2.02 - Democracy Suite® System Overview

Version: 4.19::323

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NOTICE OF CONFIDENTIALITY AND NONDISCLOSURE

RELEVANT DISCLAIMERS

Please be advised that this document may make reference to the following Democracy Suite® functionalities:

- EMS Enterprise configuration
- Election Data Exchange Station (EDES)
- Rank Choice Voting (RCV)
- Recall Issues
- Mode 2 asymmetric cryptography
- Mode 3 asymmetric cryptography
- NYS General and Primary Ballot Template
- Ballot Marking Device (BMD)
- Modem and transmission functionality
- AIMS Data Translator
- WinEDS Importer
- ImageCast Listener

These functionalities are not components of the current Democracy Suite® 4.19 certification campaign, and should be disregarded throughout the document.

Revision History

Allowed Authors (alphabetical)

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VVSG Trace Listing

Chapter 1

Introduction

Dominion Voting Systems' Democracy Suite® 4.14D platform expands on the following EAC-certified components from the Democracy Suite® 4.14B platform. Each component's upgrades are discussed in further detail within *2.13 - Democracy Suite® System Change Notes*:

- The Democracy Suite® Election Management System (EMS) software platform

- The Democracy Suite® ImageCast® Precinct optical ballot counter

- The Democracy Suite® ImageCast® Evolution optical ballot counter

- The Democracy Suite® ImageCast® Central optical ballot counter

- The Democracy Suite® ImageCast® X ballot marking platform

The Dominion Democracy Suite® Election Management System (EMS) represents a set of N-Tier software applications for pre-voting and post-voting election project activities that are applicable to jurisdictions of various sizes and geo-political complexities. The Democracy Suite® EMS platform is available in three hardware configurations ranging from a single PC/laptop configuration, to single and dual server hardware configurations.

The ImageCast® Precinct Ballot Counter is a precinct-based optical scan ballot tabulator that is used in conjunction with ImageCast compatible ballot storage boxes. The system is designed to scan marked paper ballots, interpret voter marks on the paper ballot, and safely store and tabulate each vote from each paper ballot. The ImageCast® Precinct also supports enhanced accessibility voting through optional accessories connected to the ImageCast® unit.

The Dominion Democracy Suite® ImageCast® Evolution system employs a precinct-level optical scan ballot counter (tabulator) in conjunction with an external ballot box. This tabulator is designed to mark and/or scan paper ballots, interpret voting marks, communicate these interpretations back to the voter (either visually through the integrated LCD display or audibly via integrated headphones), and upon the voter's acceptance, deposit the ballots into the secure ballot box. The unit also features an Audio Tactile Interface (ATI) which permits voters who cannot negotiate a paper ballot to generate a synchronously human and machine-readable ballot from elector-input vote selections.

The Dominion Democracy Suite® ImageCast® Central system consists of a central, high-speed, optical scan ballot counter (tabulator) called the ImageCast® Central Ballot Counter and is used for processing

absentee ballots (such as vote by mail). This ballot counter unit is based on COTS hardware coupled with custom-made ballot processing application software. It is used for high-speed, accurate and reliable centralized scanning and counting of paper ballots.

The Democracy Suite® ImageCast® X ballot marking platform is a solution that is used for creation of paper Electronic Mobile Ballots. These ballots are later scanned and tabulated by The Democracy Suite® ImageCast® Central optical ballot counter. The ImageCast® X also supports enhanced accessibility voting through optional accessories connected to the ImageCast® X unit.

1.1 Document Use

This document is intended for use with the Democracy Suite® 4.14 platform.

1.2 Purpose and Scope

This document overviews the Democracy Suite® system and does not cover detailed system functional characteristics, design, security and test specifications, or operation procedures of the Democracy Suite® components.

1.3 Document Organization

This document is organized as follows:

- Chapter 1 (*Purpose and Scope*): Provides introductory information about the new Democracy Suite® 4.14 system, as well as a list of applicable specification documents contained within the TDP.

- Chapter 2 (*System Overview*): Provides a summary of the primary components and features of the system. It also includes descriptions of the logical and physical deployment scenarios of the Democracy Suite® 4.14 system.

- Chapter 3 (*Operational Environment*): Identifies all hardware and software products and communication services used in the operation of the Democracy Suite® 4.14 system.

- Chapter 4 (*Internal and External Interfaces*): Provides a description of logical and physical interfaces, as well as interfaces among external and internal components of the system. In addition, this section provides a benchmark directory listing of all files delivered within a single release of the Democracy Suite® 4.14 system.

- Chapter 5 (*System Performance*): Includes an overview of the performance, quality, and security metrics for the system, with additional emphasis on system constraints.

1.4 Design Responsibility

Dominion Voting is the design authority

1.5 Document Status

This is a working specification for discussion and analysis. Details are subject to change.

1.6 Patent Status

Certain system concepts, as well as many implementation and construction details, are protected by a series of U.S. and foreign patents pending.

Chapter 2

System Overview

2.1 Democracy Suite® Overview

The primary function of the Democracy Suite® set of products and solutions is to help election organizations, their officials, and designees define and organize elections. Figure 2.1 illustrates Democracy Suite® components and their relationships.
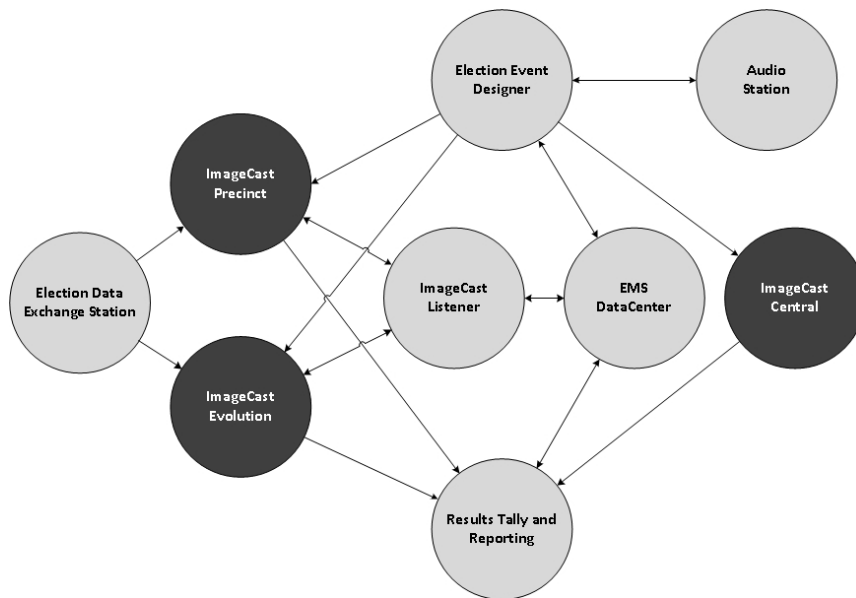
Figure 2.1: The Democracy Suite® Components

The functions provided by Democracy Suite® for achieving these tasks can be grouped into the following main activities and activity groups:

- Pre-Voting Activities:

  - Definition of political divisioning, hierarchical structure, attributes, and associations.
  - Definition of election events along with associated attributes such as election name, date, type, contests, candidates, questions/measures, voting locations, etc.
  - Design, preparation and production of paper and AVS (Accessible Voting Session) ballots for polling place and absentee voting.
  - Configuration and programming of the Dominion ImageCast® series of Precinct and Central ballot counters and ImageCast® X ballot marking sets
  - Creation of auditing, election definition, and system level reports.
  - Support of administrative functions for database, user, networking, and system management.

- Voting - Polling Place Voting:

  - Secure administration and deployment of precinct-level optical tabulation devices.
  - Secure administration and deployment of ImageCast® X ballot marking sets, zero tape printing, opening of polls.
  - Configuration of tabulators, zero tape printing, opening of polls.
  - Allowing voters to cast their paper ballots using optical tabulators.
  - Allowing voters to mark and print their Electronic Mobile Ballots using ImageCast® X .
  - Allowing running standard and accessible voting session in parallel when secondary COTS-based USB 2.0 to VGA monitor is connected.
  - Second-chance review using the integrated ballot review functionality.
  - Providing a usable and practical voting interface to voters with disabilities.
  - Separation of paper ballots (depending on pre-defined criteria) into separate ballot box compartments.
  - Secure tabulation, storage, and reporting of election results for a given polling station.
  - Printing of precinct-level reports and consolidated results at the polling station.
  - Closing of the polling place.

- Voting - Absentee (remote) Voting:

  - Receiving, unpacking and verifying absentee ballots.
  - Secure administration and deployment of central optical tabulation devices.
  - Configuration of device and network communication settings.
  - Scheduling of ballots for processing using the ImageCast® Central optical scanner.
  - Scanning of ballots in batches followed by the uploading of scanned ballot images and election results to the ICA system
  - Closure of the central e-Counting session and creation of applicable reports.

- Post-Voting Activities:

  - Adjudication of vote results

- Acquisition, import or manual data entry of election results from the ImageCast® series of tabulation devices.

- Preview and validation of election results.

- Creation of election results according to voting variations and election system rules.

- Generation of election result reports in the desired format.

- Publication of unofficial election results for further processing or reporting (i.e. news and media feeds).

- Generation of artifacts for use in canvassing, recounts or election audits.

2.2 The Democracy Suite® Election Management System (EMS)

The Democracy Suite® Election Management System (EMS) set of applications are responsible for all pre-voting and post-voting groups of activities in the process of defining and managing elections. The complete EMS software platform consists of client (end-user) and server (back-end) applications as follows:

- EMS Adjudication: Represents the server and client components responsible for adjudication, including reporting and generation of adjudicated result files from ImageCast® Central tabulators.

- EMS Adjudication Service server application: Represents a server side application which provides ballot information such as contests, candidates and their coordinates from EMS to the Adjudication application.

- EMS AIMS Data Translator: End-user application that transfers election definitions from Democracy Suite to EMS to AIMS, enabling users to program AutoMARK® devices for ImageCast® ballots.

- EMS Application Server server application: Represents a server side application responsible for executing long running processes, such as rendering ballots, generating audio files and election files, etc.

- EMS Audio Studio client application: Represents an end-user helper application used to record audio files for a given election project. As such, it is utilized during the pre-voting phase of the election cycle.

- EMS Data Center Manager server application: Represents a system level configuration application used in EMS back-end data center configuration.

- EMS Database Server: Represents a server side RDBMS repository of the election project database which holds all the election project data, including pre-voting and post-voting data.

- EMS Election Data Exchange Station (EDES) client application: Represents an end-user helper application used to program the memory cards and iButton security keys required to properly operate the ImageCast® series of counting devices. As such, it is utilized during the pre-voting phase of 5the election cycle.

- EMS Election Data Translator client application: Represents an end-user application used to export election data from election project and import election data into election project.

- EMS Election Event Designer client application: Integrates election definition functionality together with ballot styling capabilities and represents a main pre-voting phase end-user application.

- EMS File System Service client application: A stand-alone service that runs on client machines, enabling access to low level operating system API for partitioning CF cards, reading raw partition on ICP CF card, etc.

- ImageCast® Listener Server: Represents a set of server and client components, responsible for the authentication, verification and validation of the results transmitted via wireless for both ImageCast® Precinct and ImageCast® Evolution tabulators during the election.

- EMS NAS Server: Represents a server side file repository of the election project file based artifacts, such as ballots, audio files, reports, log files, election files, etc.

- EMS Result Receiver Host server application: Represents a server side application used to check status of the client RTM applications. It is only installed for jurisdictions utilizing remote results transmission.

- EMS Results Tally and Reporting client application: Integrates election results acquisition, validation, tabulation, reporting, and publishing capabilities and represents a main post-voting phase end-user application.

- EMS Result Transfer Manager client application: Represents a stand-alone application used to transfer result files from the remote locations to one or more central locations where the results can be tallied and reported on.

- EMS Service server application: Represents a server side application used to collect result data from ICPs and RTM applications and to store them to the database.

Figure 2.2 shows a simplified, high-level logical block diagram of the Democracy Suite® system. The diagram includes EMS software components as well as the Dominion ImageCast® series of ballot marking and counting devices. The diagram also contains election domain stakeholders, such as election administrative personnel and voters.

Figure 2.2: The Democracy Suite® High-level Block Diagram

As shown in Figure 2.2, election administrative officers and their designees use the Democracy Suite®
EMS EED client application to define election projects. Through this process, election definition data
can be typed in or imported from external sources. After election data is defined, the system also allows
users to define ballot styling parameters and record/synthesize the corresponding audio files. Users can
either utilize the audio synthesis capabilities of the EMS platform, or the audio recording capabilities
of the EMS Audio Studio client application to perform this process. As a primary output, this process
provides ready to print ballot artwork, and if configured to do so, electronic ballots and audio files for
AVS (Accessible Voting Session) voting.

The last step in election project definition is the generation of election definition and device behavioural
and configuration files. This process analyzes the correlation between voting locations, geo-political di-
visioning, and all election event related data, such as ballots, contests, and candidates. In doing so,
it creates a set of files for each instance of the ImageCast® device. These files are used to program
memory cards and iButton security keys for a particular election event. The EMS EED application
provides integrated memory card and iButton security key programming functionality. This integrated
programming allows for one card/key to be programmed at a time. Alternatively, jurisdictions can use
the EMS EDES application and programming station which programs up to twenty memory cards at a
time.

Before produced ballots, memory cards, and iButton security keys are used, the jurisdictions are required
to perform logic and accuracy testing to confirm that the system is ready for election day deployment.
On election day, jurisdictions can use ImageCast® Evolution or ImageCast® Precinct for polling place
voting or ImageCast® Central ballot counters for central site processing of absentee, early voting, or
vote-by-mail ballots.

No matter which ImageCast® tabulator is used to count ballots, each is designed to provide a set of
results files, log files, and scanned ballot images. These files are acquired by the EMS RTR client appli-
cation. This application is used to validate, tally, report and publish election results.[1]

Additionally, ImageCast® Central tabulator results may be processed through the EMS Adjudication
system. This processing happens prior to importing results into the EMS RTR client. EMS Adjudication
updates both result files and ballot images to reflect actions taken by election officials. The EMS
Adjudication system provides its own summary and activity reporting in addition to that provided by
the EMS RTR client.

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[1]EMS utilizes commercial off the shelf laser printers compatible with the Microsoft Windows operating system capable
of producing the full range of alphanumeric characters to properly print audit entries as well as election, office, and issue
headers and labels.

2.3   The ImageCast® Precinct Ballot Counter

The ImageCast® Precinct Ballot Counter device is a precinct optical scan ballot counter (also commonly referred to as a tabulator in the election industry) (see Figure 2.3). It is designed to provide three major functionalities:

- Ballot scanning and tabulation

- Accessible voting

- Ballot review and second chance voting
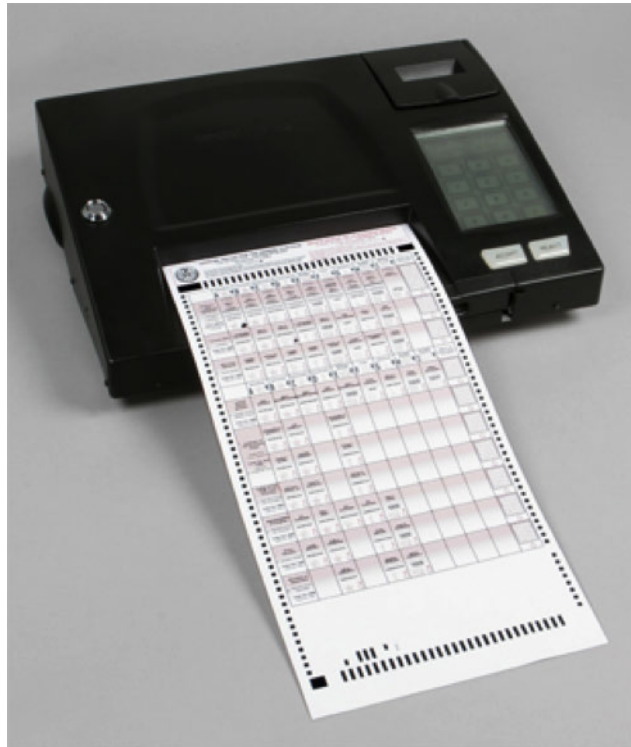
Figure 2.3: The ImageCast® Precinct Ballot Counter

Before any of these functions can take place, the tabulator first goes through a startup procedure that initializes all hardware and all software modules, authenticating the firmware and all external election files.

