● SAN FRANCISCO LOCAL AGENCY FORMATION COMMISSION

1 DR. CARLTON B. GOODLETT PL● SAN FRANCISCO, CA 94012

STUDY ON OPEN SOURCE VOTING SYSTEMS

FINAL REPORT

JASON FRIED, EXECUTIVE OFFICER

ANGELA LEE, RESEARCH INTERN

October 23, 2015

Table of Contents

I. Definition Of Terms

The following terms relate to open source voting system technology and will be used frequently in this report. For readers who are unfamiliar with open source technology, the following terms have been defined in order to avoid any confusion while reading this report. Any mention of the following terms, unless otherwise noted, will always refer to the intent and meaning as defined below:

Blended voting system: A voting system that incorporates components from more than one vendor or certified system.

Closed source: A term applied to software meaning that it is not open source. Also known as proprietary software.

Copyleft: A term that applies to when open source software is modified that those modifications must also remain open source.

COTS hardware: Commercial off-the-shelf hardware. Units that are already available in stores and can be commercially purchased, such as iPads, windows tablets, scanners, etc.

Disclosed source: A term applied to software meaning that the source code is publicly viewable. Such software can be either proprietary or non-proprietary.

Hardware: The physical part of election material—ballot box, tablet, etc. Controlled by the software.

Open source: A term applied to software meaning that the source code can be freely viewed, used, modified, and shared by the public.

Software: The program that is installed on to the hardware, controlling how the hardware functions.

Source code: The computer programming code that controls how the software functions.

II. Introduction

The objective of this report is to analyze the possibility of the City and County of San Francisco (CCSF) leading an effort to develop and use an open source voting system Currently, the CCSF contracts with the company, Dominion, for a proprietary voting system and election materials.

The impetus for this report stems from the passage of the Board of Supervisors Resolution No. 460-14: Supporting the Creation of Open Source Voting Systems – Studying New Models of Voting System Development. At the request of the Board of Supervisors, San Francisco's Local Agency Formation Commission (LAFCo) has undertaken a special study of open source voting systems and the collaborative development of such a system. This study, undertaken pursuant to Government Code §56378 and LAFCo Policies on Special Studies §2.6, §2.62, §2.63, and §2.64, was conducted with the intent of providing an objective analysis of these voting systems and relies primarily upon data and information provided by both public agencies and private groups.

To best provide empirical evidence for the purpose of this study, LAFCo examined numerous reports regarding open source election software, existing proprietary voting systems, and current open source voting system projects elsewhere in the nation; in addition to interviews with various public agencies such as the San Francisco Department of Elections (DOE) and the Secretary of State's Office of Voting Systems Technology Assessment. Interviews were also conducted with the Open Source Elections Technology (OSET) foundation, Open Voting Consortium (OVC), California Association of Voting Officials (CAVO), Los Angeles County Clerk's office, Travis County Clerk's office, Galois Inc., and professors from UC Berkeley.

III. Executive Summary

This report serves as an objective comparison of existing proprietary voting systems and a proposed open source voting system. The following also provides background information on open source voting systems and current projects taking place in other counties. Additionally, remaining questions and concerns regarding the development of an open source voting system are discussed.

While there is no complete open source voting system in place anywhere in the country, two counties are in the process of developing their own voting system that may become open source systems: Los Angeles County, California, and Travis County, Texas. Additionally, there are various organizations that have been in existence for years now, dedicated to the development of open source voting system technology. These agencies provide invaluable information on how to approach the development of an open source voting system, and which areas require more time and effort.

