ballot specifications discussed in this bulletin supplement the ballot design specifications listed in the *ES&S Ballot Production Handbook, v. 1.0.0.0*, dated July 17, 2007.

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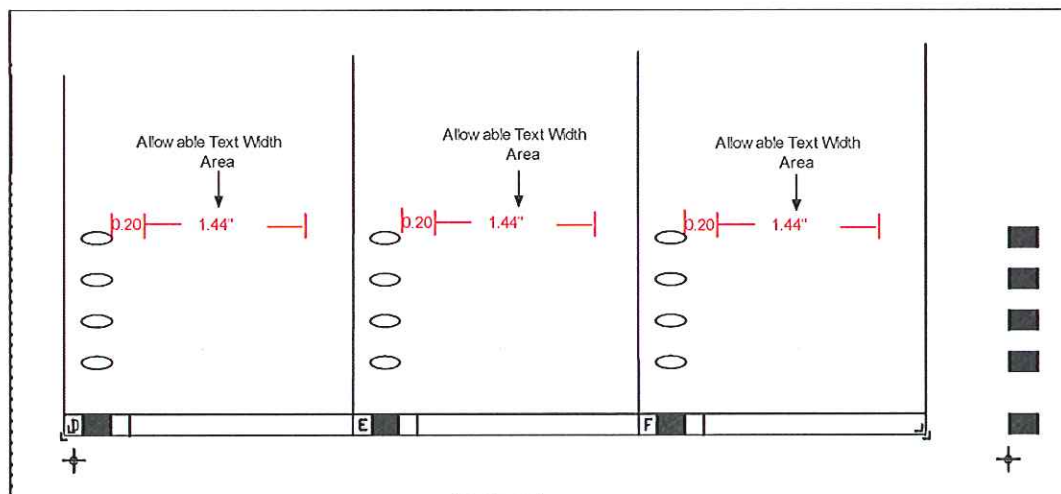
This document, as well as the software described in it, is furnished under license and may be used or copied only in accordance with the terms of such license. The content of this manual is furnished for informational use only, is subject to change without notice, and should not be construed as a commitment by Election Systems & Software, Inc. Election Systems & Software, Inc., assumes no responsibility or liability for any errors or inaccuracies that may appear in this documentation. Except as permitted by such license, no part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, recording, or otherwise, without the prior written permission of Election Systems & Software, Inc.

The following drawing is a slightly exaggerated illustration of skew. Skew can occur, when, for a variety of reasons, the ballot travels past the contact image sensor at an angle. This condition produces a data image with varying distances of the voter mark positions from the edges. Version 1.3.8.0 and 1.3.10.0 DS200 firmware compensates for the varying distances. However, on longer ballot stock (17" and 19") at the locations where the skew is most pronounced, it is possible for the firmware to mistake a small portion of the text next to an oval as part of the oval area itself. This can result in the firmware interpreting an unmarked oval as a mark.



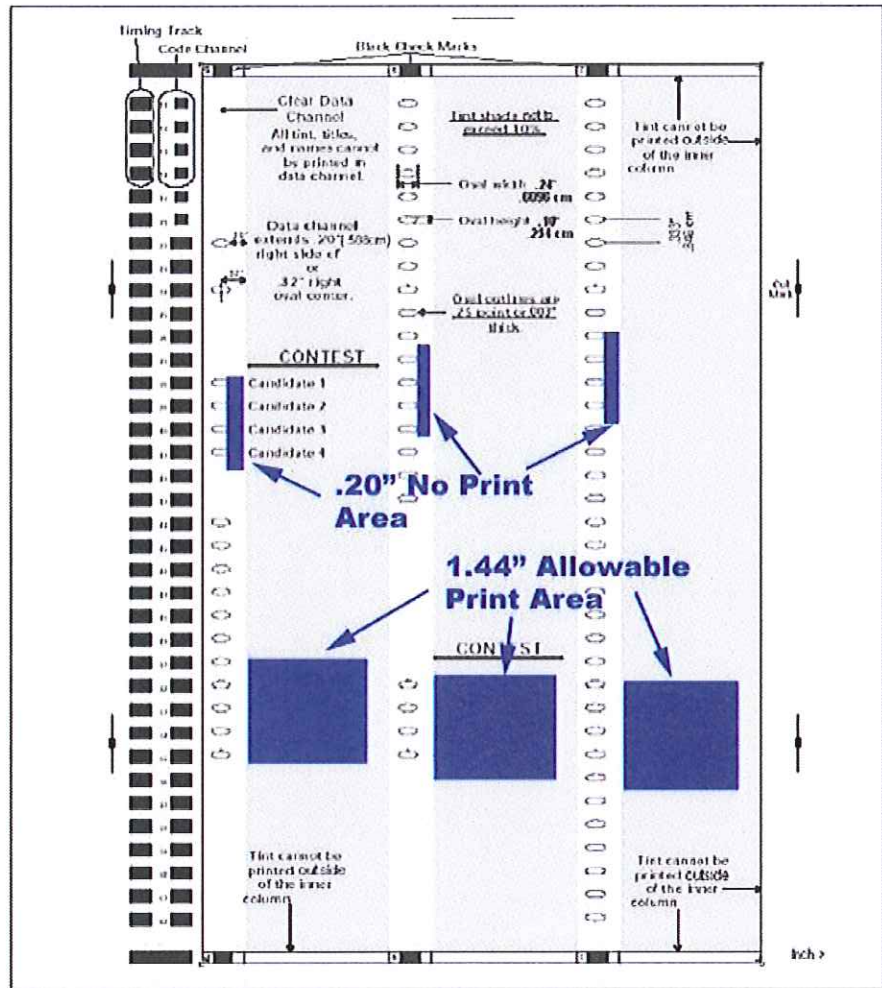
Resolution:

To completely avoid the problem, it is critical that users do not place any text or graphics closer than 0.20 inches from the edge of the oval and not allow it to extend more the 1.44 inches from that "no print zone" as shown. Contest titles and referenda can still use the full column width.



ES&S has modified the DS200's firmware to correct this issue in version 1.3.11.0 and will submit the updated firmware for EAC federal certification testing in October 2009.

Please refer to the drawing below for additional detail about the no print areas.



Appendix B - Cleveland Plain Dealer

10 percent of Cuyahoga County's voting machines fail pre-election tests

By [Joan Mazzolini, The Plain Dealer](#)

April 14, 2010, 4:00AM



Scott Shaw, The Plain Dealer

Election workers return optical scanners to storage after the November 2008 elections. Tests before this year's primaries showed problems with about 10 percent of the devices. CLEVELAND, Ohio -- About 10 percent of Cuyahoga County's voting machines checked so far have failed a pre-election test, once again challenging public confidence in the election system.

With just weeks until the May 4 primary election, the system's manufacturer, **Election Systems & Software Inc.**, has been unable to find what is causing the machines to arbitrarily power down and lock up during a test.

The problem showed up about 10 days ago when the **Cuyahoga County Board of Elections** began a series of routine tests on the voting machines. The machines froze during a specific test done to ensure the optical scanners were reading paper ballots correctly. At different points in that test, the machines simply started powering down, then freezing.

The Cuyahoga County Board of Elections has 1,200 voting machines. Of the 279 that have been tested, 28 have had this problem.

But it is hard to tell how pervasive the problem is. Board members were told at their meeting Tuesday that some machines that first passed the test, later failed when the procedure was repeated.

Employees stopped the test after 19 of the 279 machines had problems. Those 19 were put aside, and the staff started the tests on the others all over again. By the time they had retested 200 machines, nine of those that initially passed had failed the second time around.

With optical-scan machines, voters fill in ovals next to candidates' names on a printed paper ballot. The votes are tallied when the ballot is fed into the machine at the polling location.

"A 10 percent failure rates is high," said board member Inajo Davis Chappell. "We've never had this rate of failure. We don't want the public to have a lack of confidence."

The problem "is completely unacceptable," board Chairman Jeff Hastings told an ES&S representative. "I hope the secretary of state knows about this."

Kyle Weber, ES&S's project manager for Cuyahoga County, said Tuesday that officials were working hard on trying to find the problem and determine how to fix it before the election.

It isn't the first time the board has had problems with its election system.

The current board was installed in 2007 after Ohio Secretary of State Jennifer Brunner **fired the former members** because of mismanagement. The new members pledged to restore voter confidence, which was damaged by several events, including a series of **problems with the then-new touch screen voting machines**.

Those machines, which cost about \$20 million, were shelved **at Brunner's request** and the county went to a new optical scan machine that up to now had been working well. A five-year deal with ES&S cost \$13.4 million.

And officials say the failure rate in an actual election is very low; about four scanner machines have to be swapped out because of a problem in most elections.

Pat McDonald, elections board deputy director, said that if ES&S can't figure out the problem and a fix before the primary May 4, there will be a contingency plan that will include sending replacement machines to precincts.

McDonald said after the meeting that if a large number of machines freeze up, workers could bring a locked box of paper ballots from the failed machines to board headquarters and count them with high-speed scanners.

The high-speed scanners could, if necessary, scan the ballots for the entire election, which would slow down the counting process. While the board attempts to get results out by about midnight on election night, state law requires boards of election only to have tabulation complete by the next day.

Board member Eben "Sandy" McNair said that because the votes are now marked on paper ballots, voters and others don't have to worry that they will be lost or not counted.

With the touch-screen machines, votes were kept on memory cards that could be lost or erased. And while there was a paper trail similar to a cash register tape, it was hard to use to count votes and in some cases jammed during the election, making the trail non-existent.

While officials are concerned about the Election Day process, increasing numbers of Cuyahoga County residents have been choosing to vote absentee since the law changed allowing anyone to vote that way.

In the 2009 May primary, more votes were cast in Cuyahoga County through absentee ballots than at the polling locations. Fifty nine percent of the 72,447 votes cast, or 42,582, came in through absentee ballots.

So far this year, 174,594 voters have requested an absentee ballot for the May primary.

Appendix C - ES&S Guidance to Cuyahoga County (Freeze)



EXPERIENCE
RELIABILITY
SECURITY
INNOVATION

Election Systems
& Software

MEMORANDUM

TO: Jane Platten - Director, Cuyahoga County Board of Elections

CC: Ken Carbullido, ES&S Senior Vice-President
Aldo Tesi, ES&S President & CEO

FROM: Kyle Weber, ES&S Project Manager

DATE: 23 April 2010

SUBJECT: DS200(i) – Recommended Procedures for Election Day

ES&S Recommended Procedures for Election Day

If during the Cuyahoga County May 4th Primary Election a call is received by election central in reference to the DS200 shutdown issue, the following steps are recommended for your consideration and final approval. These instructions can then be utilized by election day call center personnel.

ES&S on-site support staff is available to discuss and/or demonstrate each of these recommended contingency instructions with you and your staff. We have presented the various scenarios that may be encountered.

Please see the attached page for recommended help desk staff instructions to assist poll workers.

Recommended Procedures for Election Day

If the DS200 shuts down during opening/closing of the polls...

- Press and hold the “Power” button until it turns red.
- Once the red light goes off and the machine is completely shut down, press the “Power” button to restart the DS200.
- Continue with the opening/closing polls process according to the poll worker manual.

If the DS200 shuts down during voting...

- Determine if there is a ballot attached to the back of the DS200 by instructing the poll workers to do the following:

-Go to the rear of the machine where the power cord is located.

-Look through the clear plastic windows on the back of the ballot bin below the power supply.

-If a ballot is still attached, they will see the white of the paper. If not, it will be dark inside the ballot box.

- If no ballot is attached to the back of the DS200**

- Press and hold the “Power” button until it turns red.
- Once the red light goes off and the machine is completely shut down, press the “Power” button to restart the DS200 and continue voting.
- If necessary, scan any ballots that may have been inserted into the emergency slot.
- Continue voting by having voters insert ballots directly into the DS200.

- If there is a ballot attached to the back of the DS200**

- Instruct the poll workers to begin using the emergency ballot box slot on the front of the ballot bin.
- Deploy a roving technician to the location with the backup memory stick for that precinct.
- Once onsite, have the tech remove the ballot attached to the back of the DS200 by doing the following:
 - Remove the seal and unlock the ballot bin front flap
 - Flip the ballot bin front flap down and slide the DS200 forward
 - Gently remove the ballot from the back of the DS200
 - Slide the DS200 back into place and lock and seal the ballot bin front flap.

CAUTION: When sliding the DS200 back into place, make sure the power cord does not block the ballot path.

- Press and hold the “Power” button until it turns red. Wait until the red light goes off and the DS200 completely shuts down.
- Replace the election day memory stick with the backup memory stick.
- Press the “Power” button to restart the DS200.
- With a bi-partisan team, rescan **all** ballots in the precinct, including those in the ballot bin, any that may have been inserted into the emergency slot, and the ballot removed from the back of the DS200.
- Continue voting by having voters insert ballots directly into the DS200.

Appendix D - EAC Technical Advisory ESS2010-01



**U.S. Election Assistance Commission Voting System
Testing and Certification Program**

ESS# 2010-01

1201 New York Avenue, NW, Suite 300 Washington, DC. 20005

Publication Date: June 25, 2010

**Voting System Technical Advisory
Intermittent Freeze/Shutdowns with EAC Certified
ES&S Unity 3.2.0.0 System**

System(s) Affected:	ES&S Unity 3.2.0.0 System
Component(s) Affected:	DS200
Version(s) Affected:	Firmware v. 1.3.10.0; Hardware v. 1.1, v.1.2; COTS Operating System v. 2.6.16.27
Notification Date:	May 21, 2010
Summary:	Intermittent freezes, lockups, and shutdowns

Advisory:

Counties and jurisdictions with this product should be aware of “power down” and “freeze” issue experienced during Logic & Accuracy (L&A) testing and Election Day.

Status:

EAC has launched an Informal Investigation and is working with ES&S to find a root cause to these issues.

Overview:

The DS200 precinct count optical scan voting device fielded in Cuyahoga County, Ohio is part of the EAC Certified Unity 3.2.0.0 voting system. During pre-election logic and accuracy (L&A) testing prior to the May 4, 2010 Primary Election the DS200 demonstrated intermittent screen freezes, system lockups and shutdowns. These issues were conveyed to the voting system manufacturer, Election Systems & Software (ES&S). ES&S provided the county with initial information on what they believe had occurred during L&A testing and during the subsequent election. EAC was notified of the anomaly and has contacted Cuyahoga County and other jurisdictions that use the same system, as well as ES&S to gather information. An Informal Investigation into these issues has been launched by the EAC.

Issue Descriptions:

Cuyahoga County enhanced and expanded the Logic & Accuracy (L&A) tests that were initially provided by ES&S. L&A testing was initiated 3 to 4 weeks prior to the May 4th election. Cuyahoga County has 1068 precincts with ≈1200 machines to fulfill

training and election needs. During the course of L&A testing a “power down” and “freezing” anomaly occurred on some DS200 machines. This anomaly appeared a total of 89 times during L&A testing without a distinguishable pattern in the timing or actions taken to cause the freeze/shutdown issue. In addition, another 8 of 108 new DS200’s failed Cuyahoga County’s acceptance and independent verification and validation testing which is conducted on newly received systems prior to acceptance. These systems were not deployed in the election.

During the May 4th Election, poll workers reported four DS200 shutdowns to the County. The poll workers tried to troubleshoot the DS200 machine failures and were able to restore the systems for use during the election period by rebooting the machines. Cuyahoga County officials asked poll workers who experiences this issue to reboot the DS200 and check for “hanging” or “stuck” ballots prior to allowing voters to use the machine. The county also completed a hand count in the precincts in which the shutdown occurred to make sure votes were not lost. Although the machine failures were encountered less frequently on Election Day than during L&A testing, the anomaly still presented itself in a number of machines.

Root Cause:

The EAC is working with ES&S in order to help determine a root cause.

ES&S Recommended Procedures for Election Day:

If the DS200 shuts down during opening/closing of the polls...

- Press and hold the “Power” button until it turns red.
- Once the red light goes off and the machine is completely shut down, press the “Power” button to restart the DS200.
- Continue with the opening/closing polls process according to the poll worker manual.

If the DS200 shuts down during voting...

- Determine if there is a ballot attached to the back of the DS200 by instructing the poll workers to do the following:
 - Go to the rear of the machine where the power cord is located.
 - Look through the clear plastic windows on the back of the ballot bin below the power supply.
 - If a ballot is still attached, they will see the white of the paper. If not, it will be dark inside the ballot box.

If no ballot is attached to the back of the DS200

- Press and hold the “Power” button until it turns red.
- Once the red light goes off and the machine is completely shut down, press the “Power” button to restart the DS200 and continue voting.
- If necessary, scan any ballots that may have been inserted into the emergency slot.
- Continue voting by having voters insert ballots directly into the DS200.

If there is a ballot attached to the back of the DS200

- Instruct the poll workers to begin using the emergency ballot box slot on the front of the ballot bin.
- Deploy a roving technician to the location with the backup memory stick for that precinct.
- Once onsite, have the tech remove the ballot attached to the back of the DS200 by doing the following:
 - Remove the seal and unlock the ballot bin front flap
 - Flip the ballot bin front flap down and slide the DS200 forward
 - Gently remove the ballot from the back of the DS200
 - Slide the DS200 back into place and lock and seal the ballot bin front flap.
- **CAUTION: When sliding the DS200 back into place, make sure the power cord does not block the ballot path.**
- Press and hold the “Power” button until it turns red. Wait until the red light goes off and the DS200 completely shuts down.
- Replace the Election Day memory stick with the backup memory stick.
- Press the “Power” button to restart the DS200.
- With a bi-partisan team, rescan **all** ballots in the precinct, including those in the ballot bin, any which may have been inserted into the emergency slot, and the ballot removed from the back of the DS200.
- Continue voting by having voters insert ballots directly into the DS200.