- The startup process of the tabulator consists of the following steps:

  1. The processor loads the boot loader from the onboard flash memory.
  2. The boot loader loads the uClinux operating system from the onboard flash memory.
  3. The operating system initializes the hardware and subsystems. (SDRAM, serial devices, buses, interrupts lines, driver modules, file system, system time, etc.)
  4. The operating system verifies and starts the election application from the onboard flash memory.

- The startup procedure of the election application consists of the following steps:

  1. Initialize all hardware devices and run diagnostics.
  2. Initialize all software modules.

- Once the system startup phase is completed, the main processor cycles through an event loop while it waits for key events to take place. These events include:

  1. Paper sensor triggered to inform the application that a ballot has been inserted.
  2. An Administrative iButton Security Key inserted to inform the application that the administrator needs to activate certain administrative actions (start AVS voting session, print log report, enable test ballot state, close the poll, shutdown the system, etc.).
  3. Check the battery signal interrupt.
  4. Check for critical events (compact flash ejected, memory failure, etc.)

2.3.1   Ballot Scanning and Processing

Once the first paper sensor is triggered, indicating a ballot is in the ingress slot, the event loop in the main processor will notify the firmware module responsible for scanning. This module scans the ballot by synchronously using the stepper motor, the remaining paper sensors, and the image sensors. The tabulator scans the ballot with two scan heads: one for the top and one for the bottom. The image sensors provide 1728 pixels per scan line with a resolution of 200 pixels per inch horizontally. Vertically, the stepper motors and transport allow for a resolution of approximately 195 pixels per inch. The scanner driver scans the ballot and puts two images (top and bottom) in SDRAM for processing. This processing consists of the following steps.

- Validating that the images scanned are of a valid ballot, and, if enabled, check for the presence of secure infrared (IR) paper stock elements.

- Determining the ballot barcode and verifying, by referring to the election files, that the ballot scanned should be accepted by the tabulator

- Determining which voting marks are filled

Once that ballot has been processed, the results are stored redundantly in two formats on two separate memory cards. If one memory card fails, the machine will shut down to ensure that two functioning cards are always present while the machine is in operation.

During this entire process, any ballot processing error or voting errors are reported to the voter, and he/she is given the opportunity to accept or reject the ballot.

Before the ballot is dropped into the ballot box, a summary screen displays the machine's interpretation of the votes on the ballot. The voter is then given the opportunity to verify their ballot.

2.3.2   Audio Voting, AVS Voting, and Ballot Marking Options

The ImageCast® Precinct Ballot Counter also allows a voter to cast a ballot via an audio device. The audio voting capability of the tabulator allows the voter to listen to and vote for all names on the ballot. Using the audio assisting device (which is connected to the tabulator), the voter listens to an audio voting session.

The audio assisting device allows the voter to adjust the volume of the audio, change the speed of the audio playback, jump to the next and go back to the previous name, and to cast a vote.

To start an audio voting session, the administrator inserts the iButton security key and selects the appropriate option.

Next, the administrator enters the ballot ID of the ballot to be used for voting. Because the tabulator allows paper ballots to be cast during an audio voting session, the audio session takes place on a separate processing thread on the processor.

At the end of an audio voting session, a summary of the votes is played back to the voter to allow the voter to verify their selection is correct.

2.3.3   Ballot Review and Second Chance Voting

The ImageCast® Precinct platform integrates an optional ballot review function. The ballot review feature allows voters to review their selections and change any votes by remarking the ballot. Once a paper ballot is processed, the voting results for a given ballot are displayed on the LCD for verification. The results are presented in text format, which allows voters to easily identify any voting errors they may have made and to verify that the tabulator has correctly identified the selections.

For an AVS voting session, the same verification is performed by going through an audio summary of the votes cast. The voter can accept or reject the ballot before it is cast.

2.4   The ImageCast® Evolution Ballot Counter

The ImageCast® Evolution Ballot Counter device (Figure 2.4) is a precinct-level, optical scan, ballot counter (tabulator) designed to perform three major functions:

- Ballot scanning and tabulation

- Ballot review and second chance voting

- Accessible voting and ballot marking

The following images show the ImageCast® Evolution device in operating position (Figure 2.4) and in storage position (Figure 2.5). Detailed hardware design specifications are provided in *2.04 - ImageCast® Evolution System Hardware Characteristics*, while the functional specifications are provided in *2.03 - ImageCast® Evolution Functionality Description*.

Figure 2.4: The ImageCast® Evolution Ballot Counter in Operating Position.

Figure 2.5: The ImageCast® Evolution Ballot Counter in Storage Position.

It is important to note that the system integrates a comprehensive set of security measures that address access control, physical device tampering, user authentication and authorization, and data confidentiality and integrity.

2.4.1 Ballot Scanning and Tabulation

The primary function of the ImageCast® Evolution ballot counter device is to scan and tabulate paper ballots. The device integrates dual CIS (Contact Imaging Sensor) analog scan heads in order to simultaneously scan both the top and bottom of the ballot. Each scan head provides a scan line resolution of 1728 pixels per inch with a horizontal resolution of 200 pixels per inch. Vertically, the stepper motor and paper transport allow for a resolution of approximately 200 pixels per inch. In addition to dual analog scan heads, stepper motor, and paper transport, the overall ballot paper handing mechanism integrates numerous paper sensors and paper diverters. These sensors are used to detect paper insertion and control and monitor paper inside the transport. Operational control of the paper handling and scanning mechanism is the responsibility of the integrated Field Programmable Gate Array (FPGA) hardware chip on the scanner controller board and the embedded firmware that controls the overall process.

The acquisition and processing of ballot images (top and bottom) consists of the following steps:

1. The FPGA chip detects the presence of a paper ballot and acquires a ballot image if no transport errors are detected (paper jams, etc.).

2. The FPGA chip pre-processes ballot images before images of both the top and bottom sides of ballots are posted into the main system memory and the ICE software platform is notified.

3. The ICE software platform processes ballot images by first validating that scanned images are of a valid ballot, and, if enabled, checking for the presence of secure infrared (IR) paper stock elements.

4. Using the election database, the ICE software platform is initialized to only recognize and process valid ballots for a given polling place.

5. The image processing module within the ICE software platform determines the ballot barcode and verifies (via the election database) if the tabulator should accept the barcode.

6. The election business logic module within the the ICE software platform analyzes which voting targets have been filled-in by the voter.

7. Depending on the system's ballot review and second chance voting settings, the ICE software transitions to the next state within the ballot tabulation process. During this entire image analysis process, any ballot processing or voting errors are reported to the voter in order to provide the elector with the opportunity to accept or reject the ballot.

8. Once a ballot has been fully processed and voter intent is determined, the ICE software updates the raw and tabulated results, creates a summary AuditMark®, scanned ballot images, and an updated log file. All these files are saved on a set of redundant compact flash memory cards within the ICE device.

2.4.2   Ballot Review and Second Chance Voting

The ICE software platform integrates an optional ballot review function. The ballot review feature allows voters to review their selections and change any votes by remarking the ballot. Once a paper ballot is processed, the voting results for a given ballot are displayed on the LCD for verification. The results are presented in rich text format, which allows voters to easily identify any voting errors they may have made, and to verify that the tabulator has correctly identified the selections. The same verification procedure can be performed for an Accessible Voting Session (AVS). The voter can accept or reject the ballot before it is cast.

2.4.3   Accessible Voting and Ballot Marking

The ImageCast® Evolution ballot counter also allows a voter to cast a ballot using accessible devices. The tabulator's audio voting capabilities allows voters to listen to, and vote for, any available choice on the ballot. Through the Audio Tactile Device (ATI) connected to the tabulator, the elector listens to an audio voting session consisting of contest and candidate names. The ATI also allows a voter to adjust the volume and speed of audio playback. Furthermore, the ATI provides voters the opportunity to navigate to the next or previous contest/candidate on the ballot. An elector also has the option to receive visual assistance while voting. A nineteen-inch (19") LCD touch-screen display provides visual voting information, as well as the ability to change the zoom and contrast levels during ballot presentation. As with audio based voting, electors make selections using an Audio Tactile Device (ATI) connected to the tabulator.

The audio and visual interfaces indicated can be used separately or simultaneously. All voting choices, such as write-in voting and straight party voting, can be made with the ATI. Voters who require alternative input devices do not have to use the ATI. Instead, they can use a sip and puff device or paddle (foot) switches to navigate the ballot and vote during a voting session. Accessible voting sessions begin when the administrator employs the Administrative iButton Security key and initiates a voting session from the Administrative Menu on the device. When prompted, the administrator enters the appropriate ballot ID. The Administrative iButton Security Key can be also be used to cancel a voting session. This may be necessary when a voter needs to restart their voting session to review any applicable instructions. Each voter begins an AVS session by selecting a language. Following this, instructions are provided to orient the user.

Depending on the MBS settings (please refer toImageCast Evolution Machine Behavior Settings document, for more information about MBS options) and license purchased[2], the system can have dual

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[2]Please contact Dominion representative to learn more about licensing options

monitor support feature. The feature enables running standard and accessible voting session in parallel. In other words, the ImageCast Evolution now supports a secondary COTS-based USB 2.0 to VGA monitor on which Accessible Voting Sessions can be run. The secondary monitor and the unit's LCD touchscreen are independent of one another, which allows for two simultaneous procedures to occur. In other words, this dual monitor functionality allows an Accessible Voting Session to occur while the unit is in standard operating mode and scanning paper ballots.

Figure 2.6: The ImageCast® Evolution Ballot Counter - Parallel Standard and AVS.

When the voter has made all ballot selections, the ImageCast® Evolution will mark the ballot according to the selections the voter made, rendering the ballot indistinguishable from printed and hand-marked ballots.

After marking is complete, the ballot is scanned. If the ballot review is enabled, the ballot will either be shown to the voter on the ballot review screen or played back to the voter over the headphones (the method depends on the type of AV session the voter initially selected). The voter then has the opportunity to review his/her selections and either cast or return the ballot.

2.5   The ImageCast® Central Ballot Counter

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The Dominion ImageCast® Central Ballot Counter system is a central ballot scan tabulator coupled with custom-made ballot processing application used for accurate, and reliable centralized scanning and counting applications of paper ballots.

The ImageCast® Central is typically utilized to process absentee ballots, but an entire election can be processed through it. Mail-in ballot elections are an example of a type of election in which the ImageCast® Central can be utilized to process the entire population of ballots for that election. The election definition is taken from EMS, using the same data and database that is utilized to program any

precinct scanners for a given election.

Multiple ImageCast® Central scanners can be programmed for use in an election. The ImageCast® Central software application is installed and later initialized on a computer attached to the central count scanner.

Ballots are processed through the central scanner(s) in batches based on jurisdictional preferences and requirements. Regardless of these preferences, the ImageCast® Central stores ballot images by scanning batches. The scanned ballot images are migrated to EMS Adjudication and/or EMS RTR through computer networking or by removable media. As with ballot images from any precinct scanners in use for an election, Results Tabulation and Reporting is the portion of EMS that processes the images to provide tabulation and operational reports to the jurisdiction. Batches can be appended, deleted, and processed in a number of ways to suit typical election workflows, intake of ballots before, during, and after Election Day, jurisdiction requirements surrounding absentee ballot tabulation, and Canvassing needs. Note: Optionally, results can be processed by the EMS Adjudication system prior to sending to EMS RTR.

Central scanning system hardware consists of a combination of two COTS devices used together to provide the required ballot scanning processing functionality:

- The Scanner: used to provide accurate ballot scanning and image transfers to the local ImageCast® Central Workstation.

- ImageCast® Central Workstation PC: used for ballot image and election rules processing and results transferring to the EMS Datacenter. The ImageCast® Central Workstation is a Dominion pre-approved PC workstation hardware which executes the image processing and election rules software application.

Two scanners are available for use with Democracy Suite® : the Canon DR-X10C and the Canon DR-G1130. When using the scanners, the following commercially available software applications and tools are used in order to provide the required ballot scanning processing functionality:

- OpenSSL: A FIPS-compliant security library

- Kofax VRS: An image processing tool (Canon scanners only)

For more information on procured and unmodified software items, please refer to *2.05 - ImageCast® Central Software Design and Specification.*

2.6 The ImageCast® X

The complete EMS ImageCast® X platform consists of client (end-user) and server (back-end) applications as follows:

- IVAdmin web application: This application is used for loading of election files, configuring behavior of ballot marking platform and producing needed reports (zero results, voters strike of list report, etc)

- RVAppServices back end service component: This service provides all necessary server side information to native android application and produces Electronic Mobile Ballot.

- ImageCast® X client application: This application in conjunction with RVAppServices verifies voters session eligibility and then presents the appropriate ballot to voter. When voter makes his/her selections ImageCast® X application passes this information to RVAppServices which in turn produces Electronic Mobile Ballot.

The ImageCast® X is a ballot marking set designed to perform three major functions:

- Ballot marking and printing of electronic mobile ballots

- Ballot review and second chance voting

- Accessible voting and ballot marking

Before any of these functions can take place, ballot marking set goes through a startup procedure that initializes all hardware and all software modules and all external election files. The startup process of the ballot marking set consists of the following steps:

- Installation and configuration of RVAdmin application

- Installation and configuration of RVAppServices service component

- Loading of election files generated by EMS

- Installation of prerequisites for ICX application on tablet:

  - SamsungTTS HD US English.apk Samsung High Definition Text To Speech engine for English language. This package is needed for accessible voting

  - SamsungTTS HD Spanish.apk Samsung High Definition Text To Speech engine for English language. This package is needed for accessible voting

- Installation of ICX.apk application on tablet main client application on tablet

- Starting ICX client application on tablet and entering server address and application mode: AVS enabled or AVS disabled mode

2.6.1   Marking and printing of Electronic Mobile Ballots

Having these steps completed we can proceed with Opening poll. Once poll is opened, voters can start marking and printing Electronic Mobile Ballots Marking and printing or Electronic Mobile Ballots consists of following actions:

- Poll worker identifies elector and creates voting session with regards to his precinct/ballot style and writes this identifier of voting session to magnetic card

- Voter verifies his/her voting session by swiping magnetic card through magnetic card reader attached to tablet

- Voter selects language and the type of the session (AVS or non AVS session)

- Appropriate ballot is presented to the voter

- Voter makes his/her selections

- Verification of selection made

- Casting ballot this means printing of Electronic Mobile Ballot

- Storing printed Electronic Mobile Ballots in secured ballot box. These ballots will be tabulated later using ICC

At the end of election day poll worker needs to close the poll.