Based on research surrounding current open source voting system projects, along with extensive interviews with various election and computer software experts, officials from Los Angeles and Travis County, the California Secretary of State's office, and San Francisco Department of Elections office, LAFCo was able to conclude the following:

- In studying current proprietary systems, LAFCo learned there are only three proprietary companies that have certified systems to choose from in California, providing extremely limited options to counties.
- Several ongoing voting system projects can be adopted, and provide an opportunity for the CCSF to expedite the development of an open source voting system, if the CCSF chooses to develop their own voting system.
- In the past, security flaws have been discovered in machines from proprietary companies, resulting in the Secretary of State's decertification of these systems until they made improvements. While no one can reasonably claim that open source would be more secure than proprietary systems, advocates are firm in expressing open source and disclosed source software and technology is neither more or less secure than closed source or proprietary software.
- Proponents claim the adoption of an open source voting system provides a possibility of saving money and creating more innovative voting systems. For example, existing proprietary voting systems do not currently provide all desired ranked choice voting functionality; our current system with Dominion only allows the public to rank their top three candidates, instead of allowing them to rank all

of the candidates. The adoption of an open source voting system provides an opportunity to improve the way ranked choice voting takes place in the CCSF.

- Transparency and security are key components in open source voting system proposals. Advocates claim an open source voting system would be more transparent than a proprietary system, and the transparent nature of open source systems increases security; signs of insecure code could be spotted by security or tech-savvy members of the public.
- The development of open source voting systems takes a considerable amount of time, money, and effort, most of which is undeterminable at this point.
- There are several boundaries and limits to how a new voting system would function, based on California election law. That is not to say laws could not be changed, but if CCSF is to embark on creating a new system it would need to do so using the laws as they are at the time of creation of the new system and not on hope that laws will get changed.
- CCSF staffing is a key component that needs to be addressed in open source voting system proposals.

In regard to the breadth and scope of the conducted analysis, it is important to note that a complete open source voting system does not yet exist anywhere in the country; as such, the exact costs of developing the system are undetermined, and there is a lack of empirical evidence surrounding the success of open source voting systems.

Overview Of Systems

A. Existing Voting System with Dominion

Budget

The CCSF has contracted with Dominion since 2008. The up-front cost of the system was $9.64 million in 2008. This included the hardware purchase ($6.53 million); the software purchase ($1.40 million); and installation, training, and warehouse improvements ($1.71 million). This works out to $10.65 million in 2015. In addition to the up-front costs, there are per-year costs. In a year with two elections, the per-year cost is $1.38 million; in a year with one election the cost is $883,700[1]. These figures include hardware maintenance (e.g. parts and repairs) and software licensing fees, as well as fees for personnel and election services, logistical support, and Election Day preparation and operation (ballot layout, services management, staffing, transportation costs, on-site tech support, etc). After 2016, the total cost of voting system related expenses over nine years (combining up- front and per-year costs) is expected to be $19.69 million, which includes $8.16 million for hardware and $2.86 million for software. This averages to $2.19 million per year when spreading the up-front and per-year costs over the nine-year lifetime of the system. If the CCSF had used the system only for the originally anticipated six years 14 (four years with options to extend two additional years), the cost per year would have been $2.67 million per year. If the system had been used only for the original contract length of four years, the cost would have averaged to $3.45 million per year.

By extending the life of the current system from the original contract length of 4 years to 9 years the average cost per year for hardware; election services; and maintenance and license fees per year has gone from $3.45 million a year to $2.19 million per year.

Until now, the CCSF has had at least one election every year. However, recent changes indicate that no election is scheduled in 2017, and every four years thereafter. The DOE's contract with Dominion expires on January 1, 2017, therefore no payments are currently scheduled with the company after that date. Since this is the first time the CCSF will have a non-election year, the details surrounding what funds (if any) the DOE would need to spend—whether they work with a proprietary system or open source voting system—are unknown at this time.

Ballot tabulation

Currently, ballots that are submitted by mail and in-person are marked the same way; voters mark their vote on a paper ballot by completing the arrow to indicate their choice in each category. For in-person voting at polling places, non-provisional voters feed their marked ballot

[1] Provided by Director John Arntz, San Francisco Department of Elections

into a precinct-based scanner called the Insight purchased from Sequoia (which was acquired by Dominion in 2010). The Insight scans and tabulates ballots as they are inserted.

Vote-by-Mail (VBM) ballots are either mailed to the DOE or dropped off in person. These ballots are verified and then scanned by Dominion's Optech 400-C central count optical scan machine. The scanner was originally produced by Sequoia and ES&S systems.