Appendix E - ES&S Technical Bulletin PRBD2000008



Technical Bulletin	PRBDS2000008
Date	July 7, 2010
Product Name	DS200(i)
Version	1.3.6.0 through 1.4.3.0
Distribution	All

DS200(i) Intermittent Freeze and Shutdown (PRBDS2000008)

Problem:

The DS200(i) can freeze or shutdown during heavy usage of the touch screen, it can produce the following:

- ❖ The DS200(i) can freeze, which will require the user to force a shut down of the unit.
- ❖ The unit can also produce an error message that will require the user to shut down the system.

A variety of error messages can appear when the shutdown occurs, it will most often occur when there is heavy use of the touch screen (e.g. during Pre-election L&A system testing.) The problem can also occur during Election Day but this is not as common.



The problem does not affect the data or accuracy of the ballot scanning and tabulation.

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Resolution:

The root cause of the issue was found to involve a component of the COTS (Commercial, Off the Shelf) operating system called the X-windows system. The repeating of a specific set of steps that relied upon the X-window system resulted in a breakdown in the communication between the firmware and operating system components, which resulted in the lock up/shutdown of the DS200(i).

Improvements were made to the ES&S firmware to better handle this issue when it does occur. The final solution included updating the X-windows system. The updated firmware and operating system component will be part of Unity 3.2.1.0, which is currently pending Federal certification.

Workaround:

Users that have one of the affected firmware versions (1.3.6.0 through 1.4.3.0) and operating system can use the following procedures to manage a freeze/shutdown should it occur.

If the DS200(i) freezes/shuts down during opening/closing of the polls.

1. Open the USB access door.
2. Press and hold the Power button until it turns red.
3. Wait until the red light is off and the machine completely shuts down, then press the Power button to restart the DS200(i).
4. Continue with the open/close polls process.

See **ES&S DS200(i) System Operations Procedures**



To open the polls, see Chapter 6: Election Day Tasks, Open the Polls.

To close the polls, see Chapter 6 Election Day Tasks, Close the Polls.

If DS200(i) freezes/shuts down during voting:

Determine if there is a ballot in the read area or the back of the DS200(i) by instructing the poll workers to do the following:

1. Go to the rear of the machine where the power cord is located.
2. Look through the clear plastic windows on the back of the ballot bin below the power supply.
3. If a ballot is not visible it will be dark inside the window, go to step 4. If you see the white ballot paper through the window, go to step 5.

4. If ballot is not visible through the clear plastic window:

- a. If the machine is frozen, (it did not shut down on it's own), press and hold the Power button until it turns red.
- b. Once the machine is completely shut down, press the Power button to restart the DS200(i) and continue voting.
- c. If necessary, scan any ballots that may have been inserted into the emergency slot.
- d. Continue voting by having voters insert ballots directly into the DS200(i).

5. If there is a ballot visible through the clear plastic window:

- a. Instruct the poll workers to begin using the emergency ballot box slot on the front of the ballot bin.

A poll worker or technician authorized by the jurisdiction can remove the ballot attached to the back of the DS200(i) by doing the following:

- b. Remove the seal and unlock the ballot bin front flap.
- c. Flip the ballot bin front flap down and slide the DS200(i) forward.
- d. Gently remove the ballot from the back of the DS200(i).
- e. Slide the DS200(i) back into place and lock and seal the ballot bin front flap.



Warning: When sliding the DS200(i) back into place, make sure the power cord does not block the ballot path.

- f. If the machine is frozen, (it did not shut down on it's own), press and hold the "Power" button until it turns red.
- g. Wait until the red light goes off and the DS200(i) completely shuts down.
- h. Press the Power button to restart the DS200(i).
- i. Determine if the ballot was counted before the shutdown occurred. This can be done by a hand count of the ballots by authorized election workers and comparing that total with the public count on the DS200(i).
 - If the ballot was counted, place it in the ballot bin.
 - If the ballot was not counted it will need to be re-scanned.
- j. Continue voting by having voters insert ballots directly into the DS200(i).

Appendix F - Recommendation to Refer for Formal Inquiry



U. S. ELECTION ASSISTANCE COMMISSION
VOTING SYSTEM TESTING AND CERTIFICATION PROGRAM
1201 New York Avenue, NW, Suite 300
Washington, DC. 20005

To: Tom Wilkey, *Executive Director/Decision Authority*
From: Brian Hancock, *Director of Voting System Testing and Certification*
Cc: Matthew V. Masterson, *Deputy Director, Voting System Testing and Certification*
Date: October 15, 2010
Subject: **Recommendation to Refer for Formal Inquiry**

As required under §7.3.5 of the EAC's *Voting System Testing and Certification Program Manual*, (*Manual*) this memorandum constitutes a recommendation that you refer the ES&S DS200 Informal Inquiry for Formal Investigation under § 7.4 of the *Manual*.

The focus of the Investigation shall be the ES&S DS200 Precinct Count Optical Scanner (Firmware Version 1.3.10.0) contained in the ES&S Unity 3.2.0.0 EAC certified voting system. The scope of the Investigation shall include a conclusive determination of the root cause of the freeze /shutdown anomaly first experienced in Cuyahoga County, Ohio during pre-election logic and accuracy testing in preparation for the May 4, 2010 Primary Election.

The facts and findings from our Informal Investigation into this matter are contained in the attached Informal Inquiry Report. In summary, the report concludes that the claims made by Cuyahoga County are credible and may therefore serve as a basis for decertification of the Unity 3.2.0.0 voting system by the EAC. In addition to the freeze/shutdown anomaly, the Inquiry revealed additional anomalies with the DS200 and included the following:

- Ballot skew
- Ballot insertion problems
- Unlogged errors
- Logged system halts
- TDP Errors

Based upon the inconclusive information provided by the manufacturer regarding the freeze/shutdown anomaly, the EAC has concerns with the results of the root cause analysis that was performed by ES&S regarding the anomaly. At this time, the EAC does not have confidence that the actual root cause of the anomaly was discovered nor remedied.

Attachments

EAC Informal Inquiry Report
Cleveland Plain Dealer Article
ES&S Notification to the EAC
EAC/Cuyahoga County Teleconference Minutes
ES&S DS200 System Lockup Analysis
EAC DS200 Freeze/Shutdown and XWindows Correlation

Appendix G - Addendum Recommendation to Refer for
Formal Inquiry



U. S. ELECTION ASSISTANCE COMMISSION
VOTING SYSTEM TESTING AND CERTIFICATION PROGRAM
1201 New York Avenue, NW, Suite 300
Washington, DC. 20005

To: Tom Wilkey, *Executive Director/Decision Authority*
From: Brian Hancock, *Director of Voting System Testing and Certification*
Cc: Matthew V. Masterson, *Deputy Director, Voting System Testing and Certification*
Date: December 20, 2010
Subject: **Addendum to Recommendation to Refer for Formal Inquiry**

On October 15, 2010, I forwarded to your office a memorandum constituting a recommendation that you refer the ES&S DS200 Informal Inquiry for Formal Investigation under § 7.4 as required under §7.3.5 of the EAC's *Voting System Testing and Certification Program Manual (Manual)*.

The purpose of this addendum is to provide you with additional information regarding the ES&S DS200 Precinct Count Optical Scanner (Firmware Version 1.3.10.0) contained in the ES&S Unity 3.2.0.0 voting system. Since the October memorandum, the following additional information has come to light:

As a results of the analysis and changes submitted by ES&S (See section 2.1.5.2 DS200 Field Issue –Freeze and Shutdowns in Appendix H Amended Test Plan) reliability testing of the DS200 was required at iBeta Quality Assurance (iBeta).

The test at iBeta was schedule to run eight days (64 hours) on three units. Testing required that the DS200's operate for the full period of time without a loss of one or more functions or degradation of performance such that the device was unable to perform its intended function for longer than ten seconds. On the third day execution of the DS200 Reliability test was halted due to an issue encountered during test script iteration #67. The following observation report was provided to the EAC:

- 1) *"After the first ballot was cast a second ballot was inserted in the DS200.*
- 2) *The ballot was an open primary with a vote in two parties (Cross Vote). This ballot issue was identified to the tester with the option to "Accept" or "Reject" the ballot. The tester selected "Accept" and the tester heard the ballot drop. (At this point the system has performed as "intended".)*
- 3) *The tester then observed the screen flash two messages. The first contained the word "issue". The second contained the word "return". The motor did not engage or attempt to return the ballot.*
- 4) *The voting system continued operation by resetting to the "Welcome" page. It was in a state to accept a new ballot.*
- 5) *The tester observed that the ballot counter did not increment (1 vote was displayed).*

- 6) *The tester, recorder, ESS and EAC representatives observed there were two ballots (voter 1 & voter 2) in the ballot box and the counter indicated a single vote.*
- 7) *The polls were closed. The reports were printed.*
- 8) *It was confirmed on the reports that only a single ballot was recorded. The Cross Vote audit log entry was not recorded, but a returned ballot entry was recorded in the audit log.*
- 9) *The system was shut down via the touch screen selection.*
- 10) *The system was restarted, polls were re-opened, and additional ballots were scanned and reported, without error.*

Based upon the previous inconclusive information provided by the manufacturer regarding the freeze/shutdown anomaly, as well as the potentially more serious issue of the DS200 accepting a voted ballot but not recording that ballot on its internal counter, the EAC now has concerns not only with the results of the root cause analysis that was performed by ES&S regarding the Freeze/Shutdown anomaly, but has additional concerns regarding this latest anomaly which, as of the date of this memo, has not been addressed by ES&S. Because of the reasons stated above and in the previous memorandum, I reiterate my recommendation that you refer the ES&S DS200 Informal Inquiry for Formal Investigation under § 7.4 of the EAC's *Voting System Testing and Certification Program Manual (Manual)*.

Attachments

Appendix H of Amended Test Plan

Attachment

Excerpt from iBeta VSTL Test Plan: Unity 3.2.1.0 v. 6.0 Datred 12/13/10

2.1.5.2 DS200 Field Issue- Freeze and Shutdowns

DS200 system lockup condition was observed during pre-election logic and accuracy testing for the Cuyahoga County primary election held in May 2010. Systems locked up and had to be restarted. Systems restarted immediately. Lock ups were random and could not be repeated. Following internal diagnosis and testing, ES&S submitted their root cause analysis, testing and system changes to iBeta and the EAC. ES&S analysis identified that the problem occurred more frequently when workers were conducting the Administrator functions. These functions tend to occur before or after the polls are closed at times of greater touch screen interaction. Touch screen interaction during voting is very limited. Following internal diagnosis and testing, ES&S submitted their root cause analysis, testing and system changes to iBeta and the EAC. ES&S' analysis resulted in changes to address:

- Various memory deallocation improvements (setting pointers to NULL)
- Various new audit log entries and user interface messages
- The replacement/upgrade of the flawed Linux X-windows function library used with DS200 v1.3.10.0 and certified with ESSUnity3200 on July 21, 2009.

The list of changes submitted by ES&S are identified in section 1.4.1.2 *DS200 Field Issue - System Freezes and Shut Downs*.

Scope of testing was expanded to add test scenarios (8 and 9) to the DS200 Functional Test Case (see Table 18) to test the functional enhancements and confirm the continued sufficiency of the battery backup. This testing addresses VVSG Volume 1 sections 2.1.1.b, 2.1.3, 2.1.4.g, 2.1.4.i, 2.1.5.1, 2.1.5.1.b.i, and 2.1.5.1.b.ii.

In order to identify the parameters to test the reliability of the DS200, iBeta analyzed 1,713 DS200 diagnostic tests run by ES&S. The analysis found:

- There was an average of 10% freeze failures using the ES&S Touch Test script
- The six machines tested failed between 8% and 13%

Of the 1,713 tests, ES&S ran 74 tests on the ESSUNITY3200 certified DS200 firmware v.1.3.10.0:

- The number of iterations per DS200 ranged between 9 and 14
- The average failure rate on the certified version was 15% with the individual machine rates ranging from 7% to 25%

Using this analysis iBeta established the baseline average of 10% with a range of 8% to 13% as indicative of a comparable result. A pre-requisite of the DS200 Reliability Test Case will be to determine if iBeta can demonstrate that there is a comparable result on the ESSUNITY3200 certified DS200 firmware v.1.3.10.0 using a sample of 100 tests on five DS200s, with each running the ES&S Diagnostic Touch Test script 20 times. The three DS200s that demonstrate the highest incidence of failure shall be incorporated into the Reliability testing (see Table 19).

In order to assess the impact of ENH18551, a change to the COTS X-Windows (see section 1.4.1.2), iBeta identified the modules with calls to X-Windows. These calls simulate keyboard button presses, generate keyboard events sent to X server, convert X-server character values and printable character values; create the calibration window, Recalibrate and Exit buttons and functions for X server to load/unload the driver. These calls will be tested in the DS200 Functional and Reliability Test Cases.

2.1.6 Assessment of DS200 System Halts

Attachment

The EAC has instructed iBeta that the *“Unity 3.2.1.0 test campaign is a test campaign that is testing the Unity 3.2.1.0 suite end-to-end. It is not a modification of an already certified system. There are no items within the Unity 3.2.1.0 system that are “out of scope” for testing as the entire system is being tested end-to-end. However, the EAC also recognizes that a large portion of the Unity 3.2.1.0 system has been tested and certified by the EAC as part of the 3.2.0.0 certification. Because of this the EAC has already recognized a large portion of the Unity 3.2.0.0 campaign as being applicable to Unity 3.2.1.0. Despite this allowance it is still incumbent on the EAC to fully evaluate the Unity 3.2.1.0 system especially given the already known field issues experienced by the Unity 3.2.0.0 system. Therefore, EAC instructs iBeta to examine the 27 error conditions that cause system halts per ES&S’s system documentation and test to make sure each of these halts is properly handled per the standard. If iBeta feels this has been tested already iBeta may provide evidence of this for the EAC to review and accept or reject.”*

In a preliminary assessment iBeta took a two direction approach to identify the system halts. The first was a search of the code. iBeta identified 30 types of system halts. These systems halts were generated by approximately 140 instances of errors.

The second approach was a search of the documentation. In reviewing the documentation iBeta identified less than 27 errors noted by the EAC Reviewer as system halts.

- A review of the code determined that in some instances these were system halts and in other instances they were not
- Two documented instances of system halts were not found in the code

In order to ensure all items identified by the EAC were examined, the EAC was requested to provide a list. This will be used as a cross check. (See Table 18)

iBeta analyzed the code associated with the system halts assessment following the ES&S modifications to mitigate the failures. The mitigation consisted of modifying an error handler so that all errors were logged. In the previous versions, a log entry was determined by a flag set by the caller to the error handler and thus some errors were not logged. iBeta determined that of the 140 instances of errors, these errors followed three separate paths through the code. Therefore iBeta chose three instances of errors that were reproducible to test the three paths.

Appendix H - ES&S Technical Bulletin PRBDS2000010



Public Counter Does Not Increment When Ballot Is Dropped Into Ballot Box: PRBDS2000010

Technical Bulletin	PRBDS2000010
Date	February 11, 2011
Product Name	DS200
Version	See Note*
Distribution	All



***NOTE:** This affects all current versions of the DS200. The updated firmware is part of the Unity 3.2.1.0 product suite currently pending Federal certification.

Problem:

During Federal certification testing of the DS200 by an independent test lab, an anomaly occurred under which the DS200 allowed a ballot to fall into the ballot box and the counter did not increment. After extensive follow-up testing, ES&S has determined both the root cause of the issue and that this issue occurs only rarely; approximately one instance per every nine thousand ballots cast.

When this rare situation occurs, you will likely see one of the following error messages:

- Ballot Removed During Scan (137)
- Unable to Read Timing Band (123)
- Missed Orientation Marks (100)

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Resolution:

If you see any of the aforementioned error messages, poll workers should complete any necessary actions required by the error messages. In addition, the lead poll official should be notified that a potential ballot count issue has occurred and the public counter for the affected DS200 should be monitored for reoccurrence of the problem. You may also consider removing the unit from service if the situation were to re-occur.

Any suspected ballot count issue can be validated after poll closing by comparison of the voter check-in log against the total public count from the DS200 results tapes. State procedures should be followed in the event of a discrepancy.

The root cause of this issue is due to a sensor misread in the ballot transport system. Improvements have been made to the DS200's firmware to fix this issue. The updated firmware is part of the Unity 3.2.1.0 product suite currently pending Federal certification.

Appendix I - ES&S Technical Bulletin FYIDS2000019



DS200 Threshold Settings: FYIDS2000019

Technical Bulletin	FYIDS2000019
Date	February 17, 2011
Product Name	DS200
Version	All
Distribution	All

Issue:

The threshold setting for the DS200 top and bottom Contact Image Sensor (CIS) is set at the factory at 166. A small downward adjustment of the setting can further enhance the ability of the DS200 to create the digital representation of the ballot and voter marks.