2.6.1.1   Electronic Mobile Ballot

Electronic Mobile Ballot is the new revolutionary way or compact representation of voters selection. It consists of 3 parts:
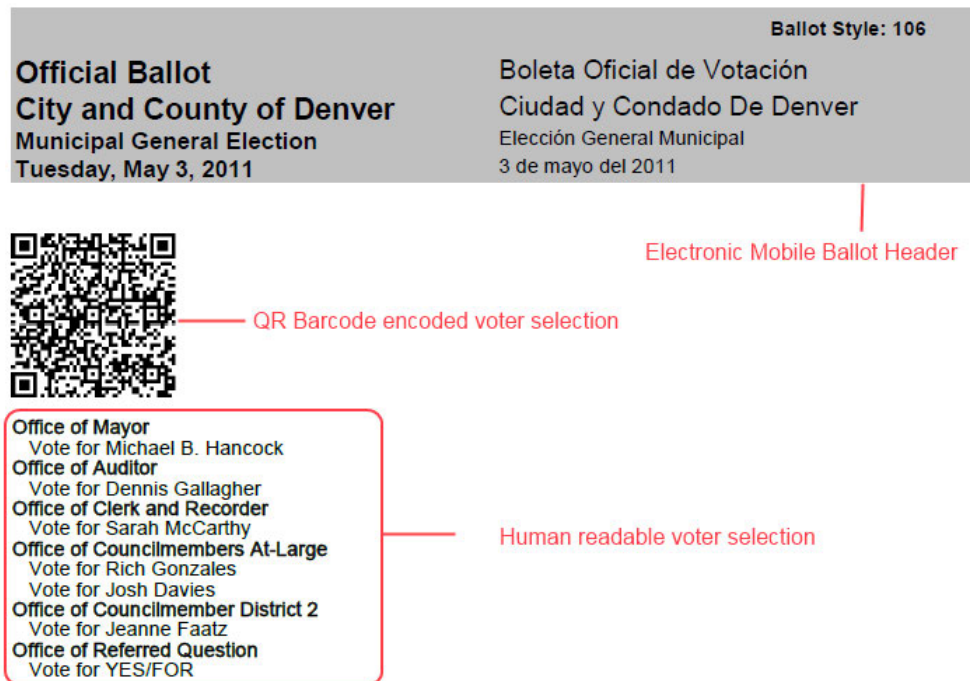
Figure 2.7: Electronic Mobile Ballot

- Electronic Mobile Ballot header: part that contains the general information about elections and ballot such as: official elections name and date, and ballot style

- QRBarcode encoded voters selection, machine readable part of Electronic mobile ballot. Electronic mobile ballot can have multiple QR Barcodes depending of data that need to be encoded (number of available contests, candidates and write-ins). Encoded data is encrypted and signed in order to prevent tampering of user selection and eliminate possibility of error during ballot scanning process

- Human readable voter selection. This part of electronic mobile ballot represent can be used for in audit process

2.6.2   Ballot review and second chance voting

At the end of each voting session, user is presented with ballot selection review as summary of selections for all contests available on ballot. At this point voter is informed about any warnings and/or errors that are applicable on selections voter made. If voter is satisfied with selections made, he can proceed with Electronic Mobile Ballot printing or can edit his/her selections otherwise.

2.6.3   AVS voting session

EMS ImageCast® X platform also allows a voter to cast a ballot using accessible devices.

AVS voting session is supported using Tecla Shield of the shelf component. This component (Tecla Shield) supports following accessible devices:

1. Paddle (foot) switches

2. Sip n Puff

3. Four position switches

Tecla shield device allows simultaneous connection of Four position switch and Paddles or Sip n Puff. Paddles and Sip n Puff devices cannot be connected at the same time. AVS voting session allows disabled voter to navigate to the next contest/candidate on the ballot and make his/her selection. An elector also has the option to receive visual assistance while voting. A touch-screen display provides visual voting information, as well as the ability to change:

- AVS session language

- The zoom levels/text size of presented ballot

- The contrast levels of presented ballot

- Adjust the volume of audio playback

The audio and visual interfaces indicated can be used separately or simultaneously. Accessible voting sessions begin when the voter or poll worker swipes the magnetic card with valid voting session. The next step is selection of session language and AVS mode/device. Voter has four available options:

- Paddles

- Sip n Puff

- 4 direction switch

- Audio only

After this point voter can complete the process of making candidates selection. Once voter completes the process of candidates selection he is presented with ballot review screen and the whole selection is played back to the voter over the headphones. At this point voter has the opportunity to review his/her selections and either cast/print electronic mobile ballot or return the ballot. Disabled voter may need poll workers assistance in process of storing printed Electronic Mobile Ballot to secured ballot box.

2.7 AuditMark®

When an ImageCast® scanner scans a ballot, it checks to ensure that the ballot is readable and valid prior to examining voter marks and tabulating them. The tabulation is stored in a cast vote record along with an image of the ballot that his been scanned. The tabulation result is presented in a human-readable format, which is appended to the scanned image. This appended information comprises the AuditMark®. The AuditMark® provides the user with the scan results for each contest. These results display the votes the scanner recorded for candidates or measures within a contest.

The AuditMark® can assist in verifying the election at several areas. These areas are: pre-election logic and accuracy testing, recount, canvass, and small batch audits (also known as risk-limiting audits). During pre-election logic and accuracy testing (pre-LAT), a jurisdiction can sample the scan images and AuditMark® from several scanners to ensure that the scanner is properly imaging the ballot. Stray lines or marks on the scan image, images showing foreign materials (specks on the image), incorrect results relative to the pre-LAT vote pattern can be observed and corrected by use of the scan image and AuditMark® during the pre-LAT process.

Once results are available from Election Day, jurisdictions can commence the canvass process. For example, if an election contest leads to a recount, the AuditMark® and scan image can provide additional confirmation regarding how the scanners read voter marks. This capability is invaluable because the canvass and recount Boards may view a voter mark differently. The AuditMark® and scan image allow the Board members to "see" what the scanner viewed and how it interpreted that voter mark. This information is only available from the ImageCast® family of scan voting machines. The EMS Adjudication system also utilizes an AuditMark®, appended to the original, to show the results of a ballot adjudication.

2.8 The Democracy Suite® Logical Deployment View

The logical view of the system presented in Figure 2.2 makes it easy to identify basic system components without taking the physical deployment scenarios into account. This view is useful for understanding which generic components are needed to establish an election event system based on the Democracy Suite® platform.

At the core of the system, the EMS Data Center server modules are responsible for orchestrating the election activities and for storing election domain data. The EMS client applications communicate with the EMS Data Center back-end system (EMS Application, Database and NAS server modules) using the TCP/IP protocol or pipes (local level inter-process communication).

For usual election project related activities, two main client applications are used: Election Event Designer (EED) and Results Tally and Reporting (RTR). The EMS platform can also include several optional components: Election Data Translator (EDT), Audio Studio (AS), Adjudication (ADJ), AIMS Data Translator (AIMS DT), Mobile Ballot Production (MBP), Results Transfer Manager (RTM), WinEDS Importer and Election Data Exchange Station (EDES). All EMS client applications that access and make use of the EMS Database on the EMS Data Center allow only authenticated and authorized user access. EMS server components enforce authenticated and authorized user access.

The primary function of the EMS EED client application is to provide accurate, efficient, and secure procedures for defining elections. In contrast, the primary function of the EMS RTR client application is to collect, process, validate, and report election results in an accurate, efficient, and secure manner. Both applications contain their own set of defined inputs and outputs.

For the EMS EED client application, inputs represent a variety of election domain related information which is either, entered manually by operators, imported via EMS EDT or from external systems in a predefined XML format, or imported from previous election projects. Outputs represent a variety of files, including ballots (paper, electronic and AVS), definition reports, and election definition files required to properly program the ImageCast® devices.

For both the EMS RTR and Adjudication applications, inputs represent encrypted and signed election result files and scanned ballot images produced by the Dominion ImageCast® optical ballot counters. For the EMS RTR client application, outputs represent a variety of election result reports in different file formats, as well as auditing information. For the EMS Adjudication application, outputs represent encrypted and signed election result files and ballot images containing appended audit marks as well as summary and activity reports.

To ensure the ImageCast R devices operate properly,the EMS platform produces memory packs with election event related definitions and iButton security keys. Within the Democracy Suite® platform, these files are either defined as election definition files, or database and device configuration or behavioral setting files. The first set defines election rules and ballots to be processed by a particular instance of the ImageCast® device, while the second set contains various device specific configuration and behavioral settings. In addition, EMS issues appropriate user credentials by programming Administrative iButton security keys.

The Democracy Suite® election platform supports all ImageCast® series tabulators : ImageCast® Precinct (ICP), ImageCast® Evolution (ICE), ImageCast® Central (ICC) and ImageCast® X (ICX). These devices are either used at polling places (ICP, ICE and ICX) for election day voting, or at central count locations (ICC) for vote-by-mail, absentee, or early voting.

Note: EMS Adjudication supports only ImageCast® Central .

2.9 The Democracy Suite® Physical Deployment View

The EMS platform is available in four hardware configurations (see Chapter 3 of this document for detailed information):

- EMS Express: All EMS software components are installed on a single physical PC or laptop.

- EMS Standard: In addition to the UPS and LAN network switch devices, the EMS server components are installed on a single physical sever, while the EMS client components are installed on one or more physical PCs, laptops, or the EMS server computer itself. All system components are interconnected in a client-server local LAN environment.

- EMS Standard/ImageCast® Listener: To mitigate the possible risks related to system exposure via a public telecommunication network (Wireless and/or Dial-Up), these configurations implement several security measures. All configurations include a firewall appliance to control the access to the network; the ImageCast® Listener services run in a separate server with dual network cards, and (when applicable) a remote access server is installed as first security layer for Dial-Up transmissions.

- EMS Enterprise: Represents a two-server configuration. In addition to the UPS and LAN network switch devices, the EMS client components are installed on one or more physical PCs or laptops. All system components are interconnected in a client-server local LAN environment.

Chapter 3

Operational Environment

3.1 Democracy Suite® EMS Operational Environment

Depending on the deployment scenario, the Democracy Suite EMS system requirements can vary. As a result of the system's modularized architecture, system requirements can be defined for each component. Consequently, the Democracy Suite® EMS platform can be deployed in one of the following hardware configurations:

- EMS Express: Deploys all EMS software components on a single PC or laptop.

- EMS Standard: Local network deployment of EMS software components that utilizes one or more client PC or laptop computers for enduser applications (EED, RTR, ADJ, AS, FSS, EDT, RTM)[1] and single server hosting backend applications (DB, NAS, APPS, RRH, EMSService and EMS ADJSVC).

- EMS Standard/ImageCast® Listener Wireless: Secured network deployment exposed to public telecommunication networks in order to receive transmissions from the ICP and/or ICE devices. The backend applications (Database Server, NAS, APPS, RRH, EMSService, EMS AJDSVC, Cartridge Manager, EMS Shell Service) run in a set of servers where all data is stored. The ImageCast® Listener Server runs the ImageCast® Listener service, which grants the ICP and/or ICE access to upload the results in the system. The end-user applications (EED, RTR, AS, FSS, EDT, RTM, DVS Transmission Dashboard) are executed from computers connected to the local network.

- EMS Standard/ImageCast® Listener Dial-Up: Secured network deployment exposed to public telecommunication networks in order to receive transmissions from the ICP and/or ICE devices using analog phone lines via Remote Access Server (RAS). The backend applications (Database Server, NAS, APPS, RRH, EMSService, EMS AJDSVC, Cartridge Manager, EMS Shell Service) run on a set of servers where all data is stored. The ImageCast® Listener Server runs the ImageCast® Listener service, which grants the ICP and/or ICE access to upload the results in the system. The end-user applications (EED, RTR, AS, FSS, ADJ, EDT, RTM, DVS Transmission Dashboard) are executed from computers connected to the local network.

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[1]Note that RTM and RTR cannot exist on the same workstation.

- EMS Enterprise: Local network deployment of EMS software components that utilizes one or more client PC or laptop computers for enduser applications (EED, RTR, AS, FSS, ADJ, EDT, RTM) and two servers that host backend applications (one server hosts APPS, RRH, EMSService, EMS ADJSVC and NAS, while another server hosts DB).

The Democracy Suite® EMS platform consists of multiple components as listed bellow:

- EMS Election Event Designer (EED): enduser application

- EMS Results Tally and Reporting (RTR): enduser application

- Adjudication (ICA): enduser application

- EMS Audio Studio (AS): enduser application

- EMS File System Service (FSS): enduser application

- EMS Election Data Translator (EDT): enduser application

- EMS Result Transfer Manager (RTM): enduser application

- EMS Election Data Exchange Station (EDES): enduser application

- EMS Application Server (APPS): backend application

- EMS Result Receiver Host (RRH): backend application

- EMS Service (EMSService): backend application

- Adjudication Service: backend application

- EMS Network Attached Storage (NAS): backend file repository component

- EMS Database Server (DB): backend database repository component

- EMS Data Center Manager (DCM): backend configuration component

- ImageCast® Listener (Listener Service): backend application

- EMS Shell Service (Web Service): backend application

- EMS AIMS Data Translator (AIMS DT): enduser application

- DVS Transmission Dashboard (Windows Application): frontend application

- Cartridge Manager (Windows Service): backend application

- Mobile Ballot Production(MBP): enduser application

- WinEDS Importer (WinEDS): enduser application

Figure 2.1 illustrates the Democracy Suite® EMS components.

3.1.1 EMS Hardware Configuration

The EMS Express configuration requires the least amount of hardware. Both its server and client components run on a single desktop or laptop. See Figure 3.1.
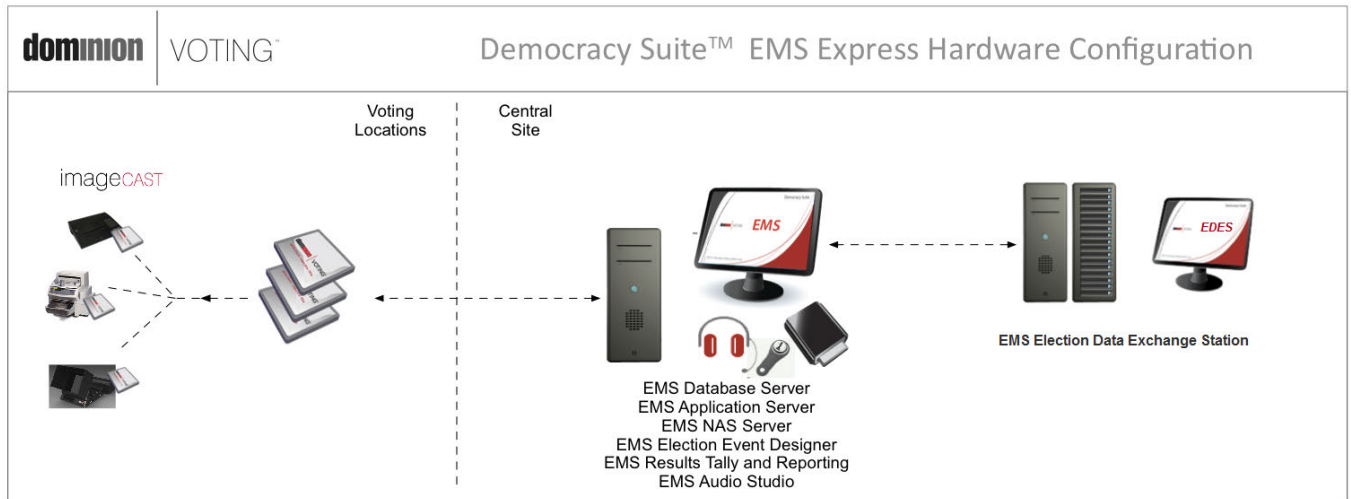
Figure 3.1: The Democracy Suite® EMS Express Hardware Configuration.