Concerns about current system

Proponents of open source voting systems raise several concerns regarding the proprietary nature of this voting system:

1) Transparency. The source code, which determines how the voting system machines are run, is unknown to the public. There is no way to confirm that the system is free of serious security vulnerabilities. Additionally, the types of election reports that are available and their data format is limited to what the vendor has decided to implement.
2) Innovation. There are only three companies that produce certified voting systems in California: Dominion, ES&S, and Hart Intercivic. Proponents of open source voting systems argue that this lack of options creates little to no competition, and as a result the voting systems in place are outdated. Counties are "locked in" to contracts with these systems and cannot make any changes to the software unless the proprietary company decides to make those changes.
3) Obsolescence. Furthermore, several computer experts expressed their concerns that the current system in place will "term out" in 5 years, meaning the software and hardware components will become obsolete, as the parts are so old they are no longer in production. This would result in the county having to purchase brand new machines, or look for spare parts in other parts of the globe. For-profit companies selling proprietary software do not have an incentive to make their products last.
4) Cost. California spends an estimated $100 million per year to run elections, averaging to about $10 spent per ballot. As previously mentioned, the CCSF spends roughly $2.2 million per year for Dominion's hardware, software, and services, averaged over the 9-year lifetime of the system. This figure does not include the cost of ballots, poll workers, and other miscellaneous costs to run elections. Proponents of open source voting systems argue that their new system would save counties millions of dollars in the long run, since the software would be free to all jurisdictions once developed. In this sense, there is an economy of scale. Once the system is developed and certified, San Francisco would need to pay only for COTS hardware and election services. In addition, Dominion charges San Francisco per election for services to use its equipment. With a non-proprietary system, San Francisco would not be limited to a single vendor for services, opening up the possibility for more competitors and lower costs. Since the design and operation of open source software is public, any company could potentially provide services for that

equipment – not just the company with the internal knowledge of how it works. San Francisco could even act as its own vendor.

5) Security. Former Secretary of State Debra Bowen ordered a top-to-bottom review of the major voting system companies in 2007, instructing a team of computer software experts to perform a security review and examination of all the major voting system companies at the time (Hart Intercivic, ES&S, Sequoia, and Diebold). ES&S did not submit its system for review and the other three company's products were deemed defective and unacceptable and that time[2] and had their certification revoked until they made the recommended improvements to the system. Sequoia, the company the CCSF partnered with at the time of the reviews, has since gone out of business and the CCSF has replaced their services with Dominion. The Dominion system that CCSF uses is not the same system that was tested in Secretary Bowen's review; there is no record of any security review of Dominion systems but it did go through a full source code review was established by the Secretary of State's office. While there are testing labs that are tasked to inspect proprietary voting systems, a conflict of interest exists. Secretary of State Bowen did have an independent review established by the University of California system to ensure that issues that may occur from the federal level did not occur at the state level. Professor David Wagner was the lead researcher on Secretary Bowen's top-to-bottom review, and testified before the Committee on House Administration and Elections Subcommittee in 2007.[3] In his testimony he stated: "Testing labs are paid and selected by the vendor who makes the equipment being tested, [so] they are surely aware that withholding approval too frequently might send vendors to competing testing labs with a reputation for more lenient treatment… Unfortunately, at present there are few checks and balances that can be used to hold testing labs accountable if they fail to serve the public interest. In the long run, source code disclosure might help to ensure that the process is effective by holding testing labs accountable in the court of public opinion if they approve systems with obvious defects in the source code."[4]