Background:

The DS200 transports the ballot across a top and bottom Contact Image Sensor (CIS). The CIS is a device that contains a row of very small photo sensors and an LED light source. The photo sensors measure the amount of light reflecting from the ballot surface to determine if a given pixel is black or white.

The DS200 has an adjustable threshold configuration setting that establishes how much reflected light is required to establish a black versus white pixel. The DS200 scans the front and back of the ballot at the same time with separate configuration settings for the top and bottom CIS. The threshold value setting is adjustable from 0 to 255. Lowering the number produces a lighter image and raising the number produces a darker image.

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Testing has revealed that a threshold value of 140 would improve the tolerance levels of the scanner and optimize the digital ballot images.

Resolution:

ES&S recommends that users reset the CIS threshold settings for the top and bottom sensors to 140. This is accomplished through the System Settings in the Administration Menu.




Refer to the **DS200 System Maintenance Manual** for detailed procedures.

Appendix J - Authorization for Formal Investigation



U. S. ELECTION ASSISTANCE COMMISSION
OFFICE OF THE EXECUTIVE DIRECTOR
1201 New York Avenue, NW, Suite 300
Washington, DC. 20005

To: Brian Hancock, *Director of Voting System Testing and Certification*

From: Thomas R. Wilkey, *Executive Director/Decision Authority* 

Date: February 25, 2011

Subject: **Authorization of Formal Investigation**

This memorandum constitutes the formal approval and authorization of formal investigation in response to your Recommendation to Refer for Formal Inquiry dated October 15, 2010 and your Addendum to the Recommendation to Refer for Formal Inquiry dated December 20, 2010 as required by §7.4.3 of the EAC's *Voting System Testing and Certification Program Manual*, (*Manual*). The referral and addendum contain relevant information obtained during your Informal Investigation and show the progression of activities by the EAC, ES&S and the VSTLs since the initial discovery of the anomaly.

The focus of the Investigation shall be the ES&S DS200 Precinct Count Optical Scanner (Firmware Version 1.3.10.0) contained in the ES&S Unity 3.2.0.0 EAC certified voting system. The scope of the Investigation shall include a conclusive determination of the root cause of the freeze /shutdown anomaly first experienced in Cuyahoga County, Ohio during pre-election logic and accuracy testing in preparation for the May 4, 2010 Primary Election. As you note in your memorandum of October 15, 2010, in addition to the freeze/shutdown anomaly, your Informal Inquiry revealed additional anomalies with the DS200 including issues related to ballot skew, ballot insertion, unlogged errors, logged system halts and TDP Errors. Further, the potentially more serious issue noted in the December 20, 2010 addendum which outlined the problem encountered when the DS200 accepted a voted test ballot without recording that ballot on its internal counter during testing at iBeta Quality Assurance should also be investigated for potential non-compliance with the 2002 Voting Systems Standards.

Following is a list of known non-conformities that ultimately will serve as the basis of any EAC determination on the certification status of this system.

1. Issue: The DS200 initiates the shutdown process whereupon it will complete approximately 90% of the shutdown process and then freeze. The screen saver will initiate after the appropriate time has elapsed. The DS200 Unit will not accept ballots in the frozen state.

System Non-conformity:

2002 VSS Volume 1 Section 2.2.1 & 3.4.3

2.2.1.b – Provide system functions that are executable only in the intended manner and order, and only under the intended conditions

3.4.3 – Reliability: The reliability of voting system devices shall be measured as Mean Time Between Failure (MTBF) for the system submitted for testing. MBTF is defined as the value of the ratio of operating time to the number of failures which have occurred in

the specified time interval. A typical system operations scenario consists of approximately 45 hours of equipment operation, consisting of 30 hours of equipment set-up and readiness testing and 15 hours of elections operations. For the purpose of demonstrating compliance with this requirement, a failure is defined as any event which results in either the:

- Loss of one or more functions
- Degradation of performance such that the device is unable to perform its intended function for longer than 10 seconds

The MTBF demonstrated during certification testing shall be at least 163 hours.

2. Issue: Ballot Skew. When a 17" ballot is not inserted correctly into the unit the lower left and right hand corners of the ballot are not accurately read.

System Non-conformity:

2002 VSS Volume I 2.2.2.1 Common Standards:

To ensure vote accuracy, all systems shall:

2.2.2.1.c – Record each vote precisely as indicated by the voter and be able to produce and accurate report of all votes cast.

3. Issue: Failure to log. Cuyahoga County election officials also provided to the EAC the logs from their May 4 and August 8, 2010 elections. The May 4 election used over 1000 DS200's. The August 8 election was smaller, providing logs from only 12 machines. Review of these records identified additional issues:

- The freeze/shutdown issue does not result any record of its occurrence in the system logs.

System Non-conformity:

2002 VSS Volume I 2.2.4.1 Integrity:

Integrity measures ensure the physical stability and function of the vote recording and counting processes.

To ensure system integrity, all systems shall:

- g. Record and report the date and time of normal and abnormal events.
- i. Detect and record every event, including the occurrence of an error condition that the system cannot overcome, and time-dependent or programmed events that occur without the intervention of the voter or a polling place operator.

4. Issue: Vote miscount: DS200 accepting a voted ballot but not recording that ballot on its internal counter.

System Non-conformity:

2002 VSS Volume I 2.1.8 Ballot Counter:

For all voting systems, each piece of voting equipment that tabulates ballots shall provide a counter that:

- b. Records the number of ballots cast during a particular test cycle or election.

Attachments

October 15, 2010 Recommendation to Refer for Formal Inquiry

December 20, 2010 Addendum to Recommendation to Refer for Formal Inquiry

Appendix K - EAC Technical Advisory ESS2011-01



EAC Certified System Technical Advisory

EAC System(s) Affected:	ES&S Unity 3.2.0.0, ES&S Unity 3.2.0.0 Rev. 1
Component(s) Affected:	DS200
Version(s) Affected:	DS200 firmware version 1.3.10.0 (Unity 3.2.0.0) and 1.4.5.0 (Unity 3.2.1.0). This may impact other DS200 firmware version (unconfirmed).
Date:	March 3, 2011
Summary:	During Federal certification testing a DS200 Ballot Scanner accepted a ballot into the ballot bin without counting the ballot.

Advisory:

Counties and jurisdictions with this product should be aware that during Federal certification testing of the Election Systems & Software (ES&S) Unity 3.2.1.0 voting system, a DS200 accepted a voted ballot and deposited it in the ballot bin without recording the ballot in the public counter. ES&S determined this anomaly can occur in versions of the DS200 firmware Federally certified with Unity 3.2.0.0 and Unity 3.2.0.0 Rev. 1. Other versions of the DS200 firmware may also be affected; however, this has not been independently confirmed by ES&S. According to ES&S, this anomaly has an extremely low rate of occurrence.

Overview:

During Reliability Testing on Unity 3.2.1.0, a DS200 accepted a ballot without incrementing the public counter and vote tally. ES&S informed the EAC that this anomaly exists in the EAC certified Unity 3.2.0.0 voting system, Unity 3.2.0.0 Rev. 1 and in the Unity 3.2.1.0 voting system currently undergoing Federal testing at Wyle Laboratories. Fielded DS200s with firmware versions 1.3.10.0, 1.4.5.0 and possibly others, have the capability of exhibiting this anomaly. ES&S submitted a proposed solution to this anomaly for incorporation in the Federal testing of the Unity 3.2.1.0 voting system.

Anomaly Description:

During the Voting System Test Laboratory's (VSTL) Reliability Test, one of the DS200 units accepted a ballot without incrementing the public counter. Two ballots were in the ballot bin and only one ballot was counted by the DS200. Reports of the messages displayed by the DS200 when the anomaly occurs have differed. Two different messages are displayed in rapid succession. The

first message informs the voter that votes for more than one party were selected. This is followed by a message advising the voter to either accept or return the ballot. Upon reviewing the audit log, the event was originally recorded by the following message: "Ballot Removed During Scan (137)." To the EAC's knowledge, instructions are not displayed on the DS200 screen to assist a pollworker in resolving this uncounted ballot anomaly when it occurs. Please refer to the Recommended Procedures section of this Technical Advisory and ES&S Technical Bulletin #PRBDS2000010 dated February 11, 2011 if this anomaly is experienced.

Root cause:

Wyle Laboratories and ES&S conducted extensive research in order to identify the root cause of this anomaly. Wyle traced the anomaly through the voting system's source code and found that when certain ballot exceptions occur while processing a ballot, a function within the scanner can incorrectly make the DS200 believe the submitted ballot is twenty-eight (28) inches long. Therefore, when a standard ballot is fed into the scanner and this error condition occurs, the ballot is accepted into the ballot bin without incrementing the counter because the scanner is expecting a longer ballot. ES&S implemented improvements to the Unity 3.2.1.0 DS200 firmware in an attempt to resolve this anomaly. This updated firmware is part of the Unity 3.2.1.0 system currently under test.

Recommended Procedures:

Due to the fact that this anomaly exists in firmware versions 1.3.10.0 and 1.4.5.0 of the DS200, local election officials using this system should take care to reconcile the voter list with the public count on all DS200 machines. EAC recommends that local election officials make pollworkers aware of this anomaly via pollworker training and Election Day instruction materials. If this anomaly is witnessed, follow jurisdiction procedures which should include contacting the lead local election official in order to correctly conduct the reconciliation process.

ES&S *Technical Bulletin #PRBDS2000010* recommends the following resolution:

"If you see any of the aforementioned error messages, poll workers should complete any necessary actions required by the error messages. In addition, the lead poll official should be notified that a potential ballot count issue has occurred and the public counter for the affected DS200 should be monitored for reoccurrence of the problem. You may also consider removing the unit from service if the situation were to re-occur."

ES&S noted:

"Any suspected ballot count issues can be validated after poll closing by comparison of the voter check-in log against the total public count from the DS200 results tapes. State procedures should be followed in the event of a discrepancy."

Appendix L - EAC Report on Cuyahoga 3.2.1.0 Upgrade



U.S. ELECTION ASSISTANCE COMMISSION

Voting System Testing and Certification Program

1201 New York Avenue, NW, Suite 300

Washington, DC. 20005

Onsite Observation – Final Report

Location: Cuyahoga County, Ohio
Observation Dates: June 13 – 14, 2011
Purpose: Observation of the upgrade from ES&S Unity 3.2.0.0 to 3.2.1.0
Report Date: June 16, 2011

The purpose of the EAC observation in Cuyahoga County was to observe the upgrade of the Unity 3.2.0.0 software to the Unity 3.2.1.0 software. This upgrade contains the fixes to the issues that were discovered in previous elections in Cuyahoga County and testing performed from EAC VSTL's. The county testers have tested 1198 out of 1200 DS200 units. Two of the units had to be returned to the manufacturer for repairs. The county uses 1068 units for election day. The remaining units are used as backups. All M650's and Automarks have been tested. During the observation there were two major issues have been found and several minor issues.

Issue: Unresponsive touchscreen

Symptoms: The touch screen will not respond to touch. If the touch screen becomes inactive it usually occurs during the calibration process. However, it was reported to the EAC that 4 out of all occurrences did not happen during the calibration mode. In addition, the EAC was on site and observed a 5th instance of the issue.

Cause: ES&S states that this is most likely cause due to user error. During the calibration process the user is required to touch multiple points on the screen. If a user performs this operation incorrectly than the calibration can be so far off as to make the screen unresponsive.

EAC assessment: The ES&S explanation is plausible and likely. However, the 5 unresponsive instances that occurred not during the calibration process require explanation from the manufacture. The information below details the events that occurred on machine TC2510 for precinct Cleveland 4a.

First test attempt – post upgrade process

- Tester powers on unit
- Enters into calibration mode
- Attempts calibration
- Screen becomes unresponsive
- Unit powered off

Second test attempt

- Tester powers on unit
- Enter into calibration mode
- Successfully completes calibration
- Continues with test – see Appendix A for details
- Finishes casting ballots

- Presses physical polls close button
- Unit prints report and screen switches to polls closed screen
- Screen is unresponsive

Third test attempt – ES&S tech now present

- Tech powers on unit
- Allows unit to boot completely
- Screen unresponsive

Fourth test attempt

- Unit powered on
- Enter into calibration mode
- Successfully completes calibration
- Continues with test – see testing instructions for details
- Finishes casting ballots
- Presses physical polls close button
- Unit prints report and screen switches to polls closed screen
- Tester was able to complete testing
- Unit marked as PASSED

Print audit log attempt – Approx 3 day elapsed between testing.

- Unit powered on
- Status tape prints and the polls closed screen comes up
- Screen unresponsive
- Clock was still running

Issue: Uncounted race

Symptoms: At the completion of running the test deck through the scanner the count was incorrect. The race is the one that is at the furthest point to the side and bottom of the ballot. Deck is a 17in ballot deck. The images that are captured by the DS200 are skewed.

Cause: ES&S is unsure as to what is causing the failure. ES&S is performing diagnostics on the images of the skewed ballots. They have developed special software that can analyze scans and predict how the DS200 will interpret the ballot.

EAC Assessment: After review of the ballot images it is apparent that the ballot is skewed. This skewing effect may be moving the race out of alignment with the timing marks and thus causing it not to be counted. It is not know if this is a mechanical or firmware issue. The skewing appears in other images from different machines.

Issue: Calibration is not logged.

Symptoms: The DS200 audit log does not contain any information to the calibration of a units being adjusted/changed.

Cause: ES&S doesn't log this information

EAC Assessment: This is a non-conformity to the standard that the system was certified to.

With the upgrade to 3.2.1.0 the EMS is now capable of using multiple upload stations. An upload test was performed to verify that this new function performed properly. The test consisted of uploading 1065 election media sticks. These were the same sticks used in the testing of the DS200 upgrade. The new

feature performed correctly. However, Cuyahoga County official were expecting it to be a simultaneous uploading process similar to the Premier GEMS EMS but instead it is more of a queue process where one server at a time can upload. The new feature does increase the efficiency of the uploading process. Previously the county officials could upload 90 stick every 15min. The test showed that they can now upload 219 stick per 15min.

Appendix M - EAC Technical Advisory ESS2011-02



U.S. ELECTION ASSISTANCE COMMISSION

Voting System Testing and Certification Program

1201 New York Avenue, NW, Suite 300

Washington, DC. 20005

EAC Certified System Technical Advisory – ESS2011-02

EAC System(s) Affected:	ES&S Unity 3.2.1.0
Component(s) Affected:	DS200
Version(s) Affected:	DS200 firmware version 1.4.3.11 (Unity 3.2.1.0)
Advisory Release Date:	July 28, 2011
Summary:	During local acceptance testing in a jurisdiction multiple DS200 Ballot Scanners exhibited an anomaly where the touch screen interface would stop responding to touches.

Advisory:

Jurisdictions currently with, or considering upgrading/purchasing, the Election Systems & Software (ES&S) Unity 3.2.1.0 voting system should be aware that during local acceptance testing of the Unity 3.2.1.0 system, touch screen interfaces on several DS200s stopped responding.

Issue Description:

During testing on the Unity 3.2.1.0 voting system, some DS200s stopped responding to interactions with the user interface. The anomaly presented itself at random times during the testing process.

Root Cause:

ES&S informed the EAC that the root cause of touch screen unresponsiveness is linked to an improperly implemented internal system log. This log is only accessible to ES&S technicians when troubleshooting errors with the fielded system. One specific event tracked by this log is the presence of the election media USB memory stick. If the unit is powered on without a memory stick inserted, the system records an event eight (8) times per second to the log. When the log reaches capacity, it causes a section of the internal compact flash (CF) card to become inaccessible. This same section of the CF card contains the calibration settings for the DS200's touch screen interface. When this section of the CF card is inaccessible the calibration settings are no longer available to the system so the screen becomes unresponsive.

ES&S Recommended Procedures:

ES&S recommends that jurisdictions do not power up a DS200 without an election media USB stick inserted.

Notice Questions:

Please direct any question on this notice to the Election Assistance Commission Testing and Certification Division at 202-566-3100.

Appendix N - EAC Technical Advisory ESS2011-03



U.S. ELECTION ASSISTANCE COMMISSION

Voting System Testing and Certification Program

1201 New York Avenue, NW, Suite 300

Washington, DC. 20005

EAC Certified System Technical Advisory – ESS2011-03

EAC System(s) Affected:	ES&S Unity 3.2.1.0
Component(s) Affected:	DS200
Version(s) Affected:	DS200 firmware version 1.4.3.11 (Unity 3.2.1.0)
Advisory Release Date:	July 28, 2011
Summary:	During local acceptance testing a DS200 Ballot Scanner failed to count a marked ballot position resulting in a lost vote.

Advisory:

Jurisdictions currently with, or considering upgrading/purchasing, the Election Systems & Software (ES&S) Unity 3.2.1.0 voting system should be aware that during local acceptance testing of the Unity 3.2.1.0 system, a DS200 Ballot Scanner failed to count a marked ballot position resulting in a lost vote.

Issue Description:

During testing on the Unity 3.2.1.0, a DS200 did not count a valid mark for a race. The anomaly was discovered when county testers reviewed the printed election summary report for the DS200 unit. The count for a single contest did not match the expected results. The test was performed to verify that ES&S had corrected a previous anomaly with similar symptoms. The county testers were using a 17" ballot with contests concentrated in the lower sections of the ballot (see Appendix A).