EMS EXPRESS HARDWARE CONFIGURATION			
Component	**Minimum**	**Recommended**	**Required by law (optional)**
Motherboard	Motherboard with integrated sound controller and SATA controller	Motherboard with integrated sound controller and SATA controller. RAID functionality **or** separate hardware RAID controller	
CPU	Intel i5 series	Intel i7 series	
RAM	4GB	8GB	
HDD	Single 500GB	Dual 500GB in RAID 1 mode (mirror)	External secure encrypted system (Rocstor AMPHIBIOUS X7 1TB)
Additional	USB Compact Flash card reader	USB Compact Flash card reader	
	USB iButton Security Key reader	USB iButton Security Key reader	
	19" or higher monitor for desktop PCs	19" or higher monitor for desktop PCs	
	Keyboard and mouse	Keyboard and mouse	
	Headset or headphones with microphone	Headset or headphones with microphone	
	Internal or external DVD R/W	Internal or external DVD R/W	

Table 3.1: EMS Express Hardware Requirements

Figure 3.2 illustrates the physical connections of the Democracy Suite® EMS Express Configuration.
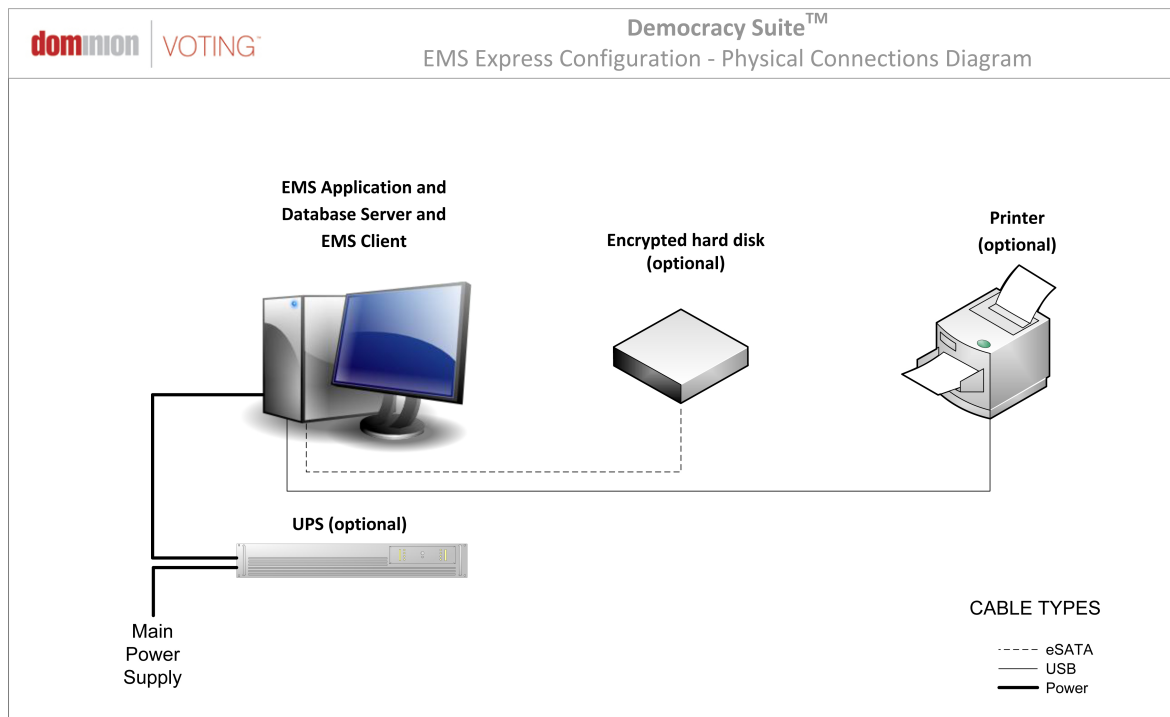
Figure 3.2: The Democracy Suite® EMS Express Configuration - Physical Connections.

The EMS Standard and Enterprise hardware configuration provides a client-server local LAN deployment environment for mid-sized jurisdictions with a maximum of 1000 electoral districts (precincts/polls). This hardware configuration separates client and server system components by utilizing a single physical server device to run all EMS server components. The client PC or laptop computers running EMS client applications are interconnected with the back-end server component through the gigabit LAN network which utilizes the network switch. The client applications can also be run on the EMS server computer.

Figure 3.3 illustrates the physical connections of the Democracy Suite® EMS Standard Configuration.
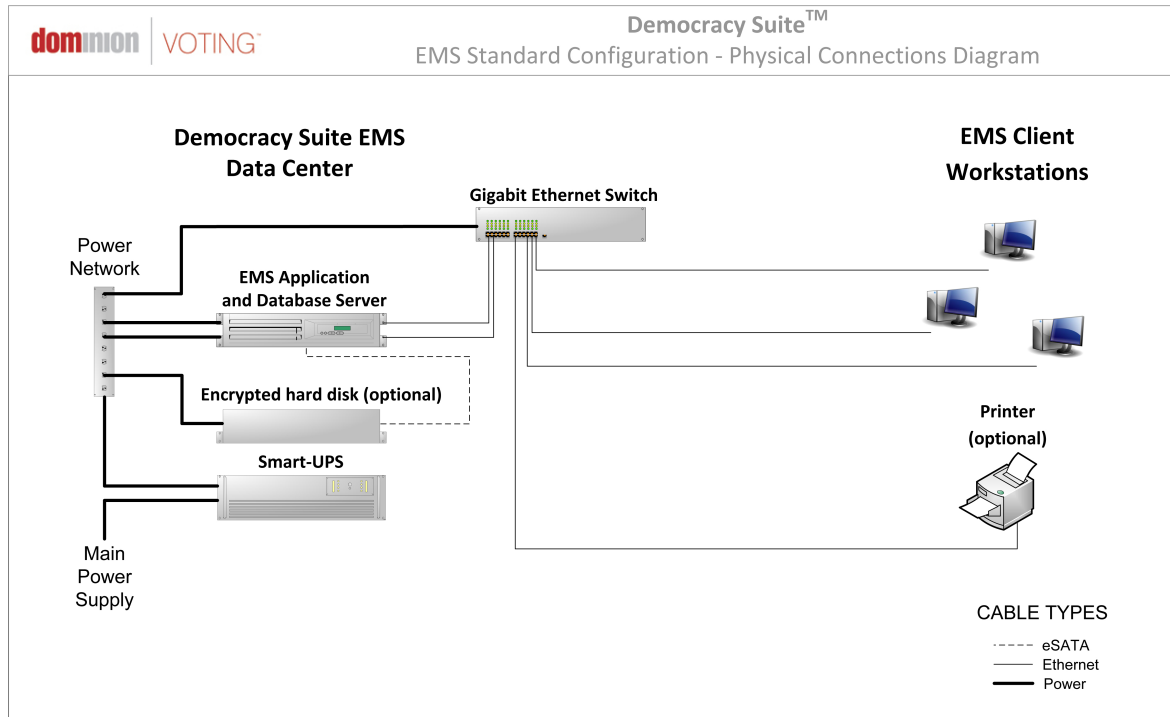
Figure 3.3: The Democracy Suite® EMS Standard Configuration - Physical Connections.

Figure 3.4 illustrates the physical connections of the Democracy Suite® EMS Enterprise Configuration.
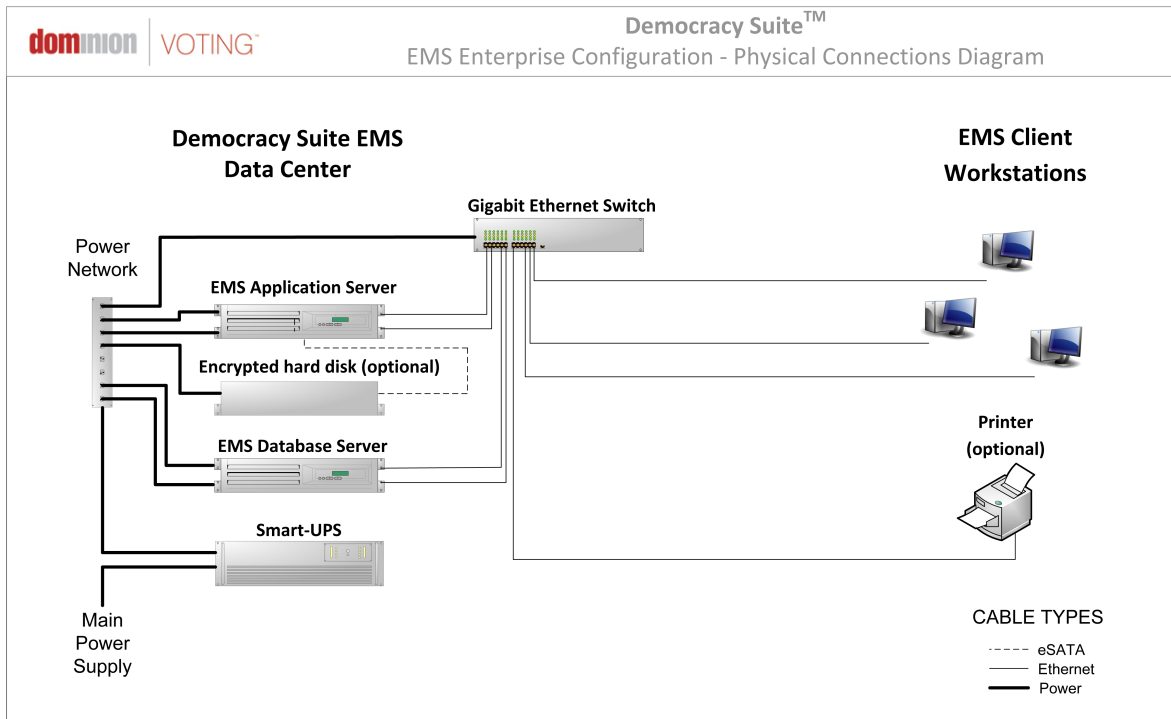
Figure 3.4: The Democracy Suite® EMS Enterprise Configuration - Physical Connections Diagram.

EMS STANDARD HARDWARE CONFIGURATION: CLIENT		
Component	**Minimum**	**Recommended**
Motherboard	Motherboard with integrated sound controller and SATA controller	Motherboard with integrated sound controller and SATA controller
CPU	Intel i5 series	Intel i7 series
RAM	4GB	8GB
HDD	Single 500GB	Single 500GB
Additional	USB Compact Flash card reader	USB Compact Flash card reader
	USB iButton Security Key reader	USB iButton Security Key reader
	19" or higher monitor for desktop PCs	19" or higher monitor for desktop PCs
	Keyboard and mouse	Keyboard and mouse
	Headset or headphones with microphone	Headset or headphones with microphone
	Internal or external DVD R/W	Internal or external DVD R/W

Table 3.2: EMS Standard & Enterprise Hardware Configuration: Client

EMS STANDARD HARDWARE CONFIGURATION: SERVER			
Component	**Minimum**	**Recommended**	**Required by law (optional)**
Motherboard	Single core CPU with integrated SATA controller	Dual quad core CPU with integrated SATA controller and RAID functionality **or** separate hardware RAID controller	
CPU	Intel Xenon L5500 series	Intel Xeon E5 series	
RAM	8GB	16GB	
HDD	Dual 500GB	Dual 500GB in RAID 1 mode, and 4x 500GB in RAID 10 mode	External secure encrypted rack mount RAID system: 4 HDDs in RAID 10 mode (Rocstore ROCSERVE 4RMe 8TB)
Additional		PCI-E card SATA controller with RAID 10 functionality, or compatible	
	Internal or external DVD R/W	Internal or external DVD R/W	
	Single or dual power supply	Single or dual power supply	
	Optional monitor, keyboard, and mouse	Optional monitor, keyboard, and mouse	

Table 3.3: EMS Standard & Enterprise Hardware Configuration: Server

3.1.2 EMS Software Configuration

EMS SOFTWARE CONFIGURATION						
EMS Software Configurations	Express Software Configuration	Standard Server Configuration	Standard Client Configuration	Enterprise Application Server	Enterprise Database Server	Enterprise Client
Adobe Acrobat Reader 10.1.1	X		X			X
Cepstral Voices	X	X	X	X		
Dallas 1-Wire Device Driver 4.0.3	X					X
EMS Client components	X		X			X
EMS Server components	X	X		X		
Java Runtime Environment 6.0.290	X	X	X	X		X
Microsoft .NET Framework 4.0	X	X	X	X	X	X
Microsoft Access Database Engine	X		X			X
Microsoft IIS 7.5	X	X		X	X	
Microsoft SQL Server 2008 R2 Express	X					
Microsoft SQL Server 2008 R2 Reporting Services only and Service Pack 2 (SP2) Installed				X		
Microsoft SQL Server 2008 R2 Standard with Service Pack 1 (SP1) Installed		X			X	
Microsoft SQL Server 2008 R2 with Advanced Series and Service Pack 1 (SP1) Installed	X					
Microsoft Visual C++ x86 Redistributable	X	X	X	X		X
Microsoft Visual J# 2.0	X	X	X	X		X
Optional additional fonts	X	X	X	X		X
Optional Avast! antivirus software	X	X	X	X	X	X
Optional eSATA card		X				
Optional Excel 2010	X		X			X
Optional printer drivers	X		X			X
Optional Uninterruptable Power Supply drivers	X	X		X	X	
Windows 7 Professional x64 with Service Pack 1 (SP1) Installed	X		X			X
Windows Server 2008 R2 with Service Pack 1 (SP1) Installed		X		X	X	

Table 3.4: EMS Software Configuration

3.1.3 EMS Standard/ImageCast® Listener - Wireless Hardware Configuration

For all the jurisdictions using data transmission capabilities, the EMS Standard/ImageCast Listener hardware configuration provides a redundant and secured WAN/LAN deployment environment. This hardware configuration isolates the clients and both the internal and external servers exposed to internet by utilizing firewall/load balancer appliances. The client PC computers running EMS client applications are interconnected with the back-end servers through the gigabit LAN network which utilizes the network switches.

The minimum recommended EMS Standard/ImageCast® Listener Wireless hardware components are as follows:

- **EMS Servers:**

  1. Server class computer (rack mount recommended or tower)
  2. Single or Dual quad core CPU (Intel Xeon)
  3. 8GB RAM minimum (16GB RAM recommended)
  4. Dual hard disk drives - RAID 1 (mirror) for OS + MS SQL + EMS APPS (500GB or more per disk)
  5. 2 Gigabit Network interfaces
  6. DVD reader

- **ImageCast® Listener Servers:**

  1. Server class computer (rack mount recommended or tower)
  2. Single or Dual quad core CPU (Intel Xeon)
  3. 8GB RAM minimum (16GB RAM recommended)
  4. 2 HDDs - RAID 1 (mirror) for OS + Services + Cartridge Results images (500GB or more per disk).
  5. 2 Gigabit Network interfaces
  6. DVD reader

- **External Access:**

  1. Customer has to provide a router with an external IP address.

- **Networking and Additional Components:**

  1. Small/Medium Size Rack (optional)
  2. 1 Gigabit network switch (Cisco/Linksys)
  3. 1 Firewall Appliance (WatchGuard XTM 5 Series)
  4. 1 UPS to support the equipment indicated above
  5. Monitor and KVM console
  6. Patch Panels
  7. Patch cord and network cables of different sizes

      8. Printer (optional)

- **EMS Client PC:**

  1. Desktop class PC or a laptop computer
  2. Motherboard with sound controller integrated (and integrated SATA controller with or without RAID 1 capability)
  3. Single Pentium class dual or quad core CPU (Intel i5/i7)
  4. 4 GB or more of RAM
  5. Integrated hard disk drive (single or dual, 250GB or more each, with or without RAID 1 capability)
  6. Compact Flash card reader (USB interface)
  7. iButton Security Key Reader (USB interface)
  8. LCD Monitor (if desktop class PC used, 19" or higher screen size)
  9. Keyboard and mouse
  10. Headset or headphones with microphone
  11. DVD R/W (internal or external)