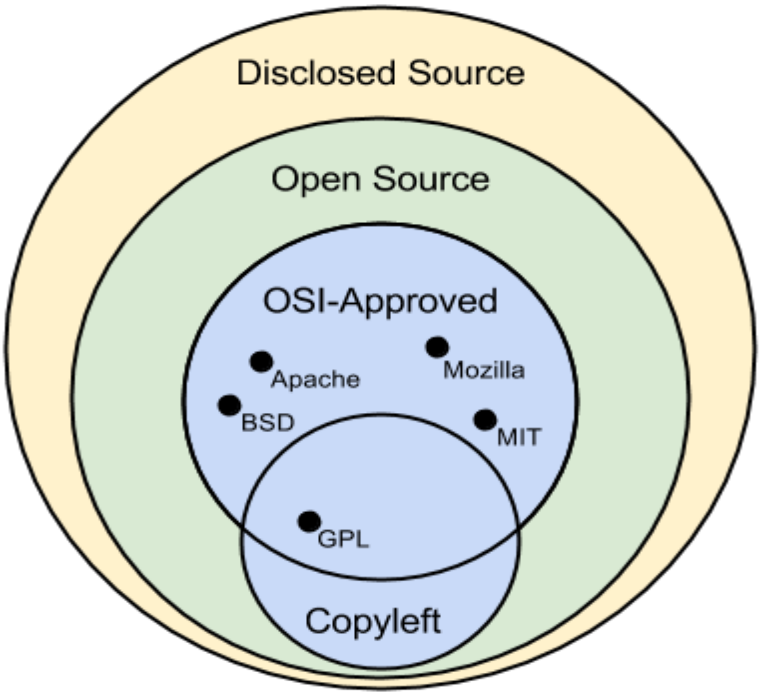
6) Inflexibility. With the current system or any proprietary voting system, if San Francisco desires even a small change to its system, San Francisco would have to go through its vendor. In particular, San Francisco would need permission from the vendor and would not be able to "shop" the costs around. With an open source system, San Francisco would be able to make changes without such approval and could benefit from more options (though any change would require recertification).

[2]Top-to-bottom review, California Secretary of State's Office http://www.sos.ca.gov/elections/voting-systems/oversight/top-bottom-review/
[3]David Wagner testimony http://www.cs.berkeley.edu/~daw/papers/testimony-house07.pdf
[4] David Wagner testimony http://www.cs.berkeley.edu/~daw/papers/testimony-house07.pdf

B. Proposed open source voting system

Supervisor Scott Wiener authored Resolution No. 460-14, which urges the CCSF to "work with other jurisdictions and organizations to create new voting systems using open source software; and to study the feasibility of the City and County of San Francisco developing and using a new voting system, either whole or in part, through a collaborative model like the Los Angeles County Voting Systems Assessment Project."[5]. The resolution was subsequently adopted by the Board of Supervisors on December 9, 2014 and approved by the Clerk of the Board on December 10, 2014.

Open source can fall into different types or categories as the chart below demonstrates. The most well known are the OSI-approved licenses, which are approved by the Open Source Initiative (OSI) group. Some more well-known examples of OSI-approved licenses are listed in the chart, but there are many more. A copyleft license means that if somebody makes changes to the open source software, then those changes must also remain open source for all. Without copyleft, someone could make changes and put additional restrictions, like making it closed or disclosed source. While not necessarily open source, a disclosed source system achieves some similar attributes of an open source system such as availability of the public to review the system, but it keeps the ability to use or modify the system with the person or group who developed it.



[5]San Francisco Board of Supervisors Resolution No. 460-14, http://www.sfgov2.org/Modules/ShowDocument.aspx?documentid=2333

Open source voting system advocates propose that the CCSF develop and certify its own open source voting system to replace contracts with proprietary companies such as Dominion. Currently, no such system exists anywhere in the nation, but two counties have been developing their own voting systems and indicating that they will be open source: Los Angeles County in California and Travis County in Texas. Both projects are still ongoing and neither system has been submitted to its state's elections department for inspection and approval yet.

If the CCSF developed its own voting system, the CCSF would own the voting system's software. The CCSF would have the choice of developing the system in-house, or partnering with other counties and/or an outside company to develop the software (note that if the CCSF partnered with other counties, the software would potentially be jointly owned by more than one county). Additionally, if the owners released this software under an open source license, the source code—the computer code that the software—would be publicly available, so people could examine and analyze the code to maintain whether it has been tampered with. Furthermore, members of the public could view the source code and make their own changes to update the way the software runs; for example, if open source voting software was available, changes could be made to the code to improve the way ranked-choice voting ballots are designed and voted upon. This does not mean that anyone can change and redeploy the code used by a jurisdiction in real-time. Rather, it means that anyone has the right to modify and distribute the software for their own use. For a given jurisdiction, the jurisdiction still has ultimate say over what software it chooses to use. Additionally, these changes would need to be submitted to and approved by the California Secretary of State's office.