Root Cause:

In discussion with the EAC, ES&S stated that they have only been able to replicate this issue in testing by removing the plastic guides and physically altering the ballot (cutting of a corner).

EAC Comments:

In an effort to understand the issue the EAC focused on reviewing ballot images from several states and previous test campaigns. The review included 11", 14", 17" and 19" ballots. In the course of the review, the EAC found various degrees of ballot image distortion; with the 17" ballot having the largest degree of skew (see Appendix B). The EAC is working with jurisdictions, VSTLs and the manufacturer to understand and resolve this issue.

Recommended Procedures:

No recommend procedures at this time.

Notice Questions:

Please direct any question on this notice to the Election Assistance Commission Testing and Certification Division at 202-566-3100.

Appendix O - ES&S Technical Bulletin FYIDS2000021



EXPERIENCE
RELIABILITY
SECURITY
INNOVATION

Election Systems & Software

August 3, 2011

RE: ES&S Technical Bulletin, FYIDS2000021, Dated 8/3/2011

Dear Valued Customer,

In their continuing efforts to function as a clearinghouse of information that affects voting system administration, the EAC has recently published two technical advisories regarding the ES&S Unity 3.2.1.0 tabulation system. Specifically, the technical advisories were focused on the DS200 firmware version 1.4.3.11.

In order to provide greater detail and context around the concerns related to this firmware version, ES&S has prepared the attached technical bulletin. This technical bulletin describes, in greater detail, the circumstances described in the attached EAC technical advisory. In addition, the technical bulletin illustrates the extensive testing performed on the DS200 by the EAC as well as independent testing authorities which have validated the reliability and accuracy of the DS200.

Our goal is to address any concerns that you may have regarding Unity 3.2.1.0 and the DS200. We believe the attached technical bulletin provides a broader and more encompassing view of the issues reported. After review of this bulletin, if you have additional questions please do not hesitate to contact your Customer Service Representative for further clarification.

The ES&S DS200 is a reliable, technologically-advanced voting system which has been tested and has passed the highest level of voting system standards. ES&S is proud to be a vendor who continues to work with the EAC to ensure that your voting systems meet the highest standards established and serve your needs and the needs of your voters.

Best Regards,

A handwritten signature in black ink, appearing to read 'Tom Burt'.

Tom Burt
Chief Operating Officer
Election Systems and Software, Inc.



Mark Reported Missed During a Customer Acceptance Testing Exercise (FYIDS2000021)

Technical Bulletin	FYIDS2000021	
Date	August 3, 2011	
Product Name	DS200	
Firmware Version	1.4.3.11	
Distribution	All	
	Unity Version	3.2.1.0

Introduction:

The EAC has published a technical advisory regarding an anomaly that occurred on one DS200 during a jurisdiction acceptance test of Unity 3.2.1.0. During the local county acceptance testing, a DS200 failed to count a single marked ballot position resulting in one lost vote. The EAC Certified System Technical Advisory - ESS2011-003 is attached.

Discussion:

ES&S and the county involved in the local acceptance testing have not been able to recreate this problem or experience this problem a second time, in spite of numerous attempts to do so.

ES&S has been able to recreate the problem only when removing the plastic ballot guide from the DS200 and inserting the ballot in a highly unusual and purposely skewed fashion. We have not been able to recreate or experience the issue when properly using the DS200 in the certified and recommended configuration.

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Election Systems & Software Inc.

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The FEC 2002 FVSS and the EAC 2005 VVSG require a scanner to achieve a maximum error rate of up to 1 mark in 500,000 ballot voting positions. The VVSG states “this rate is set at a sufficiently stringent level that the likelihood of voting system errors affecting the outcome of an election is exceptionally remote even in the closest of elections”.

For Unity 3.2.1.0, ES&S ran accuracy and reliability tests with 17,480 ballots totaling 3,779,880 voting positions on DS200 units with 100% accuracy.

The DS200 has passed all tests conducted by the independent voting system test laboratories (VSTL). In reliability, accuracy, and regression tests alone, the VSTL ran 17,484 ballots totaling 1,862,244 voting positions with 100% accuracy. The DS200 has been certified by the EAC to meet all voting system requirements including all ballot scanning and vote counting accuracy standards.

In our efforts to recreate the reported finding, ES&S conducted additional accuracy tests of the DS200 by processing 12,000 specifically designed 14”, 17”, and 19” test ballots in an effort to recreate this reported finding. These tests proved out with 100% accuracy.

The Florida Division of Elections recently tested the accuracy of the DS200 by processing nearly 10,000 specifically designed 19” test ballots containing 249,488 vote targets. These tests proved out with 100% accuracy.

Summary

The attached EAC technical advisory infers that the oval voting position is not being correctly evaluated when a ballot is skewed. In fact, the DS200 has skewed ballot compensation logic to handle ordinary ballot printing imperfections, and to handle the allowable degree of skew controlled by the DS200 ballot path and ballot guides. If a ballot is overly skewed, it is automatically rejected and provided back to the voter for re-insertion and processing. This advanced skewed ballot processing functionality of the DS200 is not mentioned in the EAC Technical Advisory and not considered in the various drawings attached to the EAC Technical Advisory.

You can be assured of the DS200 vote processing accuracy. It has been independently validated to meet and exceed all ballot processing voting system standards.

Appendix P - ES&S Technical Bulletin PRBDS2000013



EXPERIENCE
RELIABILITY
SECURITY
INNOVATION

Election Systems & Software

August 3, 2011

RE: ES&S Technical Bulletin, PRBDS2000013, Dated 8/3/2011

Dear Valued Customer,

In their continuing efforts to function as a clearinghouse of information that affects voting system administration, the EAC has recently published two technical advisories regarding the ES&S Unity 3.2.1.0 tabulation system. Specifically, the technical advisories were focused on the DS200 firmware version 1.4.3.11.

In order to provide greater detail and context around the concerns related to this firmware version, ES&S has prepared the attached technical bulletin. This technical bulletin describes, in greater detail, the circumstances described in the attached EAC technical advisory. In addition, the technical bulletin illustrates the extensive testing performed on the DS200 by the EAC as well as independent testing authorities which have validated the reliability and accuracy of the DS200.

Our goal is to address any concerns that you may have regarding Unity 3.2.1.0 and the DS200. We believe the attached technical bulletin provides a broader and more encompassing view of the issues reported. After review of this bulletin, if you have additional questions please do not hesitate to contact your Customer Service Representative for further clarification.

The ES&S DS200 is a reliable, technologically-advanced voting system which has been tested and has passed the highest level of voting system standards. ES&S is proud to be a vendor who continues to work with the EAC to ensure that your voting systems meet the highest standards established and serve your needs and the needs of your voters.

Best Regards,

A handwritten signature in black ink that reads 'Tom Burt'.

Tom Burt
Chief Operating Officer
Election Systems and Software, Inc.



System Log Fills Internal Compact Flash Card Partition in DS200 Versions 1.4.3.11 (Unity 3.2.1.0) or 1.5.2.0 (4.0.0.3 Version 2 (FL)) (PRBDS2000013)

Technical Bulletin	PRBDS2000013	
Date	August 3, 2011	
Product Name	DS200	
Firmware Version	1.4.3.11 and 1.5.2.0 (FL)	
Distribution	All	
Unity Version	3.2.1.0	4.0.0.3 Version 2 (FL)

Issue:

The EAC has published a technical advisory regarding an anomaly that occurred on multiple DS200s during a jurisdiction acceptance test. The scanners' touch screen interface stopped responding to touches. The EAC Certified Technical Advisory - ESS2011-02 is attached.



NOTE: This issue does not pertain to earlier versions of the DS200, and does not pertain to later versions, but only to version 1.4.3.11 and 1.5.2.0 (FL). These versions are not in the field and not in use by any customers.

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Discussion:

If the DS200 is used without valid election media inserted in the USB slot, an internal, low level, system diagnostic file can grow large enough to completely fill up the file system partition of the internal Compact Flash card.

When this scenario occurs, and the flash card's partition is filled, it can interfere with the DS200's touch screen calibration. This causes the DS200 to lose its calibration, or to fail to hold calibration even after the touch screen calibration procedure is completed. In this situation, the touch screen will become unresponsive, and the machine will not be usable.

Resolution:

This issue has been fixed by ES&S in firmware versions 1.4.3.12, 1.5.3.0 (FL) and all future versions. The fix has been tested and validated by an independent systems laboratory. The fix was submitted to the EAC before the EAC technical advisory was published. The EAC is currently reviewing the fix and determining what other tests they might conduct before approving the fix.

When using the DS200, always make sure to have properly formatted USB election media with a valid election definition installed in the USB slot of the DS200.



Note: If this situation occurs, the compact flash card must be re-imaged in order to return the DS200 to normal function. Please contact ES&S to inquire about having this important process performed.

Appendix Q - DS200 Lockup Analysis

MAINTAINING VOTER CONFIDENCE.
ENHANCING THE VOTING EXPERIENCE.



A HERITAGE OF PARTNERSHIP AND INNOVATION

Election Systems & Software

DS200 System Lockup Analysis Unity v. 3.2.0.0 Revision 1

June 9, 2010

Proprietary and Confidential
For Authorized Use Only



Election Systems & Software Inc.
DS200 System Lockup Analysis
Unity 3.2.0.0 Revision 1
June 10

Election Systems & Software, Inc.
11208 John Galt Blvd.
Omaha, NE 68137

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ES&S has identified and appropriately marked relevant portions of this document, which it considers confidential and proprietary. We request confidential treatment by the EAC of such information and would expect that such information is exempt from required disclosure. In the event that a third party requests disclosure of information which ES&S considers confidential and proprietary, we would ask that the EAC notify ES&S of such requested disclosure in order to provide us with an opportunity to seek exemption from disclosure.

The document sections referenced below contain Election Systems and Software, Inc. (ES&S) confidential information, which is provided for the sole purpose of permitting the recipient, to evaluate the ES&S Voting System submitted herewith. The following sections are designated as "Proprietary and Confidential" by Election Systems & Software.

Document Section	Description

NOTICE OF UNCERTIFIED FUNCTIONALITY

This document is designated for use with the Unity 3.2.0.0 voting system, which has been tested to the standards of the *2002 Voting System Standards (VSS)* to include a limited system configuration and feature set. Please be advised that this system and associated documentation includes functionality and descriptions of functionality that have not been fully tested or certified to the *VSS*.

The products and/or system features designated below *HAVE NOT COMPLETED TESTING FOR CERTIFICATION BY THE ELECTION ASSISTANCE COMMISSION (EAC)* to the requirements of the *VSS*:

UNCERTIFIED PRODUCTS

- System Hardware
 - Automated Bar Code Reader
 - iVotronic DRE Precinct Tabulator
 - Model 100 Precinct Ballot Counter

- System Software
 - Unity Data Acquisition Manager
 - Unity iVotronic Ballot Image Manager

UNCERTIFIED SYSTEM FEATURES

- Network Data Transmission
 - Including remote transmission of vote data and/or consolidated results data

If your jurisdiction requires voting system certification at the Federal level or you have questions about your jurisdiction's certification requirements, please refrain from using the products and system features listed above until you have received approval from your State Election Authority. **USE OF ANY UNCERTIFIED SYSTEM FEATURES NOTED ABOVE WILL NEGATE THE UNITY 3.2 FEDERAL CERTIFICATION.** ES&S shall not be held responsible for any unauthorized use of the foregoing products and system features.

Please visit www.eac.gov for more information regarding United States Federal voting system certification requirements and procedures. Contact the Elections Authority for your jurisdiction with any questions about your local laws and requirements.

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NOTICE OF UNCERTIFIED FUNCTIONALITY

The following products and/or system features **HAVE NOT COMPLETED TESTING FOR CERTIFICATION BY THE ELECTION ASSISTANCE COMMISSION (EAC)** to the requirements of the VSS:

- Automated Bar Code Reader (ABCR) ●iVotronic DRE ●Model 100 ●Unity Data Acquisition Manager (DAM)
- Unity iVotronic Ballot Image Manager (iVIM) ●All functions related to network data transmission



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NOTICE OF UNCERTIFIED FUNCTIONALITY

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- Automated Bar Code Reader (ABCR)
- iVotronic DRE
- Model 100
- Unity Data Acquisition Manager (DAM)
- Unity iVotronic Ballot Image Manager (iVIM)
- All functions related to network data transmission



I. INTRODUCTION

This document summarizes the events and actions taken by ES&S that lead to the ES&S update of the DS200 for Unity 3.2.0.0 Revision 1. The DS200 firmware update addresses a system lockup condition that surfaced during the Cuyahoga County primary election held in May 2010.

NOTICE OF UNCERTIFIED FUNCTIONALITY

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- Automated Bar Code Reader (ABCR)
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- Unity Data Acquisition Manager (DAM)
- Unity iVotronic Ballot Image Manager (iVIM)
- All functions related to network data transmission

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- Automated Bar Code Reader (ABCR)
- iVotronic DRE
- Model 100
- Unity Data Acquisition Manager (DAM)
- Unity iVotronic Ballot Image Manager (iVIM)
- All functions related to network data transmission



1. ACTIONS AND RESULTS

1.1. ACTION 1

Cuyahoga County, Ohio began L & A testing of the DS200 v1.3.10.0 of Unity 3.2.0.0, in preparation for their May 2010 primary and encountered a substantial number of lockups. The same DS200's performed without a notable incidence of lockups during their General Election in November 2009 and a spring 2010 special election.

ES&S personnel in Cuyahoga notified Omaha customer support.

1.2. RESULT 1

Testers in Omaha were unable to reproduce the problem. This initial analysis was performed on a DS200 shipped to Omaha from Cuyahoga that had previously failed.

1.3. ACTION 2

ES&S sent a senior hardware engineer to Cuyahoga to check for hardware problems.

1.4. RESULT 2

The ES&S engineer was able to examine a number of machines and replaced some batteries but the intermittent lockups continued.

1.5. ACTION 3

Cuyahoga then shipped a total of six machines that had failed during their L & A testing to Omaha for analysis and testing.

ES&S assigned two senior software engineers and a senior hardware engineer to diagnose the problem. The software engineers set up the six machines that had experienced problems. The team enabled core dumps in the operating system to provide low level data for analysis.

The test routine began with testers following the same L & A routine checklist as the Cuyahoga workers and used identical ballots and the actual USB sticks with the election definition shipped with the machines. (The checklist is included later in this document.)

The workers performing the test routines kept paper logs of their activity and notified an engineer if a machine locked up.

1.6. RESULT 3

During the first 4 days, the testing produced only one core dump on a lock up.

During the next 3 days, the testing produced another core dump.

NOTICE OF UNCERTIFIED FUNCTIONALITY

The following products and/or system features HAVE NOT COMPLETED TESTING FOR CERTIFICATION BY THE ELECTION ASSISTANCE COMMISSION (EAC) to the requirements of the VSS:

- Automated Bar Code Reader (ABCR)
- iVotronic DRE
- Model 100
- Unity Data Acquisition Manager (DAM)
- Unity iVotronic Ballot Image Manager (iVIM)
- All functions related to network data transmission

Analysis of the core dump outputs revealed memory management errors in the Hardware Abstraction Layer.

The memory management errors involved attempting to free the same location in memory twice, also known as a “double free”, as well as a few instances of attempting to free memory that was not allocated in the first place.

1.7. ACTION 4

In parallel with the firmware/hardware investigation, an election support and coding expert began expanding the already large Cuyahoga County election definition to test the possibility that the size and complexity of the data was contributing to the problem.

1.8. RESULT 4

The testing with the extra large election did not produce a perceptible difference in the behavior of the machines between the new data set and the original data used in the Cuyahoga L&A tests.

1.9. ACTION 5

Hardware engineers placed a machine in a temperature chamber to test for the possibility that heat was a contributing factor.

1.10. RESULT 5

The unit did not fail during 24 hours of constant operation with ambient temperatures in the heat chamber of registering over 100 degrees Fahrenheit.

1.11. ACTION 6

Additional discussions with support personnel in Cuyahoga turned up evidence that the problem occurred more frequently when workers there were entering the Administrator security code.

ES&S then modified the test checklist to emphasize touch screen use. (This checklist follows the original Cuyahoga checklist later in the document)

1.12. RESULT 6

During the next 2 days using the modified checklist, the testing produced 7 more lock ups with core dumps and using this method allowed engineers to gather enough information to see patterns that consistently pointed to the memory management issues.

The core dumps all pointed to the same location. This location was on line 1031 of a source code file named `hal_client.c` that makes a call to the `free` function. A shortened output of the back trace of the core dump is as follows:

Note: earlier entries in the trace involve more `libc` references.

```
#4 0xb7d15431 in raise () from /lib/libc.so.6
```

NOTICE OF UNCERTIFIED FUNCTIONALITY

The following products and/or system features **HAVE NOT COMPLETED TESTING FOR CERTIFICATION BY THE ELECTION ASSISTANCE COMMISSION (EAC) to the requirements of the VSS:**

- Automated Bar Code Reader (ABCR)
- iVotronic DRE
- Model 100
- Unity Data Acquisition Manager (DAM)
- Unity iVotronic Ballot Image Manager (iVIM)
- All functions related to network data transmission

```

#5 0xb7d16bab in abort () from /lib/libc.so.6
#6 0xb7d4b72a in __libc_message () from /lib/libc.so.6
#7 0xb7d51672 in malloc_printerr () from /lib/libc.so.6
#8 0xb7d52024 in free () from /lib/libc.so.6
#9 0x08069dfd in halcl_video_get_backlight_status () at
  ./src/hal_client.c:1031
#10 0x0805bfff in monitor_screen_status (prev_status=1,
     psScreenOnTimeVal=0x80998c8, pbDisregardPressFlag=0xbf838710)
     at ./src/menu.c:5833
#11 0x0805bbd2 in wait_event (events2wait_for=1, event_timeout=0)
     at ./src/menu.c:5465

```

Note: Please reference stack frame #9 -
 halcl_video_get_backlight_status () at ./src/hal_client.c:1031 This
 is the location of the call to free().