Figure 3.5 illustrates the physical connections of the Democracy Suite® EMS Standard/ImageCast® Listener Wireless Configuration.
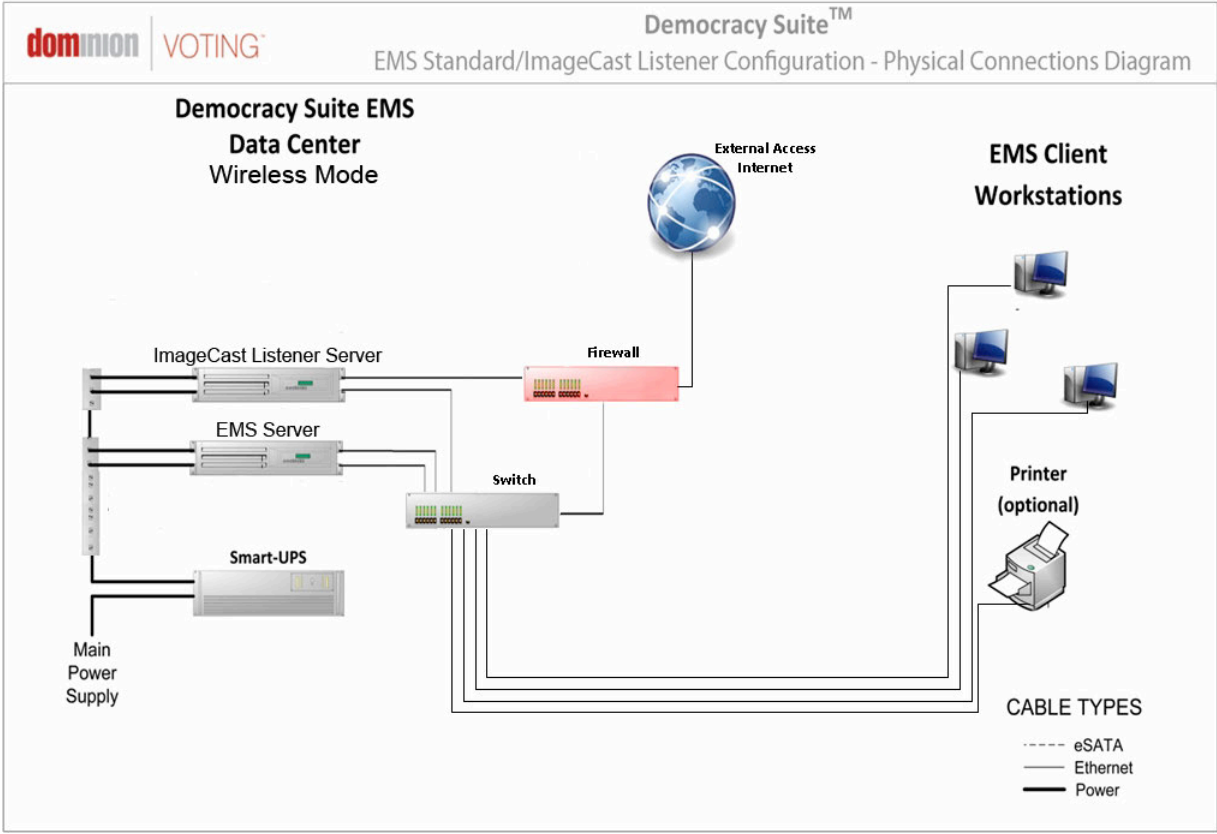
Figure 3.5: The EMS Standard/ImageCast® Listener Wireless Configuration: Physical Connections

3.1.4 EMS Standard/ImageCast® Listener - Dial-Up Hardware Configuration

For jurisdictions using Dial-Up data transmission capabilities (along with analog phone lines via Remote Access Server), the EMS Standard/ImageCast® Listener Dial-Up hardware configuration provides a secured WAN/LAN deployment environment. This hardware configuration isolates the clients and the internal and the external servers exposed to public telecommunication networks by utilizing a combination of RAS/firewall appliances. The client PC computers running EMS client applications are interconnected with the back-end servers through the gigabit LAN network.

The minimum recommended EMS Standard/ImageCast® Listener Dial-Up hardware components are as follows:

- **EMS Servers:**

    1. Server class computer (rack mount recommended or tower)
    2. Single or Dual quad core CPU (Intel Xeon)
    3. 8GB RAM minimum (16GB RAM recommended)
    4. Dual hard disk drives - RAID 1 (mirror) for OS + MS SQL + EMS APPS (500GB or more per disk)
    5. 2 Gigabit Network interfaces
    6. DVD reader

- **ImageCast® Listener Servers:**

    1. Server class computer (rack mount recommended or tower)
    2. Single or Dual quad core CPU (Intel Xeon)
    3. 8GB RAM minimum (16GB RAM recommended)
    4. 2 HDDs - RAID 1 (mirror) for OS + Services + Cartridge Results images (500GB or more per disk).
    5. 2 Gigabit Network interfaces
    6. DVD reader

- **Remote Access Server (RAS):**

    1. Server class computer (rack mount recommended or tower)
    2. Single or Dual quad core CPU (Intel Xeon)
    3. 4GB or more RAM
    4. 2 HDDs - RAID 1 (mirror) for OS + Services + Cartridge Results images (500GB or more per disk).
    5. 2 Gigabit Network interfaces
    6. DVD reader

- **Networking and Additional Components:**

    1. Small/Medium Size Rack (optional)
    2. 1 Gigabit network switch (Cisco/Linksys)
    3. 1 Firewall Appliance (WatchGuard XTM 5 Series)

4. DigiConnectPort LTS - Terminal Server

5. 1 UPS to support the equipment indicated above

6. Monitor and KVM console

7. Patch cord and network cables of different sizes

8. Printer (optional)

- **EMS Client PC:**

  1. Desktop class PC or a laptop computer

  2. Motherboard with sound controller integrated (and integrated SATA controller with or without RAID 1 capability)

  3. Single Pentium class dual or quad core CPU (Intel i5/i7)

  4. 4 GB or more of RAM

  5. Integrated hard disk drive (single or dual, 250GB or more each, with or without RAID 1 capability)

  6. Compact Flash card reader (USB interface)

  7. iButton Security Key Reader (USB interface)

  8. LCD Monitor (if desktop class PC used, 19" or higher screen size)

  9. Keyboard and mouse

  10. Headset or headphones with microphone

  11. DVD R/W (internal or external)

Figure 3.6 illustrates the physical connections of the Democracy Suite® EMS Standard/ImageCast® Listener Dial-up Configuration.
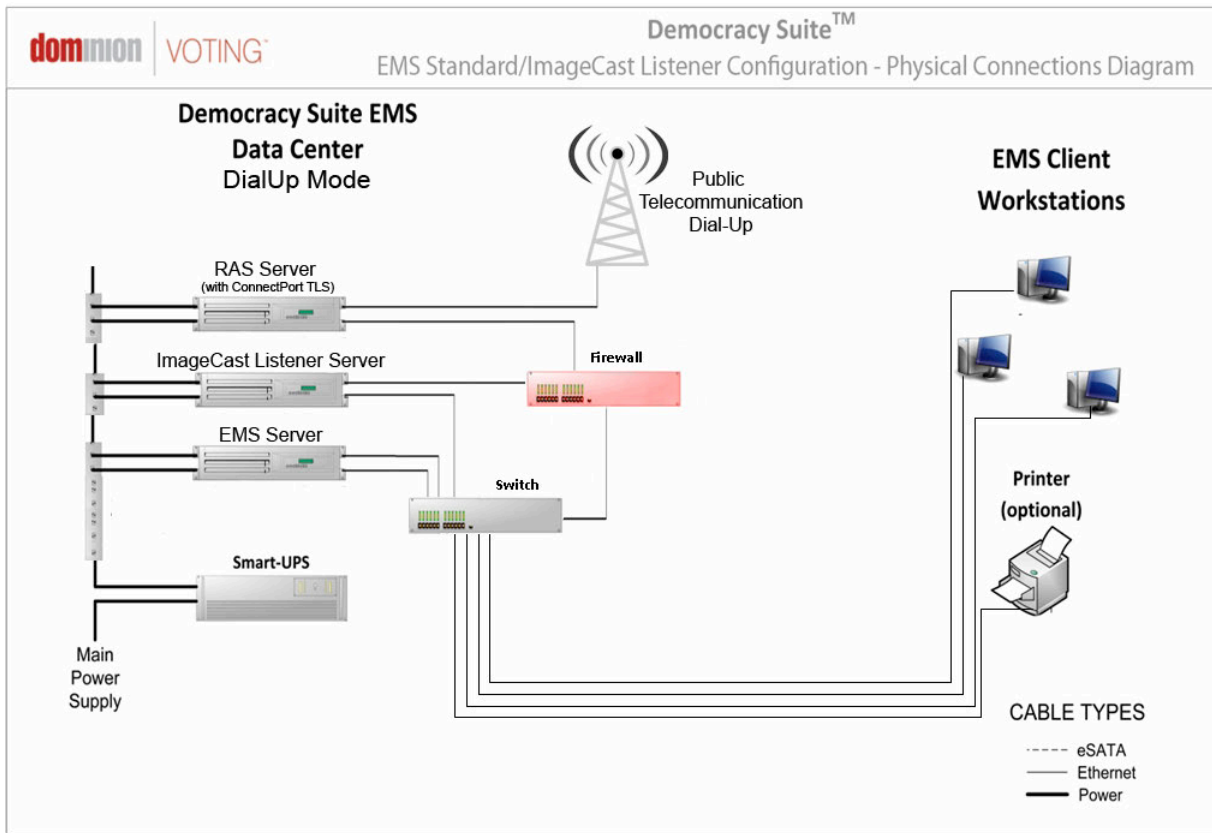
Figure 3.6: The EMS Standard/ImageCast® Listener Dial-up Configuration: Physical Connections

3.1.5 EMS Standard/ImageCast® Listener Software Configuration

NOTE: The following software configuration is applicable to all configurations that deploy both the EMS Standard and ImageCast® Listener hardware as described above.

The EMS Software requirements are as follows:

- **EMS Servers:**

  1. Microsoft Windows Server 2008 R2 with Service Pack 1 installed
  2. Microsoft .NET Framework 4.0
  3. Microsoft IIS 7.5
  4. Microsoft Visual J# 2.0
  5. Microsoft Visual C++ 2010 x86 Redistributable
  6. Microsoft SQL Server 2008 R2 Standard with Service Pack 1 installed
  7. Java Runtime Environment 6.0.290

8. Cepstral Voices (English, Spanish, etc.)

9. Additional Fonts (optional)

10. Democracy Suite EMS Software components (server)

11. Avast! version 4.08 antivirus software (optional)

12. UPS drivers (optional)

- **ImageCast® Listener Servers:**

  1. Microsoft Windows Server 2008 R2 with Service Pack 1 installed

  2. Microsoft .NET Framework 4.0

  3. ImageCast® Listener Services

- **Domain Controller Server:**

  1. Microsoft Windows Server 2008 R2 with Service Pack 1 installed

  2. Domain Controller and Active Directory Services

- **EMS Client PC:**

  1. Microsoft Windows 7 Professional x64 with Service Pack 1 installed

  2. Microsoft .NET Framework 4.0

  3. Microsoft Visual J# 2.0

  4. Microsoft Visual C++ 2010 x86 Redistributable

  5. Adobe Acrobat Reader 10.1.1

  6. Dallas 1-Wire Device Driver version 4.03

  7. Java Runtime Environment 6.0.290

  8. Microsoft Access Database Engine

  9. Additional Fonts (optional)

  10. Democracy Suite EMS Software components (client)

  11. Avast! version 4.08 antivirus software (optional)

  12. Printer drivers (optional)

  13. Microsoft Excel 2010 (optional)

3.2   The ImageCast® Precinct Operational Environment

The ImageCast® Precinct system is a precinct optical scan ballot tabulator designed to scan marked paper ballots, interpret voter marks on the paper ballot, communicate these interpretations back to the voter, and upon acceptance by the voter, deposit the ballots into the secure ballot box. The ImageCast Precinct also provides enhanced accessibility voting through an optional ATI unit, which is tethered to the ImageCast® Precinct .

3.2.1   Functional Elements
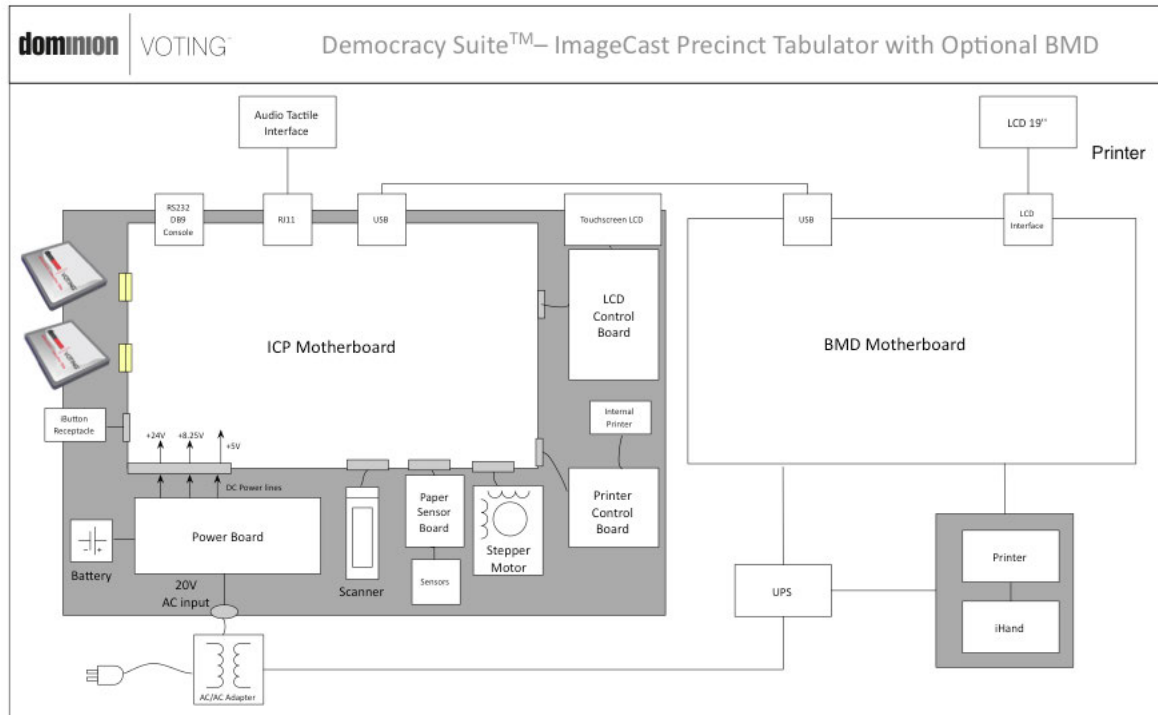
Figure 3.7: The ImageCast® Precinct Functional Block Diagram (with optional BMD).

The ImageCast® Precinct 's major system elements are:

- Operating System - uClinux

- Motherboard - MCF5249 ColdFire Processor-based circuit that provides:
  - Overall control of all system elements
  - Main connectivity point for all other subsystems
  - 32MB of SDRAM (MT48LC16M16A2), 4MB of onboard Flash (M29W320DB), Xilinx CPLD (system glue logic) and other electronic circuitry necessary for control and connectivity of other ImageCast® sub-systems.

- Removable Memory Modules - Two memory packs (internal type II Compact Flash memory cards). CompactFlash is high capacity, solid-state flash-based memory that electrically complies with the Personal Computer Memory Card.

- Optional Modem - Part of ImageCast® Precinct motherboard and provides connectivity for standard Socket Modems (includes built-in universal modem socket to support standard embedded Socket Modem modules).

- Scanners - The ImageCast® Precinct uses two optical imaging scanners (ONSemi-conductor NOM02A4-DR17G 200 DPI Contact Image Sensors) for creating a duplex scanned image of each side of the ballot.

- Display - the ImageCast® Precinct uses EDT Corp's 5.7" LCD touch panel EW32FKBNW*F0(1/4 VGA) controlled by the LCD-Printer Controller Board (based on S1D13700F01 Embedded Memory Graphics LCD Controller).

- Internal Printer - A thermal print mechanism for generating, starting, and ending reports. Internal Printer Circuitry includes a LCD-Printer Control Board and an integrated printer (thermal line dot printer with resolution of 6 dots/mm). The LCD-Printer Control Board, which consists of a printer controller (PT800P01) and step motor driver, is designed to provide logical control of the printer.

- iButton - The ImageCast® Precinct 's administrative iButton security key interface uses the iButton reader (physically attached to the top of the unit and electrically connected to the motherboard) and the Dallas DS1963S iButton security key to provide a variety of verification and security tasks, such as access control, data confidentiality, and integrity functions.