There are different approaches to developing the system, including:

1) Partnering with other counties to split the cost of development.
2) The CCSF contracting with an external company to develop the software.
3) The CCSF building an open source system in house.

Partnering with other counties

Alan Dechert, founder of the now inactive OVC, proposed a consortium model to open source voting systems. A consortium model, consisting of several counties "buying in" to a new system, could be more cost-effective; the CAVO estimates their total cost to develop an open source voting system is $4 million. This $4 million figure covers only the cost of developing the system's software, and does not include the cost of hardware and staffing. If 15-20 counties join the consortium, each county would only have to pledge an average of $200,000-$300,000. Since the OVC disbanded in 2011, CAVO has taken the lead on the open source voting project. Based on this model, the initial cost of developing an open source voting system would be considerably less than the cost if the CCSF decided to take this project on without any partners. The previously mentioned Resolution No. 460-14 also indicates a preference for this consortium approach.

Contracting with an external company

In addition to CAVO and projects spearheaded by county clerk's offices (such as Los Angeles and Travis County), there are several other agencies that are currently developing open source voting system technology. The OSET foundation, comprised of Silicon Valley executives, aims to create software for complete open source voting systems. Greg Miller, a former member of the San Francisco Voting System Task Force, has directed OSET for the past eight years, and states OSET's goal is to "remove the black box nature of the voting system, and make it a glass box". OSET has already developed parts of the voting process and aims to complete the development of ballot printers and tabulators next. If they are able to acquire an extra 12 staff members and $18 million over the next two years, Miller is confident they will have an "entire ecosystem of open source software" complete and ready for use in elections. OSET has the architecture in place for open source voting systems, and various prototypes in progress. OSET states they have started the OSI-Approval process to finish the certification model; hence the software could be completed and certified in the previously mentioned two year time frame.

Galois Inc. is a private computer science company that has provided insight into the cryptography elements of Travis County's Security, Transparency, Auditability, and Reliability (STAR) Vote system, based on Galois' work on overseas online voting for active military members. Research lead Joe Kiniry claims they are working on building high assurance open source systems, and have numerous prototypes to fit various pieces of the election. Whereas OSET would focus more on the data management side, Kiniry specializes in cyber security. Greg Miller from OSET claims Galois could be a great asset, as they have already developed a prototype of an open source voting system. According to Miller, Kiniry also has extensive experience with election auditing software development; a part of the voting process that all the experts stress is crucial for accuracy and transparency. Kiniry has taken over the OpenCount project, initially created by Professor Wagner and students in UC Berkeley's Computer Science department, which aims to improve the election auditing process. Wagner states that the technology used for this auditing system could be used as a basis to create a ballot tabulation system.

Building an open source system in-house

While there is the option of creating an open source voting system in-house, this option seems the least feasible at this time. The San Francisco DOE has not discussed the notion, and has not determined if they have the capacity to take on this task. Therefore, in order to determine the feasibility of developing this system in-house, more study and analysis is needed to determine whether or not this is a viable option.

IV. Previous and Existing Projects

A. Open Voting Consortium (OVC)

The OVC was active from 2003 to 2011. The OVC was focused primarily on design work, and during the 2008 LinuxWorld conference—held at the Moscone Center in San Francisco—founder Alan Dechert displayed a prototype of their open source voting system. Based on this model, voters would mark their choices on a touch screen tablet. Once they were done with their vote, they could double check their ballot to make sure all the right choices were marked and the ballot would then be printed with a unique barcode. In discussion with the Secretary of State's office, some concern was raised about whether or not this barcode could be tied back to a specific voter. The barcode would be scanned by a poll worker, and the scanned ballot was entered into the computer system for tabulation. At the end of the day, the results for that location would be tallied, printed onto one document, and transported to the central tallying center. The OVC disbanded in 2011, and many of the members transitioned to the California Association of Voting Officials.