The free function is part of standard C language libraries. Formal definitions of the behavior associated with attempting a “double free” state: “If a program calls free() twice with the same argument, the program's memory management data structures become corrupted. This corruption can cause the program to crash or, in some circumstances, cause the later calls to malloc() to return the same pointer.”

The source of this quote is the Common Weaknesses Enumeration Web Site under CWE – 415 Double Free. <http://cwe.mitre.org/data/definitions/415.html>

The code suspected of the double free is part of a process known as HAL (Hardware Abstraction Layer) and code used to interface other components with HAL.

Here is a bit of the source code “chain”. The first call to free() is in a file named hal.c.

```

int talk(const char* cmd, char** data, short *length)
{
NOTE: removed lines from beginning of the function for clarity.

    /* connect to the server */
    if(connect(sock, (struct sockaddr *)&address,
              SUN_LEN(&address)) == 0) {
    /* read handshake */
    if(halRead(sock, data, &len) == 0) {ret = strcmp(*data,
              HANDSHAKE, strlen(HANDSHAKE));
    /*free data allocated to read handshake*/
    free(*data); NOTE: This is the first call to free
    }
Note: more code removed here

    return ret;
}

```

NOTICE OF UNCERTIFIED FUNCTIONALITY

The following products and/or system features HAVE NOT COMPLETED TESTING FOR CERTIFICATION BY THE ELECTION ASSISTANCE COMMISSION (EAC) to the requirements of the VSS:

- Automated Bar Code Reader (ABCR) ●iVotronic DRE ●Model 100 ●Unity Data Acquisition Manager (DAM)
- Unity iVotronic Ballot Image Manager (iVIM) ●All functions related to network data transmission

The free() call at line 1031 in hal_client.c is the second free on the same piece of memory. Notice the code does surround the free call with a check for NULL but the pointer is not set to NULL after the free() call in the previous function.

```
const char* halcl_video_get_backlight_status( void )
{
    /* Get the video back light status */
#define MAX_STATUS_LEN 128 /* length of status message */
    /* Use this static to cache the returned HAL data */
    static char psz_status[MAX_STATUS_LEN] = { 0 };
    char *status = 0; /* pointer for HAL response */

    memset( psz_status, 0, MAX_STATUS_LEN );

    status = (char*) GetVideoBackLightStatus();

    // check for null pointer return
    if( NULL != status )
    {
        /*Pointer ok - copy status string allow for NULL Terminator (-1) */
        strncpy(psz_status, status, sizeof( psz_status ) - 1);
        /* free the memory from the pointer HAL gave us */
        free( *status ); Note: This is the second call to free
    }
    return psz_status;
}
```

The software engineers also discovered a call to free() that failed because it was attempting to free memory that was not allocated. This code was in the EbaClient.c source file. This is the original code.

```
char **
GetEbaNameListCopy()
{
    /* return data */
    static char **nameList = 0;
    getDeviceNameList(EBA, &nameList);
    return nameList;
}
```

This highlighted line shows a pointer declared as static. Because of the static storage classification, the pointer gets initialized only on the first call of the function.

1.13. ACTION 7

Software engineers modified the source code to always set the data pointer to NULL after a free() call and to initialize the static pointer after the initial call to its function to eliminate the memory management problems.

NOTICE OF UNCERTIFIED FUNCTIONALITY

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- Automated Bar Code Reader (ABCR) ●iVotronic DRE ●Model 100 ●Unity Data Acquisition Manager (DAM)
- Unity iVotronic Ballot Image Manager (iVIM) ●All functions related to network data transmission

This is the fix for the static pointer causing a failure of a free() call.

```
char **GetEbaNameListCopy()/* return data *
    static char **nameList = 0;
    nameList = 0;
    getDeviceNameList(EBA, &nameList);
    return nameList;
}
```

The highlighted portion is a line that makes sure the pointer is initialized after the initial call to its function.

Here is part of the source code as modified to fix the double free problems. Please notice the line following the free call. (highlighted).

```
int talk(const char* cmd, char** data, short *length)
{
NOTE: removed lines from beginning of the function for clarity.

    /* connect to the server */
    if(connect(sock, (struct sockaddr *)&address,
        SUN_LEN(&address)) == 0) {
    /* read handshake */
    if(halRead(sock, data, &len) == 0) {ret = strcmp(*data,
        HANDSHAKE, strlen(HANDSHAKE));
    /*free data allocated to read handshake*/
    free(*data);
    *data=NULL; Note: This is new set pointer to NULL
    Note: more code removed here
    return ret;
}
```

Note: Complete "diff" reports of all source code changes are available as part of the routine source code submission to the VSTL.

The team installed the new firmware on the test machines and the effort continued.

1.14. RESULT 7

After the memory management changes, the behavior of the DS200s under test changed.

Several days of testing revealed that machines no longer locked up or "froze" but, instead, generated an error message, displayed the message and initiated a controlled shut down.

The memory issues were a symptom but not the core cause of the problem although the controlled shutdowns made the issue far more manageable for users. A system re-start brought the machines up in a stable and useable state with no data loss.

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Without the lockups, some of the methods used in investigation needed to change because programs in a controlled shutdown do not produce a core dump for analysis.

1.15. ACTION 8

Software engineers began installing extensive debug logging mechanisms into the source code in an attempt to locate the exact location and reason for the shutdowns and ES&S added two more senior software engineers to the team investigating the problem.

In addition to the logging code, the team started using an open source program named strace. (s-trace)

The team used strace version 4.5.20 from the strace web site <http://strace.sf.net>

It is a system call tracer, so it can record an application's system calls, the argument values passed to them and the corresponding return values.

Also at this time, ES&S hardware engineers purchased and began using a serial analyzer and an USB analyzer to look for any hardware communication anomalies that could cause or contribute to the problem.

1.16. RESULT 8

The serial analyzer indicated the serial hardware was operating normally.

Analysis of the USB hardware was performed. This analysis did not reveal any problems with the USB hardware or subsystem.

Analysis of several weeks of debug logging and strace output revealed a discernable pattern and sequence of events that led the engineers to realize that the HAL process was exiting and that a specific section of the HAL process source code was the last to run before the exit.

Here is a sample output from logging code pointing to HAL exiting after reporting it could no longer "see" the election media and the election definition files.

```
May 21 11:01:28 intElect-DS200 mark.err ess-hald[2044]: talk: could not
connect to HAL server
May 21 11:01:38 intElect-DS200 mark.err ess-hald[2044]: talk: could not
connect to HAL server
May 21 11:01:38 intElect-DS200 mark.err ess-hald[2044]: is_elecdef_fd_valid:
NO EBA Devices Found
May 21 11:01:38 intElect-DS200 mark.err ess-hald[2044]: talk: could not
connect to HAL server
May 21 11:01:38 intElect-DS200 mark.info ess-hald[2044]: is_elecdef_fd_valid
Unomunt - No Election Definition
May 21 11:01:38 intElect-DS200 mark.err ess-hald[2044]: talk: could not
connect to HAL server
May 21 11:01:39 intElect-DS200 mark.err ess-hald[2044]: talk: could not
connect to HAL server
```

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```
May 21 11:01:39 intElect-DS200 user.notice shutdown[2671]: shutting down for
system halt
```

Here is a sample output from the logging code pointing to HAL exiting after losing communication with the power management board.

```
May 21 12:18:33 intElect-DS200 mark.err ess-hald[2044]: talk: could not
connect to HAL server
May 21 12:18:33 intElect-DS200 mark.err ess-hald[2044]: talk: could not
connect to HAL server
May 21 12:18:33 intElect-DS200 mark.err ess-hald[2044]: wait_event: PMT
Error Count: 158 of 30
May 21 12:18:33 intElect-DS200 mark.err ess-hald[2044]: talk: could not
connect to HAL server
```

Here is a representative sample of the strace program output after a HAL exit.

```
select(4, [3], NULL, NULL, {0, 100000}) = 1 (in [3], left {0, 80000})
accept(3, {sa_family=AF_FILE, NULL}, [2]) = 4
write(4, "\21\0", 2) = 2
write(4, "Server Handshake\0", 17) = 17
read(4, "$\0", 2) = 2
read(4, "GetVideoBackLightStatus\2video\2vi"... , 36) = 36
uname({sys="Linux", node="intElect-DS200", ...}) = 0
socket(PF_FILE, SOCK_STREAM, 0) = 5
getrlimit(RLIMIT_NOFILE, {rlim_cur=1024, rlim_max=1024}) = 0
uname({sys="Linux", node="intElect-DS200", ...}) = 0 uname({sys="Linux",
node="intElect-DS200", ...}) = 0
connect(5, {sa_family=AF_FILE, path="/tmp/.X11-unix/X0"}, 19) = 0
uname({sys="Linux", node="intElect-DS200", ...}) = 0
fcntl64(5, F_SETFD, FD_CLOEXEC) = 0
access("/.Xauthority", R_OK) = -1 ENOENT (No such file or
directory)
writev(5, [{"\1\0\v\0\0\0\0\0\0\0\0\0", 12}], 1) = 12
fcntl64(5, F_GETFL) = 0x2 (flags O_RDWR)
fcntl64(5, F_SETFL, O_RDWR|O_NONBLOCK) = 0
read(5, "\1\0\v\0\0\0009\0", 8) = 8
read(5, "\240B\241\3\0\0\0\0\377\377\37\0\0\1\0\0\24\0\377\377\1\7\0\0
\10\377\20\0\0\0"... , 228) = 228
write(5, "7\0\5\0\0\0\0\0\0\0\0\0\10\0\0\0\377\377\0\0b\0\5\0\f\0\0\0BIG-"... ,
64) = -1 EPIPE (Broken pipe)
--- SIGPIPE (Broken pipe) @ 0 (0) ---
socket(PF_FILE, SOCK_DGRAM, 0) = 6
fcntl64(6, F_SETFD, FD_CLOEXEC) = 0
connect(6, {sa_family=AF_FILE, path="/dev/log"}, 16) = 0
time([1274129480]) = 1274129480
stat64("/etc/localtime", {st_mode=S_IFREG|0644, st_size=1267, ...}) = 0
stat64("/etc/localtime", {st_mode=S_IFREG|0644, st_size=1267, ...}) = 0
stat64("/etc/localtime", {st_mode=S_IFREG|0644, st_size=1267, ...}) = 0
send(6, "<198>May 17 16:51:20 ess-hald[20"... , 96, MSG_NOSIGNAL) = 96
```

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```
close(6) = 0
write(2, "X connection to :0.0 broken (exp"... , 65X connection to :0.0
broken (explicit kill or server shutdown). ) = 65
exit_group(1) = ?
```

Please notice the highlighted sections. The first points to an instance of a broken pipe and Operating System raising a SIGPIPE signal. The second section points to the x windows library “exiting” the client process linked to it.

1.17. ACTION 9

In an attempt to obtain greater system level details, the team started using another open source program named ltrace. (l-trace) ltrace is a program that intercepts and records the dynamic library calls which are called by the executed process and the signals which are received by that process. It can also intercept and print the system calls executed by the program.

The team was particularly interested into looking into the x-windows library calls and used ltrace version 0.4 from <ftp://ftp.debian.org/debian/pool/main/l/ltrace/>

1.18. RESULT 9

The ltrace output is very large and to avoid exceeding the storage capacity of the DS200 testers needed to clear out the old data frequently until a machine demonstrated a shutdown.

They were able to gather a sufficient amount of data to clearly see that it was a call into the x-windows library that was the source of the problem and that was causing HAL to exit.

The following shows the critical section of the output detailing the library and system calls.

```
strncmp(0x808afdc, 0x809c488, 20480, 0x8050e10, 0xbfbd13377) = -1
strncmp(0x808b4cc, 0x809c488, 20480, 0x8050e10, 0xbfbd13377) = 0
strncmp(0x809c488, 0x808b4cc, 20480, 0x8050e5e, 0xbfbd13377) = 0
Note: here begins a call to check the backlight status
XOpenDisplay(0, 0, 0xbfbd133a8, 0x8050f42, 0x80976b0) = 0x80a2aa8
DPMSInfo(0x80a2aa8, 0xbfbd13392, 0xbfbd13391, 0x8050f42, 0x80976b0 <unfinished
...>
--- SIGPIPE (Broken pipe) ---
```

Note: the next three lines directly follow the lines above and are logging functions inserted into the signal handler.

```
openlog(0x808b420, 9, 24, 0, 0) = 1
vsyslog(198, 0x8080d5d, 0xbfbd12f64, 0, 0) = 8201
closelog(198, 0x8080d5d, 0xbfbd12f64, 0, 0) = 6
```

Note: from here on most of the functions appear to have their names “mangled” through the C++ pre-processor/compiler system. The team believes they are likely called within destructors, as the process is exiting.

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The last line is the exit call with the status set to 1 instead of a typical zero.

```
_ZNSSD1Ev(0x8098788, 1, 0xbfdd13240, 0xb7f09b18, 0xb7eea1ac) = 0xb7e07d5c
_ZNSSD1Ev(0x8098784, 1, 0xbfdd13240, 0xb7f09b18, 0xb7eea1ac) = 0xb7e07d5c
_ZNSt8ios_base4InitD1Ev(0x80989a8, 0xb7bd88a0, 0xbfdd13258, 0xb7c07fc4, 0) =
3
_ZNSt8ios_base4InitD1Ev(0x80989ac, 0xb7bd88a0, 0xbfdd13258, 0xb7c07fc4, 0) =
0xb7e07780
+++ exited (status 1) +++
```

In summary, through analysis of the accumulated data, the investigating engineers have determined that the sequence of events leading up to and causing the shutdowns is as follows:

- A program (HAL) that uses the x-windows library makes a call to the x-windows server. The specific call listed above is XOpenDisplay().
- The x-call fails and this causes the pipe between the client (HAL) and the server to break and the OS raises the SIGPIPE signal.
- The client (ES&S code) catches the signal but the x-windows system was designed such that an x-client process must exit (the exit call is contained in the x library code) if it loses contact with the server.
- The client (HAL) exits.
- The rest of the ES&S code no longer has access to the information it needs through HAL and therefore shuts itself down.

1.19. ACTION 10

ES&S software engineers then removed the parts of the code that made the failing x-windows library calls. This part of the code was used to check to see if the backlight to the display was on or off so that a user touch of a “hotspot” on the screen when the screen is dark would not cause an unintended action.

They also removed the operating system configuration options and any code that would automatically turn off the backlight. This system is known as DPMS (Display Power Management Signaling)

The hardware engineers also began testing to see if the unit would still run the required 2 hours on battery power if the screen backlight stayed on all the time.

1.20. RESULT 10

The volume of system shutdowns fell dramatically in a typical test day that included between 25 and 30 iterations of the test checklist. Before the changes, testers would experience up to 8 or more shutdowns per day. After the changes testers were recording fewer than 2 shutdowns per day.

The hardware timing testing proved that the battery ran the machine for more than 2 hours using the duty cycle prescribed in the testing requirements.

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1.21. ACTION 11

The investigating team continued their work using two approaches. The first approach is to search for patches or updates to the x-windows system that would not exhibit the problems detailed above.

The second approach was to continue to look for a problematic x-windows call that could explain the remaining few shutdowns.

1.22. SUMMARY

A vast majority of source code changes fall into 4 main categories.

The largest category is the addition of extensive diagnostic logging. Software engineers changed a function named LogIt to LogErr. The LogErr routine calls the Linux OS system function vsyslog to write entries to a log located in the log directory on the var partition of the CF card. (/var/log) This log file is named "messages" with no suffix. This file is designed to provide diagnostic information in case of a problem. ES&S software engineers felt the need to expand the diagnostics based upon a lesson learned from confronting a lack of helpful data to use to diagnose the initial problem. It is a "rotating" file that never grows beyond a limited size.

The second category is the removal of all code that accessed the x-windows library in the fashion that exposes the apparent bug in the x-windows library. This deals primarily with queries to determine the screen and backlight state. These changes also involve making sure the backlight no longer turns off after a specified period of time. This avoids the possibility that the backlight will shut off and a user could inadvertently touch the screen on a button (hotspot) when they attempt to "wake up" the display.

The third category is the code to improve memory management problems as detailed earlier in this document. Most of this is making sure data pointers are properly set to null after a free() call.

The last category contains a relatively small amount of code to look for a ballot in the transport upon start up. If a ballot is in the transport, the DS200 will automatically back it out of the machine.

The testing and discovery generally evolved along the following timeline.