- Paper Feed Mechanism - A motorized mechanism for detecting and moving the paper ballot within the tabulator. It is intended for handling ballots 8.5 inches (216 mm) wide by a variable length between 11" and 22 ". The paper feed mechanism is physically capable of moving the ballot paper forward into the machine, across image sensors, enabling complete image capture of both sides of the ballot.

- Ballot Diverter - A device that is physically able to divert ballots into a separate compartment within the ballot box.

- Power Supply Module - A module for converting 20V AC line input to all voltages needed by the system. This module includes an intelligent battery charger.

- Battery Pack - An internal battery pack capable of powering the system for at least three hours. The battery type is Li-Ion with optional NiMH+/NiCad. The battery compartment is large and has inserts to adapt to different battery types.

- Ballot Box - Contains several key elements such as multiple storage compartments (main, diverted, auxiliary), multiple locks and doors, and access control monitoring. It is an integrated component of the voting system, and it includes security arrangements to prevent unauthorized access to the tabulation component and a locking access door for all ballot locations.

- Packaging - The unit is stored and transported in a cardboard box with internal foam for vibration and impact protection.

3.2.2 Safety and Compliance

The ImageCast® Precinct system complies with the following standards:

- Safety - UL 60950-1.

- Electrical Power Disturbance - IEC 61000-4-11 (1994-06) standard (Voltage dips, short interruptions, and voltage variations immunity).

- Electrical Fast Transient - IEC 61000-4-4 (1995-01) standard (Electrical fast transient/burst immunity).

- Lightning Surge - IEC 61000-4-5 (1995-02) standard (Surge immunity test).

- Electrostatic Disruption - IEC 61000-4-2 (1995-01) standard (Electrostatic discharge immunity).

- Electromagnetic Radiation - FCC Part 15 Class B requirement.

- Electromagnetic Susceptibility - IEC 61000-4-3 (1996) standard (Radiated, radio frequency, electromagnetic field immunity).

- Conducted RF Immunity - IEC 61000-4-6 (1996-04) standard (Immunity to conducted disturbances induced by radio-frequency fields).

- Magnetic Fields RF Immunity - IEC 61000-4-8 (1993-06) standard (Power frequency magnetic field immunity).

3.2.3   Environmental

The ImageCast® Precinct system complies with the MIL-STD-810-D standard, Method 502.2 and Method 501.2, with test conditions described in VVSG Volume II § 4.7.1.

The ImageCast® Precinct system complies with the following standards:

- MIL-STD-810D, Method 516.3, Procedure VI (drop test)

- MIL-STD-810D, Method 514.3, Category 1- Basic Transportation, Common Carrier (vibration test)

- MIL-STD-810D, Method 502.2, Procedure I-Storage (high and low temperature test; 4 hours at $-4°F$ and 4 hours at $+140°F$)

- MIL-STD-810D, Method 507, (Humidity test) as specified in VVSG Volume II paragraph 4.6.1.

3.2.4   Data Network

The Democracy Suite® platform in its EMS Express, EMS Standard, and EMS Enterprise configurations does not use public communication networks for its operation. However, the EMS Standard/ImageCast® Listener includes two different hardware configurations, as described in sections 3.1.3 and 3.1.4. These configurations allow the ImageCast® Precinct and ImageCast® Evolution to use public telecommunications networks to send the results to the EMS Data Center in a secure manner.

3.2.5   Input Power

The ImageCast® Precinct uses a COTS UL approved AC adapter as a main power source that provides 20V AC power to the internal Power Module. The AC adapter requires input voltage to be 120V 60Hz.

3.2.6   Physical access control

3.2.6.1   Door Coverage

Each ImageCast® Precinct door is secured with the appropriate locking mechanism.

3.2.6.2   Security

The ImageCast® Precinct is equipped with an iButton security key reader. This reader, in combination with the iButton security key, performs a variety of verification and security tasks pertaining to access control, data confidentiality, and integrity functions. The content of the iButton security key is protected by the user's password which must be entered each time the iButton is used. Every result file created by the ImageCast® Precinct is protected by signing and encryption using the Secure Hash Algorithm (SHA) and Advanced Encrypted Standard (AES). The algorithm can be protected by the security hardware machine or the open SSL FIPS certified library.

A detailed hardware description is provided in the *2.04 - ImageCast® Precinct System Hardware Specification*.

3.3 ImageCast® Evolution Operational Environment

The ImageCast® Evolution system is a precinct optical scan ballot tabulator designed to scan marked paper ballots, interpret voter marks on a paper ballot, communicate these interpretations back to the voter, and upon the voter's acceptance, securely deposit the ballots into the secure ballot box. The ImageCast® Evolution also provides enhanced accessibility voting, accomplished via an ATI unit, LCD screen and ballot printer.

3.3.1 Functional Elements
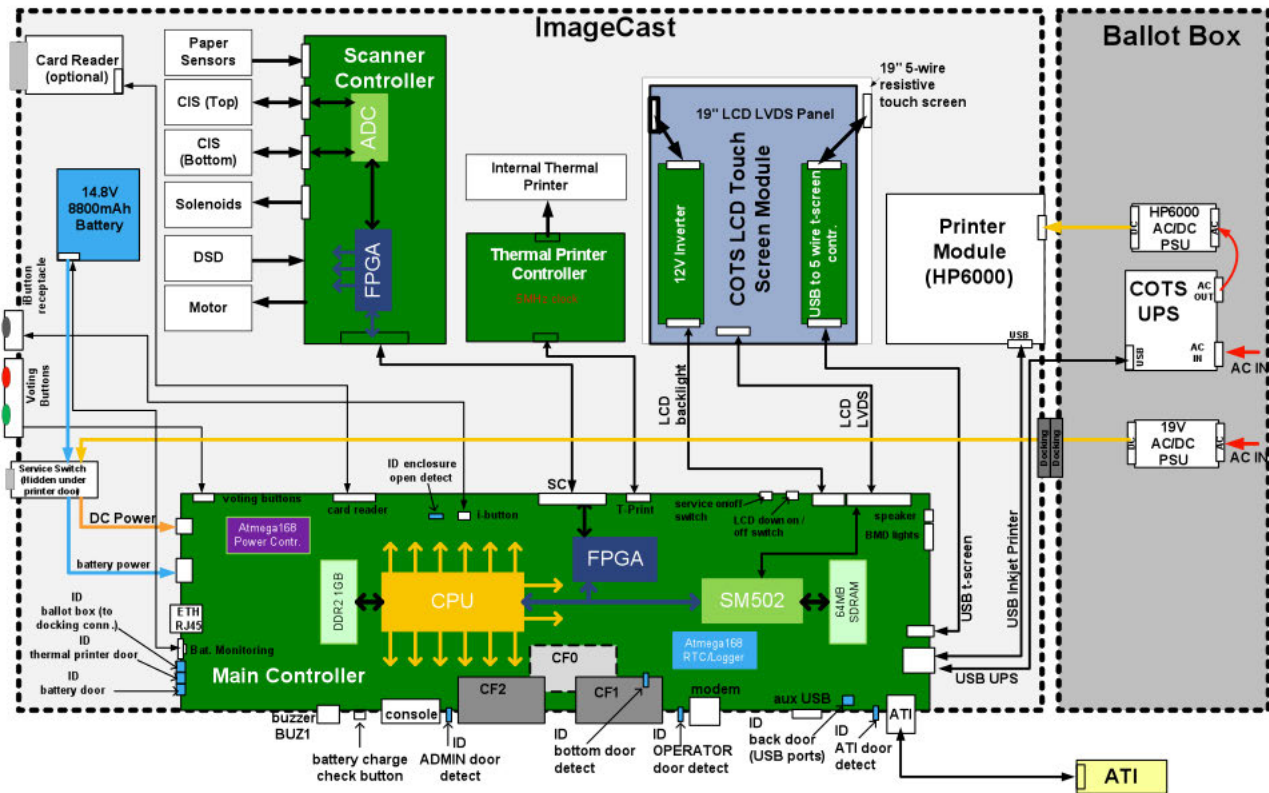
Figure 3.8: The ImageCast® Evolution Functional Block Diagram.

The ImageCast® Evolution major system elements are:

- Operating System - Linux 2.6.30

- Main Controller - MPC8347E PowerPC Processor-based circuit that provides:

  - Overall control of all system elements

  - Main connectivity point for all other subsystems

  - 1GB of DDR2 DRAM, 4MB of onboard Flash, Xilinx FPGA (scan and print transport control, additional communication interfaces and system glue logic) and other electronic circuitry necessary for control of, and connectivity to, other ImageCast® sub-systems.

- Removable Memory Modules - Two memory packs (internal type II Compact Flash memory cards). CompactFlash is high-capacity solid-state flash-based memory that electronically complies with the Personal Computer Memory Card International Association ATA standards and supports a True IDE Mode that is electronically compatible with an IDE disk drive. The ImageCast® Evolution uses standard CF modules, like SanDisk Ultra II or similar, as Primary and Administration modules. Both modules have a Mean Time Before Failure (MTBF) greater than 1,000,000 hours and over 100,000 erase/program cycles.

- Scanner Controller - Part of the ImageCast® Evolution system that represents a centralized place for paper feed mechanism control which connects optical, mechanical, and electrical peripherals that are used in the process of ballot scanning and printing. The main control logic for the ballot scanning process is located inside the Main Controller FPGA which feeds the Scanner Controller with commands. Based on these commands, the Scanner Controller controls and monitors scanning peripherals. It also processes signals from these peripherals and passes them to the Main Controller FPGA.

- Scanners - The ImageCast® Evolution uses two optical imaging scanners (ON Semi's dual output analog 200 DPI Contact Image Scanners) to create a duplexed scanned image of each side of the ballot.

- Display - A 19" backlit liquid crystal display with integrated touch screen functionality. that is used for displaying software-controlled messages to voters and election officials. The ImageCast® Evolution uses a custom assembled 19" LCD Touch screen module that contains the following electrical subsystems:

  - M190EG01 LCD panel with 5 wire touch screen 97M190E1N0F-06

  - LCD Inverter 32AQF132V3F

  - Touchpanel Controller 89C150UA0F

- Graphic Chip-SM502 located on the Main Controller, responsible for driving the 19" LCD.

- Internal Printer - A thermal print mechanism for generating, starting, and ending reports. Internal Printer Circuitry includes a Printer Control Board and an integrated printer LTPC235 (off-the-shelf thermal line dot printer with a resolution of 6 dots/mm). The Printer Control Board provides logical control of the printer and consists of the printer controller, PT800P01, and a step motor driver.

- iButton - The ImageCast® Evolution 's iButton security key interface uses an iButton reader (physically attached to the side of the unit and electrically connected to the motherboard) and an iButton security key (Dallas DS1963S SHA-1) to provide a variety of verification and security tasks related to access control, data confidentiality, and integrity functions.

- Paper Feed Mechanism - A motorized mechanism that detects and moves the paper ballot within the tabulator. It is intended for handling ballots 8.5 inches (216 mm) wide by a variable length (minimum 11", maximum 22"). The paper feed mechanism that is able to move the ballot paper forward into the machine and across image sensors and enable complete images to be captured of both sides of the ballot. The Paper Feed Mechanism can also transport paper during ballot printing.

- Ballot Diverter - Device that is physically able to divert ballots into a separate compartment within the ballot box.

- External AC/DC Power Adapter - External Power Supply with all required safety and FCC approvals.

- Battery Pack - Internal battery pack capable of powering the scanning system for at least three hours. The battery type is Li-Ion. The battery compartment is large and contains inserts that allow it to be adapted to different battery types.

- Ballot Printer (printer module) - The COTS USB-based printer is part of the accessible voting hardware and is used to print ballots when the voter has finished making their ballot selections.

- ATI - The Audio Tactile Interface is a handheld device used by a voter during an accessible voting session to navigate and make selections to their ballot.

- LCD Screen - As part of the ballot marking capabilities of the ImageCast$^{\circledR}$ Evolution platform, a large (19") LCD display is used to preview electronic versions of the ballot used during the accessible voting session. The system allows zoom and contrast control.

- Ballot box - contains several key elements, such as multiple storage compartments (main, diverted, auxiliary), and multiple locks and doors. It is an integrated component of the voting system, with security arrangements to prevent unauthorized access to the tabulation component, and has a locking access door for all ballot areas.

- Packaging - The unit is stored and transported in a cardboard box packed with foam for vibration and impact protection and ease of use.

3.3.2   Safety and Compliance

The ImageCast$^{\circledR}$ Evolution system complies with the following standards:

- Safety - UL 60950-1.

- Electrical Power Disturbance - IEC 61000-4-11 (1994-06) standard (Voltage dips, short interruptions, and voltage variations immunity)

- Electrical Fast Transient - IEC 61000-4-4 (1995-01) standard (Electrical fast transient/burst immunity)

- Lightning Surge - IEC 61000-4-5 (1995-02) standard (Surge immunity test)

- Electrostatic Disruption - IEC 61000-4-2 (1995-01) standard (Electrostatic discharge immunity)

- Electromagnetic Radiation - FCC Part 15 Class B requirement

- Electromagnetic Susceptibility - IEC 61000-4-3 (1996) standard (Radiated, radio frequency, electromagnetic field immunity)

- Conducted RF Immunity - IEC 61000-4-6 (1996-04) standard (Immunity to conducted disturbances induced by radio-frequency fields)

- Magnetic Fields RF Immunity - IEC 61000-4-8 (1993-06) standard (Power frequency magnetic field immunity)

3.3.3 Environmental

The ImageCast® Evolution system complies with the MIL-STD-810-D standard, Method 502.2 and Method 501.2, with test conditions described in VVSG Volume II § 4.7.1 (low and high temperature tests). In addition, the ImageCast® Evolution system complies with the following standards:

- MIL-STD-810D, Method 516.3, Procedure VI (drop test)

- MIL-STD-810D, Method 514.3, Category 1 - Basic Transportation, Common Carrier (vibration test)

- MIL-STD-810D, Method 502.2, Procedure I-Storage (high and low temperature test; 4 hours at $-4\,°F$) and 4 hours at $+140\,°F$)

- MIL-STD-810D, Method 507 Humidity test, as specified in VVSG Volume II § 4.6.1.

3.3.4 Data Network

The Democracy Suite® platform in its EMS Express, EMS Standard, and EMS Enterprise configurations does not use public communication networks for its operation. However, the EMS Standard/ImageCast® Listener includes two different hardware configurations, as described in sections 3.1.3 and 3.1.4. These configurations are specifically designed to allow the ImageCast® Precinct and ImageCast® Evolution to use public telecommunications networks to send results to the EMS Data Center in a secure manner.

3.3.5 Input Power

The ImageCast® Evolution uses a COTS UL approved FranMar AC Adaptor as a main power source to provide 19V DC power to the ImageCast® Evolution internal electronic subsystems. The AC adapter requires an input voltage of 120V 60Hz.

3.3.6 Physical Access Control

3.3.6.1 Door Coverage

Each ImageCast® Evolution door is secured with an appropriate locking mechanism.

3.3.6.2 Security

The ImageCast® Evolution is equipped with an electronic iButton security key reader. This reader, in combination with the iButton security key, performs a variety of verification and security tasks pertaining to access control, data confidentiality and integrity functions. The content of the iButton security key is protected by the user's password which must be entered each time the key is used. Every result file created by the ImageCast® Evolution is protected by signing and encryption using the Secure Hash Algorithm (SHA) and Advanced Encrypted Standard (AES). The algorithm can be protected by the security hardware machine or the open SSL FIPS certified library.

A detailed hardware description is provided in *2.04 - ImageCast® Evolution System Hardware Specification* and *2.04.1 - ImageCast® Evolution System Hardware Characteristics*.

3.4 The ImageCast® Central Operational Environment

3.4.1 Functional Elements

The ImageCast® Central consists of an optical ballot scanner and an attached ballot image and an election rules processing workstation.

The ImageCast® Central Scanner uses internal cameras to capture and digitize both sides of a document in a single scan. Depending on the scanner model used, scanner speeds can reach as high as 150 pages per minute (letter size paper).