- Work to recreate the problem and gather data through core dumps
- Analysis of core dumps reveals memory management issues
- Heat chamber testing
- Serial communication testing
- Memory management improvements
- Low level USB subsystem testing
- Introduce extensive debug logging and analysis of the output (evolved over course of investigation)
- Use strace to track all system calls in addition to logging
- Move from strace to ltrace to trace library activity as well as system calls and logging
- Accumulation of enough evidence to isolate x-windows call as root cause
- Changes to the source code to always check for an return a ballot in the transport on startup

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- Unity iVotronic Ballot Image Manager (iVIM) •All functions related to network data transmission

- Changes to source code to avoid specific x-windows calls
- Changes to the source code to leave on the backlight
- Continued testing for effectiveness of changes

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- Unity iVotronic Ballot Image Manager (iVIM) ●All functions related to network data transmission

2. TEST PROCEDURES

LOGIC AND ACCURACY CHECKLIST L&A Testing Procedure for ES&S DS200 Precinct Optical Scanner

Polling Location Name:

Precinct Assigned:

DS200 TC Number: _____

Comments:

If at any time an operator experiences ANYTHING unexpected, it MUST be recorded in the space provided above. The importance of recording these incidents cannot be overstated.

- Insert each memory stick with the label side facing to the right in to Port “B”. Make sure the precinct on the memory stick matches the precinct labels on the front and top of the scanner.
- Open Emergency Slot door and Ballot Box Door and ensure nothing is inside of unit
- Close and lock both doors
- Press the “**Power**” button. Each DS200 will take approximately two minutes to boot.
- Once ready, the DS200 screen will read “Election Definition Found”. If you do not see this screen once the system is ready, notify a Supervisor immediately.
- Press the **Arrow** located on the bottom right side of the DS200 screen.
- Press the “**Go To Admin**” button. Enter the correct password. Press Enter.
- Screen will show “Administration Mode”. Press “**System Settings**”
- Press **Date & Time**.
- Ensure the following information is correct on both the Initial State Report and the DS200 screen:

Both Team Members must initial the Date and Time are correct R_____
D_____

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If Date and Time are correct – SKIP the following steps.

- Time Zone – **Make sure EST is always selected in the dropdown provided**
 - Year
 - Month
 - Date
 - Time – **(Time Format must be 12)**
 - **If the Time Zone is incorrect, this must be the first correction made prior to making any other changes.**
- Note: Each DS200 will shut off and re-boot when the Time Zone has been changed.**
- If additional information in the Date & Time setting is incorrect, press the proper button on the DS200 screen to make the necessary changes. Enter all changes on the screen or keypad provided. Press “Previous” button.
 - Once changes have been made press “Accept New Time”
 - Press “Previous” button.
 - Verify the Date & Time are correct on the top right of the DS200 screen. If no, go back to make necessary corrections.
 - If Yes, Press the “Previous” button.
- Screen will show “Administration Menu”. Press the “**Previous**” button.
 - Screen will show “Election Definition Found”.
 - Press “**Open Polls**”. A Zero Results report will print. Confirm that all results are “0”.
 - Insert each ballot in the test deck through the scanner. Ensure that the on-screen counter increments for each ballot scanned.
 - After scanning all ballots in the deck, ensure that the on-screen counter indicates the correct number of ballots scanned.
 - Remove the scanned ballots from the ballot compartment at the bottom of the front of the ballot box.
 - Press the “**Close Polls**” button.
 - Press “**Yes**” to Cancel after the first print out is complete.
 - Screen will show “Polls Closed”.
 - Remove the memory stick and place it, along with the ballots, on top of the scanner.
 - Take all memory sticks from a complete polling location to the upload team in the tabulation area.
 - The Upload Team will upload the memory sticks and generate a results report.
 - The Verification team will ensure that your results are correct.
 - If any results are not as expected, notify a supervisor immediately. This unit has FAILED testing.
 - Re-insert the memory stick in to Slot “B”. A status report will print.
 - Press “**Re-Open Polls**”. Enter the correct password.

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- The screen will show “Re-Open Polls – Election Counts Exist – Resume Voting or Clear Counts”
- Press “**Clear Counts**”. Screen will show “Warning! Results will be cleared Continue? Press “**Yes**”.
- DS200 will clear results. Screen will show “Election Definition Found”. **Leave the DS200 screen open and turned on in the current mode.**
- Both team members will sign the bottom of the DS200 L&A checklist.
- Staple the DS200 results report from each unit to its corresponding checklist.
- Apply a piece of tamper tape to the Maintenance Access Panel (**if missing**).
- Apply a colored dot sticker to the top right area of the unit’s lid, near the pre-existing dots.
- Put the test ballots, key lanyard, and completed checklist back in the testing box and return to the input table team.

Each scanner must be left ON, in the voting mode, for a minimum of 14 hours to ensure that no errors are detected. The Post L&A verification team will reset the results to zero and turn the scanners off during their process.

Democrat Signature: _____ Date: _____

Republican Signature: _____ Date: _____

Unit PASSED Test

Unit FAILED Test

NOTICE OF UNCERTIFIED FUNCTIONALITY

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- Unity iVotronic Ballot Image Manager (iVIM) ●All functions related to network data transmission



TOUCHSCREEN CHECKLIST
Touchscreen Testing Procedure for ES&S DS200 Precinct Optical Scanner

Name: _____

DS200 TC Number: _____

<p>Comments:</p>

If at any time an operator experiences ANYTHING unexpected, it MUST be recorded in the space provided above. The importance of recording these incidents cannot be overstated.

- Insert each memory stick with the label side facing to the right in to Port "B". Make sure the precinct on the memory stick matches the precinct labels on the front and top of the scanner.
- Open Emergency Slot door and Ballot Box Door and ensure nothing is inside of unit
- Close and lock both doors
- Press the **"Power"** button. Each DS200 will take approximately two minutes to boot.
- Once ready, the DS200 screen will read "Election Definition Found". If you do not see this screen once the system is ready, notify a Supervisor immediately.
- Press the **Arrow** located on the bottom right side of the DS200 screen.
- Press the **"Go To Admin"** button. Enter the correct password. Press Enter.
- Screen will show "Administration Mode". Press **"System Settings"**
- Press **Date & Time**.
- Scroll from the top of the Time Zones to the Bottom of all available time zones. Then go back to EST time zone which was set before.
- Exit **Date & Time**
- Exit System Settings
- Exit **Admin Menu**
- For 20 iterations do the following:
 - o Press the **Arrow** located on the bottom right side of the DS200 screen.
 - o Press the **"Go To Admin"** button. Enter the correct password. Press Enter.
 - o Exit **Admin Menu**

Signature: _____ Date: _____

Unit PASSED Test

Unit FAILED Test

NOTICE OF UNCERTIFIED FUNCTIONALITY

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Appendix R - Notice of Formal Investigation



U.S. ELECTION ASSISTANCE COMMISSION

Voting System Testing and Certification Program

1201 New York Avenue, NW, Suite 300

Washington, DC. 20005

March 1, 2011

Steve Pearson
Vice President, Certification
Election Systems & Software
11208 John Galt Blvd.
Omaha, NE 68137

Sent via mail and e-mail

RE: Notice of Initiation of Formal Investigation

Pursuant to section 7.4 of the Election Assistance Commission's (EAC) Voting System Testing and Certification Program Manual the Decision Authority (Executive Director, Tom Wilkey) has authorized (attached) the EAC's Certification Program Director (Brian Hancock) to open a formal investigation of Election Systems and Software's (ES&S) Unity 3.2.0.0 voting system. This formal investigation arises as a result of an issue reported by ES&S to the EAC on June 6, 2010 and is based on an informal staff investigation of the issues following county notification and public notice of the issues.

Facts

EAC first became aware of a possible issue with the Unity 3.2.0.0 voting system used in Cuyahoga County, Ohio as a result of an article published in the *Cleveland Plain Dealer* on April 10, 2010. This issue was later confirmed by Cuyahoga County in conversations with the EAC. ES&S then reported the issue to EAC in June of 2010. As a result of ES&S's report on the freeze/shutdown issue, EAC began an informal inquiry into the nature and cause of the problem. ES&S has worked with EAC throughout the informal inquiry to provide all information necessary to fully understand the issue, including a detailed root cause analysis. ES&S's cooperation was vital to EAC understanding the cause of the freeze/shutdown and proposed solutions to the issue.

Since identifying the freeze/shutdown issue EAC identified two additional possible non-conformities. These non-conformities arose as result of information gathered during the informal inquiry and testing conducted on the DS200 to evaluate proposed solutions to the freeze/shutdown issue. ES&S is aware of these additional issues and worked with EAC to inform all DS200 users of the issues and workarounds for them. None of the issues identified are likely to have had an impact on the integrity or results of an election or to impact the integrity of future elections. They do, however, represent possible non-conformities to the Voluntary Voting System Guidelines (VVSG).

ES&S identified and submitted possible fixes for each of the issues identified in the summary below. These fixes are part of the Unity 3.2.1.0 certification effort currently under test at Wyle Laboratories. EAC will closely monitor the progress of this testing and understands that ES&S plans on upgrading all Unity 3.2.0.0 customers to Unity 3.2.1.0, should the system pass testing.

Scope of Investigation

The focus of the Investigation shall be the ES&S DS200 Precinct Count Optical Scanner (Firmware Version 1.3.10.0) contained in the ES&S Unity 3.2.0.0 EAC certified voting system. Specifically, the investigation will focus on the following possible non-conformities with the VVSG:

1. **Issue:** Freeze/shutdown. The DS200 initiates the shutdown process whereupon it will complete approximately 90% of the shutdown process and then freeze. The screen saver will initiate after the appropriate time has elapsed. The DS200 Unit will not accept ballots in the frozen state.

System Non-conformity:

2002 VSS Volume 1 Section 2.2.1 & 3.4.3

2.2.1.b – Provide system functions that are executable only in the intended manner and order, and only under the intended conditions

3.4.3 – Reliability: The reliability of voting system devices shall be measured as Mean Time Between Failure (MTBF) for the system submitted for testing. MTBF is defined as the value of the ratio of operating time to the number of failures which have occurred in the specified time interval. A typical system operations scenario consists of approx. 45 hours of equipment operation, consisting of 30 hours of equipment set-up and readiness testing and 15 hours of elections operations. For the purpose of demonstrating compliance with this requirement defined as any event which results in either the:

- *Loss of one or more functions*
- *Degradation of performance such that the device is unable to perform its intended function for longer than 10 seconds*

The MTBF demonstrated during certification testing shall be at least 163 hours.

2. **Issue:** Failure to log. Cuyahoga County election officials provided EAC the logs from their May 4 and August 8, 2010 elections. The May 4 election used over 1,000 DS200's; the August 8 election was smaller, providing logs from only 12 machines. Review of these records identified an additional issue. The freeze/shutdown issue does not result in any record of its occurrence in the system logs.

System Non-conformity:

2002 VSS Volume I 2.2.4.1 Integrity:

Integrity measures ensure the physical stability and function of the vote recording and counting processes.

To ensure system integrity, all systems shall:

- g. Record and report the date and time of normal and abnormal events.*
- i. Detect and record every event, including the occurrence of an error condition that the system cannot overcome, and time-dependent or programmed events that occur without the intervention of the voter or a polling place operator.*

3. **Issue:** Ballot Skew. When a 17" ballot is inserted incorrectly into the unit the lower left and right hand corners of the ballot are not accurately read.

System Non-conformity:

2002 VSS Volume I 2.2.2.1 Common Standards:

To ensure vote accuracy, all systems shall:

2.2.2.1.c – Record each vote precisely as indicated by the voter and be able to produce and accurate report of all votes cast.

4. **Issue:** Vote miscount. The DS200 accepts a voted ballot but does not record that ballot on its internal counter.

System Non-conformity:

2002 VSS Volume I 2.1.8 Ballot Counter:

For all voting systems, each piece of voting equipment that tabulates ballots shall provide a counter that:

- b. Records the number of ballots cast during a particular test cycle or election.*

Manufacturer Opportunity to Provide Information

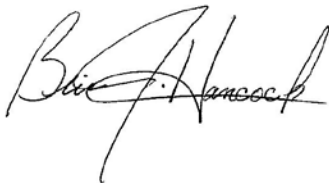
As stated in section 7.4.4.2 of the Certification Manual ES&S has the opportunity to provide any information it deems relevant to the scope of the investigation detailed above. ES&S is encouraged to provide any documents, testing data, or system specs it believes could help aid the EAC in making a determination. All information should be sent to the Program Director.

Estimated Timeline for Investigation

EAC estimates this investigation will take approximately 10 weeks to conduct. Several additional weeks may be necessary to compile the information and create the final report of investigation.

Conclusion

As you are aware, a formal investigation is concluded with the issuance of a formal report by the EAC. The purpose of the formal report is to document all relevant and reliable information gathered during the investigation and to document the conclusions reached by the Decision Authority. Per section 7.4.7 of the Certification Manual the Decision Authority can determine each allegation to be either substantiated or unsubstantiated. Please refer to section 7.0 of the Certification Manual for all of the details regarding the formal investigation, notices of non-compliance, and decertification. If you have any questions please do not hesitate to contact me.



Brian J. Hancock
Director
Testing & Certification Program
U.S. Election Assistance Commission

Appendix S - Interrogatory: iBeta Quality Assurance

EAC Request for Information 1-iBeta Quality Assurance

As a participant in the EAC Testing and Certification Program, ES&S is required to submit certain documentation regarding quality control to a VSTL prior to testing. The questions below refer to documents received prior to or during testing for the freeze/shutdown modification.

1. Please provide all documentation ES&S supplied to iBeta Quality Assurance relating to the testing ES&S conducted to diagnose and fix the freeze/shutdown issue, ballot skew issue, or ballot presentation issue. This documentation includes, but is not limited to: ES&S created test cases, test data and logs, notes from testing, and any evaluations or reports created pertaining to this testing.
2. Please provide all documentation ES&S submitted to iBeta related to Configuration Management review and verification ES&S conducted on the DS200 prior to submitting the fixes to the freeze/shutdown issue, ballot skew issue, or ballot presentation issue to iBeta. This documentation includes, but is not limited to: tracking logs, policy, notes and any evaluations or reports created pertaining to this process.
3. Please provide all documentation ES&S submitted to iBeta related to Quality Assurance process and verification ES&S conducted on the DS200 prior to submitting the fixes to the freeze/shutdown issue, ballot skew issue, or ballot presentation issue to iBeta. This documentation includes, but is not limited to: ES&S created test cases, test data and logs, notes from testing, information about personnel or consultants conducting the tests, and any evaluations or reports created pertaining to outcomes and results of this testing.

Appendix T - Interrogatory: Wyle Laboratories

EAC Request for Information 1-Wyle Laboratories

As a participant in the EAC Testing and Certification Program, ES&S is required to submit certain documentation regarding quality control to a VSTL prior to testing. The questions below refer to documents received prior to or during testing for the freeze/shutdown modification.

1. Please provide all documentation ES&S supplied to Wyle Laboratories relating to testing ES&S conducted to diagnose and fix the freeze/shutdown issue, ballot skew issue, or ballot presentation issue. This documentation includes, but is not limited to: ES&S created test cases, test data and logs, notes from testing, and any evaluations or reports created pertaining to this testing.
2. Please provide all documentation ES&S submitted to Wyle Laboratories related to Configuration Management review and verification ES&S conducted on the DS200 prior to submitting the fixes to the freeze/shutdown issue, ballot skew issue, ballot presentation issue, or accuracy issue to Wyle Laboratories. This documentation includes, but is not limited to: tracking logs, policy, notes and any evaluations or reports created pertaining to this process.
3. Please provide all documentation ES&S submitted to Wyle Laboratories related to Quality Assurance process and verification ES&S conducted on the DS200 prior to submitting the fixes to the freeze/shutdown issue, ballot skew issue, or ballot presentation issue to Wyle. This documentation includes, but is not limited to: ES&S created test cases, test data and logs, notes from testing, information about personnel or consultants conducting the tests, and any evaluations or reports created pertaining to outcomes and results of this testing.

Appendix U - Interrogatory: Cuyahoga County

EAC Request for Information 1-Cuyahoga County, OH

1. General Questions
 - 1.1 When did you perform Logic and Accuracy Testing?
 - 1.2 If testing occurred on more than one day, what date(s) did you experience the freeze/shutdown issue?
 - 1.3 Did you contact ES&S regarding the freeze/shutdown issue prior to the election? If so, when and what was their response?
 - 1.4 In your testimony to EAC, you stated you contacted other states regarding the issues with the DS200. Please identify the states contacted.

2. Number of machines affected by the issues outlined in the Scope of Investigation.
 - 2.1 What is the total number of DS200s that experienced the freeze or shutdown issue during Logic and Accuracy Testing conducted in preparation for the May 2010 Primary Election?
 - 2.2 What is the total number of DS200s that experienced the freeze or shutdown issue during the May 2010 Primary Election?
 - 2.3 How many machines did Cuyahoga County, OH send to ES&S in Omaha, NE for testing and diagnosis of the freeze or shutdown issue? Please provide documentation that demonstrates the chain of custody and/or inventory control of these machines.

3. ES&S notification to DS200 users regarding issues identified in Cuyahoga County.
 - 3.1 Please provide dates and copies of all notifications received from ES&S pertaining to the issues cited in the Scope of Investigation (attached).
 - 3.2 Please provide any other documents provided by ES&S related to the issues outlined in the Scope of Investigation or proposed solutions for those issues.
 - 3.3 Please provide documents pertaining to the identification and reporting of the ballot skew issue from Cuyahoga County, OH to ES&S.
 - 3.4 Please provide any communications sent from ES&S to Cuyahoga County regarding the ballot skew issue.

Appendix V - Interrogatory: ES&S

EAC Request for Information 1-ES&S

General

1. Please define the term “DS200.”
2. Please define the term “DS200(i).”
3. Describe the differences between the use of the terms “DS200” and the “DS200(i)” system.
4. Please provide any schematics or drawings of the DS200 that changed as a result of notification from jurisdictions experiencing the freeze/shutdown, ballot skew, ballot presentation, or accuracy issues.
5. Please provide documents relating to how ES&S was alerted to the ballot skew issue and the steps taken to resolve the issue.
6. Please provide information and documentation on how and when DS200 users were notified of the ballot skew issue.
7. Please provide any other documents, letters, testing, reports, notes, emails and any other information regarding the ballot skew issue.

Testing Conducted by ES&S

As a participant in the EAC Testing and Certification Program, ES&S is required to submit certain documentation regarding quality control to a VSTL prior to testing. The questions below refer to documents given to the VSTL prior to or during testing for the freeze/shutdown modification.

1. Quality Assurance
 - 1.1 Please provide all documentation related to Quality Assurance testing conducted on the DS200 by ES&S prior to submitting the fixes for all issues identified in the notice of formal investigation to iBeta and Wyle laboratories. This documentation includes, but is not limited to: ES&S created test cases, test data and logs, notes from testing, and any evaluations or reports created pertaining to this testing.
 - 1.2 Please provide information about ES&S personnel and contractors that participated in this process, including, but not limited to: name, title, date of employment, and any relevant technical expertise.
2. Configuration Management
 - 2.1 Please provide all documentation related to Configuration Management review and verification conducted on the DS200 by ES&S prior to submitting the fixes for all issues identified in the notice of formal investigation to iBeta and Wyle laboratories. This documentation includes, but is not limited to: tracking logs, policy, notes and any evaluations or reports created pertaining to this process.
 - 2.2 Please provide information about ES&S personnel and contractors that participated in this process, including, but not limited to: name, title, date of employment, and any relevant technical expertise.
3. Quality Conformance
 - 3.1 Please provide all documentation related to Quality Conformance procedures and verification conducted on the DS200 by ES&S prior to submitting the fixes for all issues identified in the notice of formal investigation to iBeta and Wyle laboratories. This documentation includes, but is not limited to: ES&S created test cases, test data and

logs, notes from testing, information about personnel or consultants conducting the tests, and any evaluations or reports created pertaining to outcomes and results of this testing.

- 3.2 Please provide information about ES&S personnel and contractors that participated in this process, including, but not limited to: name, title, date of employment, and any relevant technical expertise.
4. Issue Notification to System Users
 - 4.1 Please provide all documentation related to notification of DS200 users affected by the issues outlined in the Notice of Formal Investigation. Please include information regarding when the users were notified, how affected users were identified and all notification(s) sent to the users regarding these issues.
 - 4.2 Please provide information about ES&S personnel and contractors that participated in this process, including: name, title, date of employment, and any relevant technical expertise.
 - 4.3 Please provide any communications received from Counties experiencing the issues outlined in the Scope of Investigation. Provide all documents, correspondence and notices regarding these issues that were sent to Counties.

Appendix W - Expectations for Freeze Shutdown Testing



U. S. Election Assistance Commission
Voting System Testing and Certification Program
1201 New York Avenue, NW, Suite 300
Washington, DC. 20005

July 28, 2010

Carolyn Coggins
iBeta Quality Assurance
2675 South Abilene Street
Suite 300
Aurora, Colorado 80014

Sent via email

In an effort to expedite the testing process for the freeze/shutdown error, the EAC is providing the following expectations to iBeta. Please refer to the expectations listed below while developing the test plan and test cases.

1. iBeta will forward test plan and test cases to the EAC before testing begins, including;
 - a. Test plan/case to include all the mechanisms that will be used to collect and analyze the system performance, i.e. criteria for pass/fail, logs, reports, tally's etc.
 - b. Tests that are to determine if other side effects or impacts occur from changing the code and x windows.
2. iBeta will provide a minimum of one week notice of when testing will commence, in order to allow the EAC the opportunity to send one or more representatives to observe the tests.
3. iBeta will use the provided ES&S analysis to induce the freeze/shutdown on multiple DS200's when configured to the certified condition.
 - a. A baseline of the failure rate will be established
 - i. Statistics by unit
 - ii. Statistics by test run
 - iii. Compare to determine consistency with ES&S data
 - b. The process will be reviewed to see if the failure rate can be further optimized, so that it creates the symptom more predictably.
 - c. Determine if the failure frequency is adequate to determine if the new build eliminates the failure. Assess if the length of test, number of test cycles or other factors should be modified for the next test.
 - d. Data will be forwarded to the EAC at completion of this phase including: all the system logs, event logs, and system records by any other title or description
4. iBeta will use information from Step 3 of this document and the ES&S root cause analysis to design a test (plan, method, case, procedures, data sheets etc) that will

exercise the DS200 thoroughly enough to provide a high assurance that the test will detect any evidence of the issue or side effects of the new product configuration. The rationale as to why the extent of testing specified is adequate, is to be provided to the EAC in quantitative terms.

5. iBeta will provide all the system logs, event logs, and system records by any other title to the EAC upon completion of the testing.
6. iBeta will confirm that the fix conforms to the following requirements:
 - a. 2.1.1.b – Provide system functions that are executable only in the intended manner and order, and only under the intended conditions
 - b. 2.1.3 – Error Recovery
 - c. 2.1.4.g – Record and report the date and time of normal and abnormal event.
 - d. 2.1.4.i – Detect and record every event, including the occurrence of an error condition that the system cannot overcome, and time-dependent or programmed events that occur without the intervention of the voter or a polling place operator
 - e. 2.1.5.1 – Operational Requirements
 - f. 4.3.3 – Reliability
 - i. This test is to be run continuously for the 163 hours required.
 - g. 4.3.5 – Availability
 - i. The calculations will be provided for both before and after configurations.
7. iBeta will provide a break down of all changes identified to the source code from their independent review not from ES&S. (Run a dif)
8. iBeta will also check to see if a unit can remain operational for two hours on battery while performing normal user operations. This will confirm that the backlight being on continuously does not negatively impact the system.
9. If a test has questionable results or the pass/fail margin is small, further analysis (i.e. uncertainty of measurement) or additional testing may be required to provide adequate assurance of test results.

If you have any questions or need further information, please do not hesitate to contact me at your earliest convenience. I thank you in advance for your time and attention to this matter.

Sincerely,



Brian Hancock
Director of Voting System Testing and Certification

07/27/10
Date

Appendix X - iBeta VSTL Withdrawal Letter



November 29, 2010
Sent via email

Brian Hancock
Director of Voting System Testing & Certification
U.S. Election Assistance Commission
1201 New York Avenue, NW, Ste. 300
Washington, DC 20005

Dear Mr. Hancock,

As a result of the actions taken by the EAC on August 17, 2010 iBeta no longer finds it practical to continue operation as a VSTL. We therefore wish to serve notice of iBeta's intention to withdraw from the EAC's program on December 13th, fifteen calendar days from today (per section 2.7.1 of the Voting System Test Laboratory Program Manual).

NVLAP, Dominion Voting Systems, and Elections Systems and Software are being notified of this intention today.

Best regards,

A handwritten signature in blue ink, appearing to read "Earl Wing", with a long horizontal flourish extending to the right.

Earl Wing
Vice President & CFO
iBeta Quality Assurance
Earl@iBeta.com 303-627-1110 x143

cc: Matt Masterson, EAC
Copy to: Dominion- Ed Smith
ES&S- Steve Pearson & Sue McKay

attachment



November 29, 2010
Sent via email

Dana Leaman
National Voluntary Laboratory Accreditation Program
100 Bureau Drive
Gaithersburg, MD 20899

Dear Ms. Leaman,

iBeta has come to the conclusion that it is no longer practical to continue operations as an EAC Voting System Test Lab. iBeta has served notice to the EAC of their intention to withdraw from the EAC's program on December 13th, fifteen calendar days from today per section 2.7.1 of the EAC Voting System Test Laboratory Program Manual.

As a result of this conclusion iBeta has decided not to renew our NVLAP Voting System Testing Accreditation for 2011. We shall submit our request for voluntary termination and return our Certificate and Scope of Accreditation to NVLAP on December 30, 2010. At that time the NVLAP symbol shall be removed from our test documentation and advertising.

Please advise if NVLAP wishes to go forward with the audit scheduled for next week.

Best regards,

A handwritten signature in blue ink, appearing to read "Earl Wing", with a long horizontal flourish extending to the right.

Earl Wing
Vice President & CFO
iBeta Quality Assurance
Earl@iBeta.com 303-627-1110 x143

Copy to: Brian Hancock/EAC
Matt Masterson/EAC

Appendix Y - Approval to move Unity 3.2.1.0 to Wyle



U. S. ELECTION ASSISTANCE COMMISSION
VOTING SYSTEM TESTING AND CERTIFICATION PROGRAM
1201 New York Avenue, NW, Suite 300
Washington, DC. 20005

January 11, 2011

Steve M. Pearson
Vice President, Certification
Election Systems and Software (ES&S)
11208 John Galt Boulevard
Omaha, NE 68137

Dear Mr. Pearson,

We are in receipt of your December 17, 2010 letter (attached) regarding your request to change the lead Voting System Test Laboratory from iBeta Quality Assurance (iBeta) to Wyle Laboratories (Wyle) for the remainder of testing on Unity 3.2.1.0.

Section 4.3.1.2 of the EAC's *Voting System Testing and Certification Program Manual* allows the Program Director of the EAC to grant permission to a manufacturer to change VSTL's when good cause is shown for the change. This decision is at the sole discretion of the Program Director and is made after careful consideration of the facts leading to the request.

In this case, the decision by iBeta to discontinue operation as an EAC accredited voting system test laboratory absolutely required ES&S to choose another VSTL to complete testing of Unity 3.2.1.0. Given these facts I find that there is good cause to allow Election Systems & Software (ES&S) to change the lead VSTL. Your amended application for testing has been accepted and the testing record will reflect this change of VSTL.

Please be aware that per section 4.3.1.2. Wyle is now the lead VSTL responsible for the testing of the Unity 3.2.1.0 system and as such cannot be changed as the lead VSTL without the express written permission of the EAC Program Director.

Please let me know if you have any further questions. Thank you.

Sincerely,

A handwritten signature in black ink, appearing to read "Brian J. Hancock". The signature is fluid and cursive, with the first name "Brian" being the most prominent.

Brian J. Hancock
Director, Testing and Certification

Appendix Z - ES&S Response to Investigation



*Proprietary and Confidential
ES&S Company Information*

July 28, 2011

Mr. Brian Hancock
Director, Testing & Certification Program
US Election Assistance Commission
1201 New York Avenue, NW, Ste. 300
Washington, D.C. 20005

RE: Request for Information – Unity 3.2.0.0, 3.2.1.0, 3.3.0.0

Dear Mr. Hancock:

In reply to your July 19, 2011 request for information regarding the EAC's Notice of Formal Investigation concerning ES&S' Unity 3.2.0.0 voting system certified by the EAC on July 21, 2009, we provide the following information pertaining to ES&S Unity releases 3.2.0.0, 3.2.1.0, and 3.3.0.0:

1. ES&S DS200 scanning technology
2. Root cause analysis of Cuyahoga County Ohio acceptance test findings
3. Matrix outlining these findings with these respective Unity releases

Item 1 – ES&S DS200 Scanning Technology

1. Detailed description of the hardware
 - a. Ballot path and tolerances
 - b. Ballot detection sensor location
 - c. Motor stepping process
 - d. Imaging sensor scan rates and dpi
2. Detailed description of how the ballot is interpreted by the software
 - a. Type of scan
 - a. Infrared
 - b. Digital
 - b. Mark recognition
 - c. Target area locating
 - d. Ballot skew detection feature

"Maintaining Voter Confidence. Enhancing the Voting Experience."

The DS200 is a digital scanner that utilizes bitonal imaging technology. It scans at a rate of 200 pixels per inch with a dpi of 200 (200 x 200) using an ES&S patented intelligent mark recognition algorithm. The scanner utilizes contact image sensor technology to create a digitized pixilated image of the ballot. Using the ballot channel markings (column, code channel and timing channel marks) the orientation of the ballot images is first determined. The DS200 then determines vote mark evaluation areas (cell areas or windows) at the intersections of each of the 6 column channels (three on each side of the ballot) and timing marks based on ballot layout definition data. Figure 1 represents a pixilated view of a mark evaluation cell window typical when an unmarked oval is scanned. This entire rectangular area is used and evaluated by the DS200 in the mark analysis.

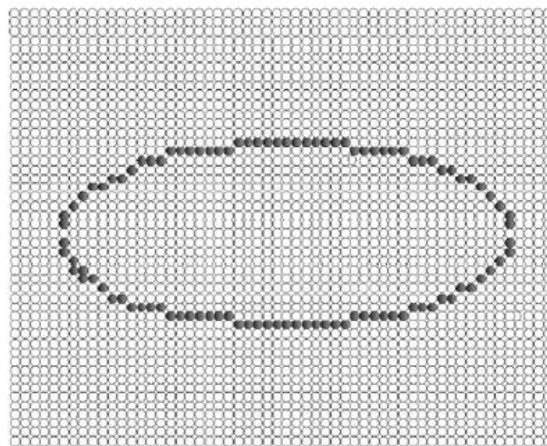


Figure 1 - Mark Evaluation Cell Window

The system is designed to accommodate a number of characteristics inherent with this type of technology and meet the accuracy requirements of the FEC 2002 Voting System Standard (VSS). Some of these characteristics include imperfect digital ballot printing, manufacturing sensor mounting variances, ballot wear, paper variances, and the need for a slightly larger ballot path (than the physical ballot) for ease of insertion that results in a slight measure of ballot skew.

Because of these variables the oval evaluation cell window may not always be centered fully on or around the oval, and could be shifted left, right, up or down as much as 10 pixels off of center, especially in the vertical dimension or y-axis. Therefore, the evaluation cell window is designed to be sufficiently larger than the oval to ensure a valid mark within the oval area will be consistently detected even with maximum shift. Figure 2 illustrates an evaluation cell window where the oval appears shifted off of center, slightly toward the upper region of the cell window.

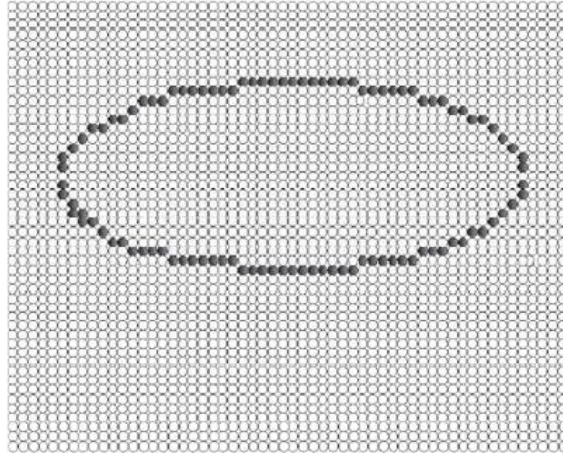


Figure 2 – Mark Evaluation Cell Window with Oval Shifting

DS200 Mark Recognition Design:

1. Marks within oval area – Within the oval area, the DS200 will consistently read and accurately count all valid vote marks.
2. Marks outside evaluation cell window – Outside of the evaluation cell window, the DS200 will consistently disregard all marks.

Attachments have been provided describe the DS200 ballot path tolerances and sensor locations.

Item 2 – Root Cause Analysis of Cuyahoga County Ohio Acceptance Test Findings

During acceptance testing in Cuyahoga County, Ohio, county workers reported the items listed below. All issues were reported while the DS200s were running firmware v1.4.3.11 certified with Unity 3.2.1.0.

- DS200 units with unresponsive touch screens
- Skewed ballot image
- DS200 spontaneously activation

DS200 Units with Unresponsive Touch Screens

Background

During acceptance testing of Unity 3.2.1.0, Cuyahoga County staff members reported a number of DS200 units appeared to be freezing during their pre-test calibration process. For these units, ES&S personnel on site copied the contents of internal compact flash cards from machines with unresponsive touch screens and sent the data to Omaha for inspection.

Analysis of the images from the cards revealed one of the three file system partitions was full and that the file responsible for filling it up was a low-level Linux operating system file named sys.log used in prior system troubleshooting. (*Note - This file was introduced as one of the tools used to aid in the analysis of the freeze/lockup issue experienced with DS200 v1.3.10.0 that was certified by the EAC with Unity 3.2.0.0 on July 21, 2009.*) The partition that filled up is a 42MB file system partition on the CF card and is the same partition that holds the touch screen calibration data for the DS200. The touch screen needs the data in the calibration to operate properly.

Further investigation revealed that when the system runs without a USB stick (contains the election definition) in a slot under the front door, this log fills up quickly and consequently fills up the partition. Once the partition is full, the system's ability to retrieve the calibration data is compromised and the touch screen becomes unresponsive. It was this circumstance that lead Cuyahoga County to be concerned that the freeze/lockup condition was not fully solved with the newer firmware release.