The ballot image processing station is a COTS PC workstation, connected to the ImageCast® Central Scanner via a USB interface. All ImageCast® Central Workstations are connected via a Gigabit Ethernet port (through a local area network) to the EMS datacenter network. This network stores all results. The ImageCast® Central Workstation consists of the following main parts:

- Microsoft Operating System - Windows 8.1 Professional x64

- Processor - Intel Core 2 Duo or better

- Memory - 4GB or more

- Hard Drive - 320GB or higher SATA Hard Drive

3.4.2 ImageCast® Central Scanner Safety and Compliance

3.4.2.1 FCC Compliance

Following Part 15 of FCC rules, this equipment has been tested and found to comply with the limits of a Class B digital device.

For complete safety and compliance information, please read the vendor's original documentation.

3.4.3 The ImageCast® Central Workstation Safety and Compliance

For a detailed list of safety and compliance certifications, please read the PC Workstation safety and compliance reports which are supplied as part of this Technical Data Package.

3.4.4 Environmental

The ImageCast® Central Scanner equipment has been designed to operate in a normal office environment. To ensure that the environment complies with the required setup conditions, perform the following:

- Ensure that room housing the scanner is clean, well ventilated, and free of combustible vapors.

- Ensure the minimum clearance on both sides and the rear of the scanner is at least 4" (101.6 mm). Physical Device size is (H x W x D): 14.8" x 20.8" x 22.2".

- Ensure all electrical outlets are properly grounded. Use of a dedicated power line is recommended.

- Place the scanner on a level surface.

For the ImageCast Workstation environmental information, please read the vendor's original documentation.

3.4.5 Data Network

The ImageCast® Central Scanner is not connected to any data network directly. However, it is directly connected to the ImageCast® Central Workstation.

The ImageCast® Central Workstation uses a standard Gigabit Ethernet port to connect to a Local Area Network.

3.4.6 Input Power

Canon scanners require input voltage to be 120-240 V, 50-60 Hz (or 120V, 60Hz depending on the region) and auto-sensing. Power consumption is a maximum of 125 watts.

For the ImageCast® Central Workstation power input requirements, please read the vendor's original documentation.

3.5 The ImageCast® Listener Operational Environment

The system requirements for the Democracy Suite® EMS using the ImageCast® Listener may vary depending on the deployment scenario. However, because of its modularized architecture, it is possible to define the system requirements for each of the components.

EMS Standard/ImageCast® Listener hardware configuration consists of local network deployment of EMS software components with access to the public telecommunication networks used to receive data result transmissions from the ICP and ICE devices. The access to public telecommunication networks requires the implementation of security measures to assure the integrity of the platform with this particular configuration. Refer to the sections 3.1.3 and 3.1.4 for more information about the hardware configurations available.

The Democracy Suite® EMS/ImageCast® Listener platform consists of multiple software components:

- EMS Election Event Designer (EED): Enduser application

- EMS Results Tally and Reporting (RTR): Enduser application

- EMS Audio Studio (AS): Enduser application

- EMS Adjudication Application (ADJ): Enduser application

- EMS File System Service (FSS): Enduser application

- EMS Election Data Translator (EDT): Enduser application

- EMS Results Transfer Manager (RTM): Enduser application

- EMS Election Data Exchange Station (EDES): Enduser application

- EMS Application Server (APPS): Backend application

- ImageCast Listener (Listener Service): Backend application

- EMS Shell Service (Web Service): Backend application

- DVS Transmission Dashboard (Windows Application): Frontend application

- Cartridge Manager (Windows Service): Backend application

- EMS Service (Web Service): Backend application

- EMS Network Attached Storage (NAS): Backend file repository component

- EMS Database Server (DB): Backend database repository component

- EMS Datacenter Manager (DCM): Backend configuration component

- EMS AIMS Data Translator (AIMS DT): Enduser application

- EMS Mobile Ballot Production (MBP): Enduser application

- EMS WinEDS Importer (WinEDS): Enduser application

- ImageCast® Adjudication (ADJSVC): Backend application

3.6 The ImageCast® X Operational Environment

3.6.1 Functional Elements

The ImageCast® X platform consists of following elements:

- One or more voting terminals - Android tablet: Samsung Galaxy Tab Pro 12.2

- Printer (one per voting terminal) - Dell B1260dn Mono Laser Printer

- Magtek Dynamag USB magnetic card reader (attached to each Android tablet via Lava Adapter)

- Local data center - Dell Latitude 7440

- MSR606 Magnetic Stripe Card Reader Writer Encoder attached to Local data center

- Network switch - Dell PowerConnect 2824 24-port switch

3.6.2 The ImageCast® X Hardware Configuration

ImageCast® X platform consists of following elements:

- Local data center

- One or more voting terminals

ImageCast® X local data center can be any desktop class PC or a laptop computer. Recommended hardware configuration for Local data center is:

- Intel ® Core i7-4600U Processor (2.1 GHz, 4M Cache) or equivalent

- 16GB of 1600MHz DDR3 Memory

- 250GB SSD hard drive

- Network interface (Ethernet)

- USB 2.0 Port

ImageCast® X Tablet consists of:

- Android tablet Samsung Galaxy Tab Pro 12.2

- Lava STS-2UE (2-port USB Hub and LAN adapter)

- Tecla Shield DOS

- Dell B1260dn Mono Laser Printer

Local data center and voting terminals are interconnected through wired network. For interconnections requirements are:

- Dell PowerConnect 2824 (24-port switch with DHCP) or similar

- CAT 5E network cables (two per voting terminal plus one for local data center

Following image represents physical connections in standard Voting Service Center:
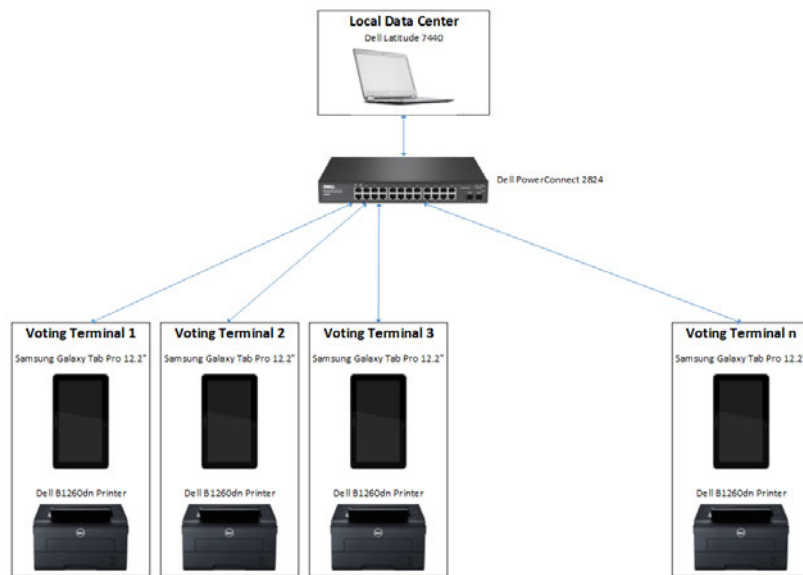
Figure 3.9: Voting Center

3.6.3 ImageCast® X Software Configuration

Local data center software requirements are as follows:

- Microsoft Windows 8.1

- Microsoft .NET Framework 4.5.1

- Microsoft IIS 7.5

- Microsoft SQL Server 2012 with SQL Server Express 2012 Advanced Services installed

Voting terminal software requirements are as follows:

- Android OS version 4.4.2

- SamsungTTS HD Spanish version 1.2

- SamsungTTS HD US English version 1.2

3.6.4 ImageCast® X Physical Interfaces

The ImageCast X Local data center has an integrated USB port that is used to connect MSR606 Magnetic Stripe Card Reader Writer Encoder. The ImageCast X Local data center also contains built-in standard PC physical interfaces (USB, keyboard, mouse, monitor, Ethernet etc.). Ethernet port is connected to the network switch using CAT 5E LAN cable.

The ImageCast X Voting Terminal has standard USB port that is used to connect to Lava USB Hub and LAN Adapter (which has 2 USB ports, one Ethernet port and power mini USB port). Lava Adapter has one USB port connected to Magtek Dynamag USB magnetic card reader, Ethernet port is connected to network switch using CAT 5E LAN cable and mini USB port connected to tablets power adapter.

If ImageCast X Voting Terminal need to comply to Americans with Disabilities Act, then Lavas Adapters second USB port is connected to Tecla Shield device. Tecla Shield device supports connection to assistive switches (buttons, sip-and-puff controllers, pedals, joysticks, wheelchair driving controls).

Chapter 4

System Performance

4.1   The Democracy Suite® EMS System Capacity

The Democracy Suite® EMS platform does not impose any restrictions on the following system capacity aspects related to the problem domain:

- Number of EMS EED client applications simultaneously used within the system

- Number of EMS RTR client applications simultaneously used within the system

- Number of election projects supported by a single instance of the system

- Size and complexity of the election project structure (number of political subdivisions, number of contests and candidates, number of polling locations, ImageCast® tabulators, etc.)

The tables 4.1 and 4.2 presents the system limitations in regards to ballot orientation:

Limit (Maximum Number of)	Value (by configuration)			Limiting Component
	Express	Standard	Enterprise	
Ballot Positions	292	292	292	22 Inch Landscape Ballot (240 candidates + 24 write-ins + 28 Yes/No choices)
Precincts in Election	250	1000	10000	Memory
Contests in Election	250	1000	4000	Memory
Candidates/Counters in Election	2500	10000	40000	Memory
Candidates/Counters in Precinct	240	240	240	22 Inch Landscape Ballot
Candidates/Counters in Tabulator	2500	10000	10000	Memory
Ballot Styles in Election	750	3000	30000	Memory
Contests in a Ballot Style	38	38	38	22 Inch Landscape Ballot (24 candidacy contests + 14 propositions)
Candidates in a Contests	240	240	240	22 Inch Landscape Ballot
Ballot Styles in a Precinct	5	5	5	Memory
Number of Parties	30	30	30	Memory
Vote For in Contest	24	24	24	22 Inch Landscape Ballot
Supported Languages per Election	5	5	5	Memory
Number of Write-ins	24	24	24	22 Inch Landscape Ballot

Table 4.1: Democracy Suite® System Limits (Landscape Ballot Orientation).

Limit (Maximum Number of)	Value (by configuration)			Limiting Component
	Express	Standard	Enterprise	
Ballot Positions	462	462	462	22 Inch Portrait Ballot
Precincts in Election	250	1000	10000	Memory
Contests in Election	250	1000	4000	Memory
Candidates/Counters in Election	2500	10000	40000	Memory
Candidates/Counters in Precinct	462	462	462	22 Inch Portrait Ballot
Candidates/Counters in Tabulator	2500	10000	10000	Memory
Ballot Styles in Election	750	3000	30000	Memory
Contests in a Ballot Style	156	156	156	22 Inch Portrait Ballot
Candidates in a Contests	231	231	231	22 Inch Portrait Ballot (Column Span 3)
Ballot Styles in a Precinct	5	5	5	Memory
Number of Parties	30	30	30	No Limitation
Vote For in Contest	30	30	30	No Limitation
Supported Languages per Election	5	5	5	Memory
Number of Write-ins	462	462	462	22 Inch Portrait Ballot

Table 4.2: The Democracy Suite® System Limits (Portrait Ballot Orientation).

All of the above listed system capacity attributes are limited with regards to the number and size of the underlying computing and networking infrastructure:

- EMS hardware configuration deployed

- Number of Gigabit Ethernet ports on the active network equipment

- Number and size of the hard disk storage media on the EMS Database Server and NAS servers

4.2   The ImageCast® Evolution System Capacity

The following is a list of recommended precinct system limitations:

- 2500 stored ballots per scanner unit

- 100 EDs per scanner unit

- 100 ballot styles per scanner unit

- 900-2000 voters per day depending on the ballot complexity

The ImageCast® Evolution (ICE) system capacity can be measured by processing speed and memory card capacity. The ballot processing speed is defined by the ballot size (length). The average ImageCast® ballot processing speed is in the range of two seconds.

Images of all paper ballots are processed on the tabulator and saved on the memory card. Memory card size (available in 2GB, 4GB, 8GB and 16GB) is important in determining the ImageCast® 's ballot storage capacity.

The ICE memory card has only one partition that holds the ballot images, election database, audio files, etc. Table 4.3 below shows the approximate ballot capacities for various ballot size and memory card size when 512MB is estimated for the election database, audio files, etc. and the remaining space is allocated for storing ballot images. The ICE requires approximately 600kb per processed 22" double-sided ballot.

The ICE unit monitors the memory card free space and will warn the pollworker when the remaining free spaces reaches 5%. At 2% remaining free space, the ICE unit will process the current ballot in progress and will not allow any further ballots to be processed on that memory card.

Ballot Size (Single-Sided)	Approx. Ballot Image Size (KB)	Memory Card Size			
		2GB	4GB	8GB	16GB
8.5" x 11"	250	6000	14000	30000	62000
8.5" x 14"	277	5400	12600	27000	55800
8.5" x 17"	312	4800	11200	24000	49600
8.5" x 20"	334	4500	10500	22400	46400
8.5" x 22"	357	4200	9800	21000	43400
Ballot Size (Double-Sided)					
8.5" x 11"	357	4200	9800	21000	43400
8.5" x 14"	454	3300	7700	16500	34100
8.5" x 17"	499	3000	7000	15000	31100
8.5" x 20"	555	2700	6300	13500	27900
8.5" x 22"	624	2400	5600	12000	24800

Table 4.3: ImageCast® Evolution Ballot Image Capacity for Various Ballot Sizes and Memory Card Sizes

As an example, on a memory card programmed for Miami-Dade election on an early voting unit that contains 749 precincts (with some splits), the election database with audio files and other required files consumes approximately 2.7GB of the memory card space. Alternatively, on a memory card programmed with for the same election with one (1) precinct, the election database, audio files and other required files only consumes 12MB of the memory card space. When determining memory card capacity, it is important to understand how much of the memory card space will be consumed with the election programming data and how much space remains for ballot image storage.

4.3 The ImageCast® Precinct System Capacity

The following is a list of recommended precinct system limitations:

- 2500 stored ballots per scanner unit

- 100 EDs per scanner unit

- 100 ballot styles per scanner unit

- 900-2000 voters per day depending on the ballot complexity

The ImageCast® Precinct system capacity can be measured by processing speed and memory card capacity. The ballot processing speed is defined by the ballot size (length). The average ImageCast® Precinct ballot processing speed is within the range of six to seven seconds.

Images of all paper ballots are processed on the tabulator and saved on the memory card. Memory card size (available in 2GB, 4GB, 8GB, and 16GB) determines the ImageCast® 's ballot storage capacity.

The ICP memory card has a fixed partition that holds the election database, audio files, etc., and the remaining space on the memory card is used for storing ballot image files. Table 4.4 shows the approximate ballot capacities for various ballot size and memory card size when 512MB is used for the fixed partition that holds the election database, audio files, etc., and the remaining space is allocated for storing ballot images. The ICP requires approximately 600kb per each processed, 22" double-sided ballot.

The ICP can be configured through its DCF configuration settings to limit the maximum number of ballots that can be processed onto a memory card. Based on the ballot sizes to be processed through a unit, along with the information in the table below, the election administrator can determine a maximum value for the number of ballots to be processed on a memory card in order to configure the DCF configuration settings for that unit.

Ballot Size (Single-Sided)	Approx. Ballot Image Size (KB)	Memory Card Size			
		2GB	4GB	8GB	16GB
8.5" x 11"	258	5800	13500	29000	59900
8.5" x 14"	286	5200	12200	26200	54200
8.5" x 17"	325	4600	10700	23000	47700
8.5" x 20"	352	4200	9900	21300	44000
8.5" x 22"	382	3900	9100	19600	40500
Ballot Size (Double-Sided)					
8.5" x 11"	382	3900	9100	19600	40500
8.5" x 14"	476	3100	7300	15700	32600
8.5" x 17"	517	2900	6800	14500	30000
8.5" x 20"	564	2600	6200	13300	27500
8.5" x 22"	633	2400	5500	11800	24500

Table 4.4: ImageCast® Precinct Ballot Image Capacity for Various Ballot Sizes and Memory Card Sizes

4.4 The ImageCast® Listener System Capacity

The ImageCast® Listener has the default capacity to handle a queue of up-to 250 concurrent incoming transmissions. The number of concurrent cartridges that can be processed is dependent on server's resources.

4.5 The ImageCast® Central Count System Capacity

Depending on the scanner used, ImageCast® Central provides a scanning speed of up to 150 pages per minute. Multiple ImageCast® Central systems can be used in parallel to increase overall system capacity.

4.6   Quality Attributes

4.6.1   The Democracy Suite® EMS Quality Attributes

The Democracy Suite® EMS platform is architected, designed, and developed according to the software quality metrics defined in ISO 9126, which was overseen by ISO 25000:2005. In addition to the subjects described in this section, these software quality metrics include system functional areas, such as security, accuracy, interoperability, etc.

In some cases, overlap occurs between international standards that contain IEEE recommendations. This is especially true with the IEEE 982 series of recommendations, which are also related to software level quality metrics. In addition, the EMS platform quality attributes are strongly related to the accepted software development processes and methodologies. In this situation, these processes and methodologies are based on Unified Process (UP) and Agile software development practices.

4.6.1.1   Reliability

Software system reliability is determined by the quality of the software development processes, as well as the products of these processes. Some examples include functional, design and test document sets, source code, and accepted development best practices.

As a primary goal, these processes, and the products of these processes, must help prevent software errors from occurring. They must also assist in the detection and removal of faults. Doing so provides more reliable and fault-free software platforms.

To prevent errors related to programmer actions or omissions that result in software failures, the system functional requirements must be clearly defined to begin. If software development teams know what they must design and develop from the outset, they will produce a smaller number of errors. However, in this case, the software methodology process is based on the Unified Process which is iterative in nature. This means that the definition of requirements is also repetitive.

During the initiation of a software development project, more emphasis is placed on the definition of requirements and less on development and testing. However, in later iterations, the amount of time spent on defining requirements is reduced, while the time spent on development and testing increases. This approach is based on the rational that it is often impossible to define all software system functional requirements before the rationale development process begins. This approach is most common for the failure-prone "waterfall" software development methodology. According to this perspective, the Democracy Suite® EMS platform is based on the clearly defined, documented, reviewed, and approved functional requirements blueprint document.

The next step in preventing errors is to reduce the complexity of the software modules that comprise the Democracy Suite® EMS platform. The complexity of software modules is slightly more difficult to define for object-oriented software platforms such as the Democracy Suite® EMS platform than for procedural programming languages. However, in both cases, software module complexity can be analyzed by taking into account the size, dependencies and logical (data flow) complexity of the software modules.

The next step in refining the source code is the execution of two additional code analysis tools:

- Microsoft FxCop: A code analysis tool that checks .NET C# (programming language used for Democracy Suite® EMS development) managed code assemblies so that they conform to the Microsoft .NET Framework Design Guidelines. This tool uses reflection, MSIL (Microsoft Intermediate Language) parsing, and call-graph analysis to inspect assemblies for more than 200 defects in the following areas:

  - Assembly design
  - Localization
  - Naming conventions
  - Performance
  - Security

- Refactoring and code inspection tools: Code refactoring improves source code readability, simplifies its structure, and enforces coding standards and best practices without changing the code logic. The code inspection tools aid in the process of peer-to-peer code review among developers and business stakeholders.

According to functional specifications and the corresponding test specifications, Democracy Suite® EMS source code is only prepared and approved for system level testing procedures after these phases are performed. Because Democracy Suite® EMS follows this approach, it is one of the most reliable election management systems.

4.6.1.2 Maintainability

Software development practices used in the Democracy Suite® EMS development process are fully applicable to the maintainability quality metrics. The primary maintainability attributes provided by this development methodology are greater system stability, analyzability, changeability, and testability. As a result it is easier to maintain source code and correct problems found in the field or testing lab after the initial software release and, by following the over all ISO 20000 (ITIL), to maintain source code and correct problems found in change and release management process.

4.6.1.3 Availability

The Democracy Suite® EMS platform utilizes off-the-shelf standard computing technologies, such as server and workstation computers. In addition, full system deployment relies on active and passive networking equipment. Proper configuration of these application-hosting platforms is essential in establishing overall system availability. Democracy Suite® EMS is an election project oriented platform, where as the EMS Database Server is the central repository of the defined pre-voting data and post-voting election results. As a result, the main goal of this availability strategy is to properly architect the back-end system components.

As described previously, the EMS Database Server is implemented on top of MS SQL Server 2008 and hosted on industrial-grade server hardware. By utilizing RAID disks and redundant pairs of database server platforms with scheduled replications of the database, seamless availability of the back-end system is achieved.

4.6.1.4 Usability

The graphical user interface of the Democracy Suite® client applications (Election Event Designer and Results Tally and Reporting) is designed with usability best practices in mind, and take into account the following usability attributes:

- The size of the text and the graphical components of the application interface

- The color selection of the interface components

- Support for all hosting operating system accessibility functions (magnification, etc.)

- Availability of context help screens, as well as detailed user manuals

- Availability of dynamic training materials

4.6.1.5 Portability

Three main attributes are considered in the definition of portability: installability, replaceability, and adaptability. Democracy Suite® EMS integrates a simple procedure to be followed in the installation of Election Event Designer and Results Tally and Reporting client applications. The process is similar to the installation of any MS Windows application.

Replaceability can be considered at an application, library, or source code level. From an application point of view, new releases of the EED and RTR client applications can be installed without uninstalling the previous versions, while maintaining backward compatibility.

On the library level, the system does not allow single library files to be replaced without re-installing the complete application. This practice is enforced to protect the application's overall integrity.

Finally, on the source level, the application code is written in the .NET Framework C# programming language, but components of the system can be replaced by using differently managed components written in other object-oriented programming languages.

Adaptability of the EMS platform components is defined on the level of the overall application. This means that applications contain certain operational requirements that cannot be changed (for example, EED and RTR both require Windows OS with .NET Framework 4.0 to be installed). However, the application may be adapted towards different user groups based on the application's roles or language profiles.

4.6.2 The ImageCast® Evolution and ImageCast® Precinct Ballot Counter Quality Attributes

The ImageCast® Evolution and ImageCast® Precinct Ballot Counter Quality Attributes (reliability, maintainability, availability, etc.) are fully defined in *2.04.1, ImageCast® Evolution System Hardware Characteristics* and *2.04.1, ImageCast® Precinct System Hardware Characteristics*. The following is a brief overview of the Ballot Counter Quality Attributes.

4.6.2.1 Reliability

The ImageCast® system is designed for use in real-world election conditions. The measurements below measure the total operating time before failure.

For certification testing, the system operations scenario consists of approximately 45 hours of equipment operation, 30 hours of equipment set-up and readiness testing, and 15 hours of elections operations.

For Dominion's internal purposes, system operation only consists of the hours in which the machines are in operation in the voting locations (approximately 11 hours each voting day). This is significantly more stringent than the certification requirement.

The measured values from 2008 onwards are as follows:

MTBF	900 hours

4.6.2.2 Maintainability

The ImageCast® system is designed to be used in real-world election conditions. One aspect of the mobile computing equipment is that repairs can be made if damage occurs.

The system meets the maintainability requirements of the VVSG. Please refer to *2.04 - ImageCast® Precinct System Hardware Specification* and *2.04.1 - ImageCast® Precinct System Hardware Characteristics* for performance measurements.

The measured values from 2008 onwards are as follows:

MTTR	0.54 hours

4.6.2.3 Availability

The ImageCast® system is designed for use in real-world election conditions. Availability is a key performance indicator taken into account in the design of the system.

The system meets the reliability requirements of the VVSG. Please refer to section 4.6.2.1

The measured values from 2008 onwards are as follows:

Ai	99.94%

4.6.2.4 Usability

The ImageCast® system is designed for use in real-world election conditions. Usability is a key performance indicator considered during system design.

Deterministic study objectives are defined to evaluate the voting system against a set of usability requirements. The primary objective is to provide the voter with the opportunity to test and help improve the usability of the device. Studies are conducted regularly to collect and identify areas that require improvement and to determine to what level the system suits the needs of each voter.

An important aspect worth noting is the ability to provide feedback to the design team to facilitate final improvements to the ballot counting system. Changes may be performed on existing units or may be the subject of future enhancements. Test results for the ImageCast® Evolution will be added when available.

4.6.2.5 Portability

Based on its weight and size (as described in *2.04.1 - ImageCast® Precinct System Hardware Characteristics* and *2.04.1 - ImageCast® Evolution System Hardware Characteristics*) the ImageCast® Evolution and ImageCast® Precinct Counter hardware satisfies practical portability requirements for the precinct optical scan ballot tabulator.

4.6.3 The ImageCast® Central Ballot Counter Quality Attributes

The ImageCast® Central Ballot Counter Quality Attributes (reliability, maintainability, availability, etc.) are covered in the scanner and ImageCast® Central Workstation vendor's documentation.

4.6.4 The Democracy Suite® Security Attributes

4.6.4.1 Safety

All system hardware components are tested against various standards to ensure safe operation and reduction of hazards. The ImageCast® Evolution ballot counter complies with the applicable UL 60950-1 standards for safety as well as the required performance characteristics prescribed in the VVSG:

- IEC 61000-4-2 through 6, 61000-4-8, and 61000-4-11

- FCC Class B

- MIL-STD-810D, various Methods

For more information, please refer to *2.04 ImageCast® Evolution Hardware Specification, Section Compliance.*

4.6.4.2 Security

Detailed security characteristics of the Democracy Suite® EMS platform are provided in *2.06 - Democracy Suite® System Security Specifications.* This section will briefly describe some of the security mechanisms used:

- Access control - authentication and authorization mechanisms are integrated within the core of the Democracy Suite® EMS system.

  - Access to the central EMS Database can only be performed indirectly by using the EMS EED, EMS RTR, and EMS EDT client applications.
  - The system integrates centrally managed role-based user management.
  - Each role contains a set of permissions that allow or disallow certain system functions.
  - Users always belong to a certain role and cannot perform actions outside the scope of this role.
  - Users have a set of credentials they must use to log in and use the system.

- Data security - data confidentiality and integrity are the mechanisms used to manage data security.

  - Election definition data and voting results data are always stored and transferred in encrypted format.
  - The algorithms used are standards-based and NIST approved (AES).

- Election definition data and voting results data are always signed using one-way hashing algorithms for data integrity purposes.

- Algorithms used are standards-based and NIST approved (SHA).

- Network security - active networking equipment is selected and configured to support needed network level security mechanisms:

  - Anti-virus client protection is utilized for both internet and intranet facing systems.

4.6.4.3 Privacy

The Democracy Suite® EMS platform does not store any sensitive personal information, and especially not any information related to voters (electors). For the limited candidate information that the system does maintain, data is stored in the EMS Database, and any transference of such data, internally or externally, is protected with regards to authentication, authorization, confidentiality, and integrity. Voter privacy is maintained at all times in the voting location. Ballot secrecy folders are provided to cover ballot selections. No system function is able to tie a voter to a vote selection, even indirectly via an activation key.

4.6.4.4 Continuity of Operation

As part of the overall risk management process, risk analysis and mitigation techniques have been defined for the Democracy Suite® EMS continuity of operation. Appropriate processes for the system continuity actions have been defined based on EMS system architecture, impact analysis, and threat analysis.

In the case of the EMS platform, system operation can be jeopardized due to a variety of factors, such as natural disasters, power failures, computing hardware failures, system security breaches, or internal faults within the system. The latter is the most controllable aspect within the system, and some of its mitigation processes have already been addressed. Mitigation for most of the remaining threats should be covered according to defined procedures.

In the case of power failure, the system should deploy appropriate uninterruptible power supply devices that preserve the current state of the system. The damage caused by possible computer hardware failures can be lessened by using redundant systems and by performing scheduled backups. Proper security mechanisms, briefly described in the previous section, should be integrated at the core of the system, thus providing the least amount of vulnerable surface area.

With regards to precinct equipment, all systems are designed to be replaceable during voting hours in order to maintain continuous operation.

4.6.5 The Democracy Suite® System Constraints

4.6.5.1 Design Constraints

The Democracy Suite® EMS system operation requirements were defined in Section 3. There are no other software platform constraints.

4.6.5.2 Applicable Standards

The following standards and recommendations are applicable to Democracy Suite® EMS platforms:

- ISO 20000

- ISO 25000

- ISO 17799/27002

- Dominion Democracy Suite® Coding Standards (internal)

- ECMA 224 - C# Language Specification

4.6.5.3 Compatibility

The Democracy Suite® EMS system operation requirements were defined in Section 3. The system is compatible with VVSG 2005 Volume I and II requirements.

4.6.6 The ImageCast® Evolution System Constraints

4.6.6.1 Continuity of Operation

Please refer to the following TDP documents: *2.03 - ImageCast® Evolution Functionality Description 2.04 - ImageCast® Evolution System Hardware Specification*

4.6.6.2 Design Constraints

The ImageCast® Evolution has been designed to meet functional, performance, safety, regulatory, and cost requirements. Design constraints are covered in *2.04.1 - ImageCast® Evolution System Hardware Characteristics.*

4.6.6.3 Applicable Standards

Applicable ImageCast® Evolution HW-related standards are covered in *2.04 - ImageCast® Evolution System Hardware Specification* and in *2.04.1 - ImageCast® Evolution System Hardware Characteristics.* These documents include compliance and interface (Compact Flash, RS232, USB, etc.) standards.

4.6.7 The ImageCast® Listener System Constraints

4.6.7.1 Continuity of Operation

Please refer to *2.08 - ImageCast® Listener System Operation Procedures* for more information.

4.6.7.2 Design Constraints

The ImageCast® Listener has been designed to meet functional, performance, safety, regulatory, and cost requirements. Design constraints are covered in *2.08 - ImageCast® Listener System Operation Procedures* and *2.05 - ImageCast® Listener Software Design and Specification.*

4.6.8   The ImageCast® Precinct System Constraints

4.6.8.1   Continuity of Operation

Please refer to the following TDP documents: *2.03 - ImageCast® Precinct Functionality Description*, *2.04 - ImageCast® Precinct Tabulator System Hardware Specification* and *2.08 - ImageCast® Precinct System Operation Procedures*

4.6.8.2   Design Constraints

The ImageCast® Precinct has been designed to meet functional, performance, safety, regulatory and cost requirements. Such design constraints are covered in *2.04.1 - ImageCast® Precinct System Hardware Characteristics.*

4.6.8.3   Applicable Standards

Applicable ImageCast® Evolution Hardware-related standards are covered in *2.04 - ImageCast® Precinct System Hardware Specification* and *2.04.1 - ImageCast® Precinct System Hardware Characteristics* These documents include compliance and interface (Compact Flash, RS232, USB, etc.) standards.

4.6.8.4   Compatibility

The ImageCast® Precinct system is compatible with VVSG 2005 Volume I and II requirements.

4.6.9   The ImageCast® Central System Constraints

4.6.9.1   Design Constraints

ImageCast® Central hardware is based on two COTS devices which are selected to meet functional, performance, safety, and regulatory requirements. Design constraints for both COTS devices are covered in the scanner's and ImageCast® Central Workstation vendor's documentation.

4.6.9.2   Applicable Standards

Applicable ImageCast® Central Hardware-related standards are covered in the scanner's and ImageCast® Central Workstation vendor's documentation. If hardware related questions arise, please refer to the vendor's User manual that is provided with the hardware equipment, or contact your vendor for support.

4.6.9.3   Compatibility

The ImageCast® Central system is compatible with VVSG 2005 Volume I and II requirements.