The Linux operating system has a logging service utility named syslog that is configured with an OS file named syslog.conf. ES&S engineers used this utility to direct and store a lot of activity associated with detecting a USB stick in the file named sys.log as part of the original freeze/lockup analysis. The problem is that the developers did not limit the eventual size of the file as it grows as it was never intended to be a permanent file in the system.

Resolution

The use of the Linux sys.log was only introduced in DS200 v1.4.3.11 and certified by the EAC with Unity 3.2.1.0 on March 29, 2001.

To resolve the condition requires a modification to two configuration files, *xinitrc_dc* and *syslog.conf*, to eliminate the creation and use of the sys.log file and a rebuild of the DS200 system

firmware. No changes are required to the application firmware and all other event and audit logging required by the VSS and VVSG remain unaffected and in place.

Removal of this file is not a violation of either the VSS or VVSG standards nor a concern to ES&S as the information captured in this file during the freeze/lockup analysis had minimal value and there is sufficient other low-level data captured elsewhere in the system for diagnostics and troubleshooting.

Applications for certification were submitted to your office for Unity 3.2.0.0 Rev 2, Unity 3.2.1.0 Rev 1, and Unity 3.3.0.0 on July 21st and 22nd to include these changes in the creation of DS200 v1.4.3.12 for use with those systems. In addition these same modifications are being incorporated into Unity 3.4.0.0, as well. Application for certification of Unity 3.4.0.0 was submitted to your office also on July 21, 2011. It is our desire to proceed with Wyle Laboratories in the assessment of this modification.

Ballot Skew Image

Background

Also during acceptance testing of Unity 3.2.1.0 in Cuyahoga County, there was an occurrence of a skewed ballot image that resulted in a missing mark on one ballot style in one precinct and on one DS200 unit. Cuyahoga County uses county staff and contract temps to perform their acceptance testing in a warehouse environment. The test involved 1,091 single and two-page 17" ballot styles (w/splits) and 1,068 DS200 units. The number of scans per precinct varied due to rotation rules, but in excess of 6,000 ballots were scanned during the acceptance test.

Verification of results in ERM later identified the unexpected result in question. Cuyahoga and ES&S onsite personnel were able then to determine the polling location and isolate the precinct and DS200 unit that produced the missing mark. It was determined the missing mark was from the bottom row of column D (backside, bottom left corner) of the ballot. The election definition and some sample ballots were delivered to ES&S' Omaha office for further analysis. Immediately, a test team of ten (10) ES&S experts was assembled in Omaha consisting of DS200 hardware and software engineers, quality assurance testers, and certification specialists to perform a series of volume tests designed specifically for ballot skew and mark detection to provide additional input into the possible cause of the Cuyahoga anomaly.

Cuyahoga staff then attempted to recreate the anomaly using the same ballot test deck, same election definition, on the same DS200 unit unsuccessfully. The Cuyahoga staff then performed the same test with the original test deck and original election definition on a different DS200 and again was not able to recreate the original reported anomaly.

ES&S onsite representatives were then granted permission by the Director of the Cuyahoga County Board of Elections to conduct their own set of tests using the same ballot test deck and election definition on the same DS200 unit, only to have the same unsuccessful results as the Cuyahoga test team in recreating the missing mark. All onsite tests by County and ES&S personnel on properly configured DS200 units subsequent to the initial finding were completed with 100% accuracy.

The ES&S onsite implementation team then continued their testing with the same test deck on the same DS200, but with the ballot guide from the ballot input tray on the DS200 removed from the unit. This guide, when properly in place, ensures ballots are inserted properly and within the skew tolerances of the system. Using this technique, the ES&S onsite team was able to recreate the anomaly reported by the Cuyahoga, as was the Omaha test team in separate lab tests. It was only when a machine was used in this manner that the test teams were able to recreate the anomaly. Examination of the graphical ballot images from these tests had a higher degree of vertical skew than images from a properly configured machine. These new images added a new dimension of skew that resemble more of a trapezoid representation where the ballot image was longer on one side than the other.

The ES&S Omaha test team continued with their own investigative and validation testing on ten (10) properly configured (ballot guide securely in place) DS200 units using specifically designed 14", 17", and 19" double-sided ballots laid out in a manner to stress test the corner oval positions for each ballot size. Ten test decks of 400 ballots each with marked ovals in the bottom code channel for columns A, C, D, and F were run on each DS200 test unit with the sole purpose of trying to recreate the Cuyahoga anomaly over several days by the Omaha test team. Every ballot was purposely inserted in a skewed manner. Getting the DS200 to accept and tabulate 4,000 ballots inserted in a skewed manner required feed attempts 2-3 times for each accepted ballot. A total of 12,000 ballots were run in this fashion with 100% accuracy. Attached are copies of the ES&S Test Cases for the 14", 17", and 19" skew and accuracy test along with the PDF's for each ballot style used in the test.

Conclusion

ES&S cannot confirm or deny the DS200 ballot guide was properly snapped into place at the time the anomaly occurred though the customer has stated it was.

The DS200 does use a vertical skew correction scheme but it was not designed nor tested to handle ballots fed without the ballot guide in place. In the case of a severely skewed ballot image, the compensation routine does not adjust the data such that the oval registers in the area the image processor expects it to exist. It was not showing up in what is referred to as the evaluation cell window. The evaluation cell window is the area of the image in which the image processor looks for a mark.

ES&S engineers use an in-house tool to inspect and visualize the data at different stages of processing and confirmed that the actual ovals are not "adjusted" into the cell window in cases of severe vertical skew.

It should also be noted that this Cuyahoga skew report is different than the skew issue reported by Cuyahoga County in 2009. That particular case involved skew adjustments along the horizontal axis and was corrected in the newer versions of DS200 firmware, including v1.4.3.11 certified with the Unity 3.2.1.0 release.

ES&S takes all reports from our customers very seriously including this anomaly experienced by Cuyahoga County. Immediate and extensive steps were taken to investigate this matter. Tens of thousands of ballots have been scanned in the weeks following Cuyahoga's acceptance testing by multiple test teams with the sole purpose of creating a missing mark. The test results all

demonstrated 100% accuracy. When a DS200 is operated in its certified configuration with the ballot guide snapped firmly in place, test results have shown DS200 v1.4.3.11 meets all accuracy requirements.

The result of the investigative testing performed both by the Cuyahoga acceptance test team and the ES&S test teams provide further confirmation that DS200 v1.4.3.11 which underwent in excess of one year extensive VSTL testing by two EAC accredited VSTL labs under the oversight of the EAC, conforms to the accuracy requirements of the FEC 2002 VSS as certified by the EAC on March 29, 2011. ES&S believes that the DS200 is compliant and accurate and meets all standards without modification.

DS200 Report of Spontaneous Activation

Background

During a phone conversation between ES&S and the Cuyahoga County Election office, members of the Cuyahoga office reported occurrences of DS200 systems spontaneously activating/powering on from a powered off state.

We are not aware of any ES&S personnel ever witnessing unsolicited powering on of a DS200 unit, but we believe there may be scenarios that could explain why Cuyahoga would make this statement.

Conclusion

Regardless if the machine is on or off, opening the lid causes it to boot up automatically. If the machine is on, closing the lid will cause it to power down in 5 minutes. It beeps occasionally during this 5 minute period to alert the user that something is happening.

There is another situation customers need to be aware of. Assuming the machine is off, if the last user does not lock the lid in the down position, there is slight chance that during transport or an inadvertent bump, it can open just enough to begin the boot process. The lid needs to be raised only approximately 1 inch to activate the system. If the lid is slightly raised and then "dropped" back into the closed position, the DS200 will boot and then immediately begin the 5 minute auto shutdown procedure. In other words, even if the machine was accidentally started, it will automatically turn itself off after 5 minutes.

ES&S will continue to monitor Cuyahoga's reports and be sure to instruct our customers of the activation process for the DS200 system.

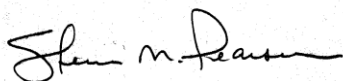
Item 3 – Matrix outlining these findings with these respective Unity releases

The following table provides a complete representation of Unity releases either certified or in progress under the EAC Program and any outstanding respective known issues.

Unity Release	EAC Status	Outstanding Issues
3.2.0.0	Certified 7/21/09	Under EAC investigation for freeze/shutdown, failure to log freeze/shutdown condition, ballot skew, and ballot counter. DS200 sys.log not present. No other known issues.
3.2.0.0 Rev 1	Certified 10/8/10	DS200 sys.log file not present. Corrected ballot skew with 3.2.0.0. Known issues include freeze/shutdown, failure to log freeze/shutdown condition, and ballot counter. No other known issues.
3.2.0.0 Rev 2	Revised Application submitted 7/22/11	Revised application submitted to substitute DS200 v1.4.3.11 with v1.4.3.12. This release provides cure for all EAC item of formal investigation and sys.log removal.
3.2.1.0	Certified 3/29/11	DS200 sys.log introduced. No customer deployments. Known issue with sys.log/screen calibration settings.
3.2.1.0 Rev 1	New EAC Application submitted 7/22/11	New application submitted for modification to remove DS200 sys.log. No application firmware changes required.
3.3.0.0	VSTL testing in progress. Revised EAC application submitted 7/21/11	Revised application submitted to replace DS200 v1.4.3.11 with v1.4.3.12 for DS200 sys.log removal. No DS200 application firmware changes required. No known issues.
3.4.0.0	New EAC Application submitted 7/22/11	New application. No DS200 sys.log. No known issues.

Please feel free to contact me at any time if you have questions regarding the material provided with this response.

Sincerely,



Steve M. Pearson
 Vice President, Certification
 Election Systems & Software, Inc.

cc: Kathy Rogers, SVP Government Relations
 Sue L. McKay, Director of Certification

Attachments:

- | | |
|---------------------------|--------------------------------|
| DS200 Paper Path.pdf | T19DS200_MARKED.pdf |
| DS200 Sensor Layout.pdf | DS200 Testing 14 Ballot TC.pdf |
| DS200 Sensor Functino.pdf | DS200 Testing 17 Ballot TC.pdf |
| T14DS200_MARKED.pdf | DS200 Testing 19 Ballot TC.pdf |
| T17DS200_MARKED.pdf | |

Appendix AA - Cuyahoga 3.2.1.0 Upgrade Checklist

PLACE TEAM LABELS HERE

PRINT NAMES – Democrat: _____

Republican: _____

**DS200 Post Upgrade Acceptance & IV&V Testing Checklist
Acceptance & IV&V Testing for the ES&S DS200 Precinct Optical Scanner**

Precinct Assigned: Back-up1

TC Number: TC2002

Serial Number: ES0108370095

Comments:

EΣ0108370095

If at any time an operator experiences ANYTHING unexpected, it MUST be recorded in the space provided above. The importance of recording these incidents cannot be overstated.

- Write your **Names** and **TC Number**, which are found on the inside of the lid of your DS200, in the space provided above.
- Apply your team sticker in the box marked "PLACE TEAM STICKER HERE."
- Verify TC Number on DS200 unit matches TC Number on Lid behind DS200 unit.
- Insert each memory stick with the label side facing to the right in Port "B." Make sure the precinct on the memory stick matches the precinct labels on the front and top of the scanner.
- Press the "**Power**" button. Each DS200 will take approximately two minutes to boot.
- While booting, a grey screen with an "X" will appear, press "**Close Polls**" button next to the power button.
- When white calibration screen appears, tap the "**O**" in the top left corner and then bottom right corner of screen.
- Once "Recalibrate / Save & Exit" appears, tap screen to verify the pointer moves where your finger touches.
- If correct, continue by pressing "**Save & Exit**" and Initial State Report will print automatically.
 - o If incorrect, press "Recalibrate" and repeat above step.
- Verify and circle on Initial State Report proper
 - "**DS200 Firmware Version**" **1.4.3.11**
 - "**Power Management Firmware Version**" **1.2.0.1**
 - "**Scanner Firmware Version**" **2.21.0.0**
- Once ready, the DS200 screen will display "Election Definition Found." If you do not see this screen once the system is ready, notify a Supervisor immediately.
- Press the "**↻**" located on the bottom right side of the DS200 screen.
- Press the "**Go To Admin**" button. Enter the correct password. Press "**Enter**."
- Screen will show "Administration Menu." Press "**System Settings**."
- Record time found on DS200:** _____. **Was the time correct? Yes / NO** **Record Difference:** _____

If time is off by more than two minutes use the following steps to change the time otherwise it is considered acceptable.

- o Press the "**↻**" located on the bottom right side of the DS200 screen.
- o Press the "**Go to Admin**" button. Enter the correct password. Press "**ENTER**."
- o Screen will show "Administration Mode." Press "**SYSTEM SETTINGS**."
- o Press "**DATE & TIME**."
- o Time Zone – **Make sure EST5EDT is always selected in the dropdown provided**
- o **If the Time Zone is incorrect, this must be the first correction made prior to making any other changes.**
- o Year - Month - Date
- o Time – **(Time Format must be 12 hour and set off the master digital clock.)**

Note: Each DS200 will shut off and re-boot when the Time Zone has been changed from certain zones.

- o If additional information in the Date & Time setting is incorrect, press the "**CLEAR**" button on the DS200 screen then make the necessary changes. Enter all changes on the screen or keypad provided. Press "**Previous**" button.
- o Once changes have been made, press "**ACCEPT NEW TIME**."
- o Verify the Date & Time are correct on the DS200 status bar. If not, go back to make necessary corrections.

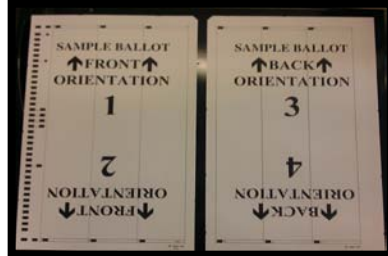
Both Team Members must initial that Date and Time are correct. R: _____ D: _____

- Screen will show "System Settings." Press "**Top CIS Threshold**" Button.
 - o Clear and then input 140 and select ENTER
- Screen will show "System Settings." Press "**Bottom CIS Threshold**" Button.
 - o Clear and then input 140 and select ENTER
- Screen will show "System Settings." Press "**Previous**" Button.
- Screen will show "Administration Menu." Press "**Previous**" Button.
- Screen will show "Election Definition Found." Press "**Open Polls**."
- A Zero Results report will print. Confirm that all results are "0."



- Ensure all status bar icons are accurately marked as pictured.
- Take Overvoted & Blank ballots and stack them together, insert both ballots, screen will show "Alert! There is an issue with your ballot." Press "**Continue in English.**" Once continue has been pressed screen will show "Ballot Read Error, Multiple Ballots Detected (119)." Remove the ballot from the DS200.
- Separate Overvoted and Blank ballots. Insert Overvoted ballot, screen will show "Alert! There is an issue with your ballot." Press "**Continue in English.**" Once continue has been pressed screen will show "You have made too many votes in # contests!" Press "**Correct Your Ballot.**"
- Reinsert Overvoted ballot this time selecting "**Continúe en Español.**" Once continue has been pressed, press "**Emitir su boleta con errores**" to accept the ballot.
- Insert Blank ballot, screen will show "¡Atención! Hay un problema con su boleta electoral." Press "**Continúe en Español.**" Once continue has been pressed screen will show "No se detectaron votos en la boleta electoral." Press "**Regresar.**" This will release the ballot.
- Reinsert Blank ballot, this time selecting "**Continue in English.**" Once continue has been pressed, press "**Accept**" to accept the ballot.

- Once Overvoted and Blank ballots have been run, Insert a ballot in *Orientation 1.*
- Insert a ballot in *Orientation 2.*
- Insert a ballot in *Orientation 3.*
- Insert a ballot in *Orientation 4.*



- After scanning all ballots in the deck, ensure that the on-screen counter indicates the correct number of ballots scanned. Write the **Public Count:**_____

- Press the "**Close Polls**" white button. Press "**Cancel Printing.**" Press "**Yes**" to Cancel Printing.
- Press "**Results Report.**" (Let the entire Report Print)
- Remove the scanned ballots from the ballot compartment at the bottom of the ballot box.
- Screen will show "POLLS CLOSED."
- Remove the memory stick and place it in the location's zip-loc bag and place the ballots in the location box. Continue until the entire polling location is complete.
- Screen will show "Election Definition Not Found." Press "**Shutdown**" button.
- Both team members sign the bottom of the DS200 Post Firmware Upgrade test checklist.
- Staple the DS200 results report from each unit to the back of the corresponding checklist.
- Apply an "ACCEPTED" sticker to the top right area of the unit's lid near the pre-existing dots.
- Take the test ballots in the completed location's box and move them to the completed shelves in the tabulation area.
- Take to the Drop Off Area: **1)** Memory sticks in plastic bag by location **2)** Check Lists (*with team stickers*) **3)** Expected Results
 - o The Upload Team & Verification team will ensure that your results are correct.
 - o All sticks will be kept in the tabulation area to further test the upgraded server stations.
- Verification team should check "Unit PASSED Testing" or "Unit FAILED Testing. NOTIFY SUPERVISOR IMMEDIATELY."

Democrat Signature: _____ Date: _____

Republican Signature: _____ Date: _____

Unit PASSED Testing

Unit FAILED Testing. NOTIFY SUPERVISOR IMMEDIATELY