B. California Association of Voting Officials (CAVO)

CAVO is a non-profit association focused on the creation and implementation of open source voting systems. Although several OVC members moved over to CAVO, the organizations are separate and have different goals. OVC was more design-focused, whereas CAVO is focused on standards, education, and implementation. Composed of software and technology experts and voting officials from several counties, CAVO aims to bring open source voting systems to fruition.

Drawing upon the prototype developed by the OVC, CAVO created an outline/proposal for an open source voting system, including possible hardware options. The prototype developed by CAVO would entail the following steps:

- Voter checks in with poll worker.
- Voter enters voting booth, equipped with a touch screen tablet and printer.
- Voter marks their choices on touch screen tablet.
- Voter prints ballot and exits voting booth.
- Printed ballot is given to poll worker, which is scanned and deposited into ballot box.
- Ballot count would display on monitor. If the same ballot is scanned more than once, the message "ballot already counted" will show up on the monitor, and that ballot will not be counted another time.
- Final count and tally are transmitted to City Hall tallying center.

CAVO proposes Vote-by-Mail Ballots could be scanned with 10 new off-the-shelf high-speed flat bed scanners (each scanner costs $4400) using open source software to tabulate the votes. They state these scanners work faster than the machines provided by Dominion.

C. LA County Voting Systems Assessment Project

LA County has used ES&S's InkaVote system since 2003, after punch card ballots were decertified. InkaVote is a very similar system to the previous punch card ballot, with the biggest difference being that the cards are no longer pre-scored. The Voting Systems Assessment Project (VSAP) launched in Los Angeles County in 2009 with the goal of creating a more transparent and innovative voting system. Formed by the LA County's Registrar-Recorder/County Clerk's office, VSAP received a $150K grant to conduct initial research for their project. Partnering with the Voting Technology Project, VSAP took a heavily user-focused approach to the notion of an open source voting system; conducting countywide voter surveys, poll worker surveys, focus groups, and internal discussion groups. In addition, they conducted an Open Design Search, comprised of experts, designers, and members of the general public. The search aimed to determine what the public wanted out of a voting system, and which components would provide a stronger sense of legitimacy, accuracy, and transparency. Additionally, the Open Design Search initiated the conversation on how the Ballot Marking Device (BMD) should be designed. Their research concluded that a paper trail was still necessary for election accuracy, thus a link between paper and electronic ballot was deemed a key element of the voting process. As a result, VSAP's system is focused around a paper-ballot, as opposed to a completely electronic voting system.

VSAP has been primarily focused on user research and hardware design, so a complete voting process has not been finalized. VSAP created a timeline for their project, composed of five phases. Phases one and two focused on the aforementioned user research, and they are now in phase three: system design and engineering. VSAP is currently partnering with design-firm IDEO to develop an intuitive, user-centered voting system. This phase lasts 17 months, and will culminate with a finalized prototype of the BMD. This does not entail a product-ready BMD; the prototype will first be released electronically as an interactive sample for public feedback**.** While IDEO will work on the architecture of the software—or a prototype of the software—they will not create the finalized version of the source code or software. The details behind which company will create the finalized software are still undetermined. IDEO is working with VSAP primarily to create a BMD from industrial hardware components as opposed to commercial off the shelf components, and has not yet begun the discussion around the software architecture. However, they suggest they are leaning towards a Linux operating system.

Ultimately, VSAP predicts to have a soft rollout of the new voting system by 2018.

D. Travis County STAR System

In Texas, Travis County Clerk Dana DeBeauvoir has been working on developing the county's own voting system, dubbed the STAR Voting System. Travis County currently contracts with Hart Intercivic for election materials. Travis County purchased new Helping America Vote Act (HAVA) compliant voting machines in 2006, but County Clerk DeBeauvoir said they were simply buying "a second version of the same machine"; echoing the sentiments of other open source voting system proponents, DeBeauvoir felt the existing systems were outdated, and lacked reliability and security. Travis County also performed extensive voter/user research, and their citizens panel and study group also reiterated the same concerns. Another group of Travis County voters, led by the Austin NAACP, filed a lawsuit against the county in 2006[6], alleging that the Hart Intercivic ESlate voting machines did not provide enough security and ability to audit due to a lack of a paper trail; the Texas Supreme Court dismissed the case in 2011.[7]

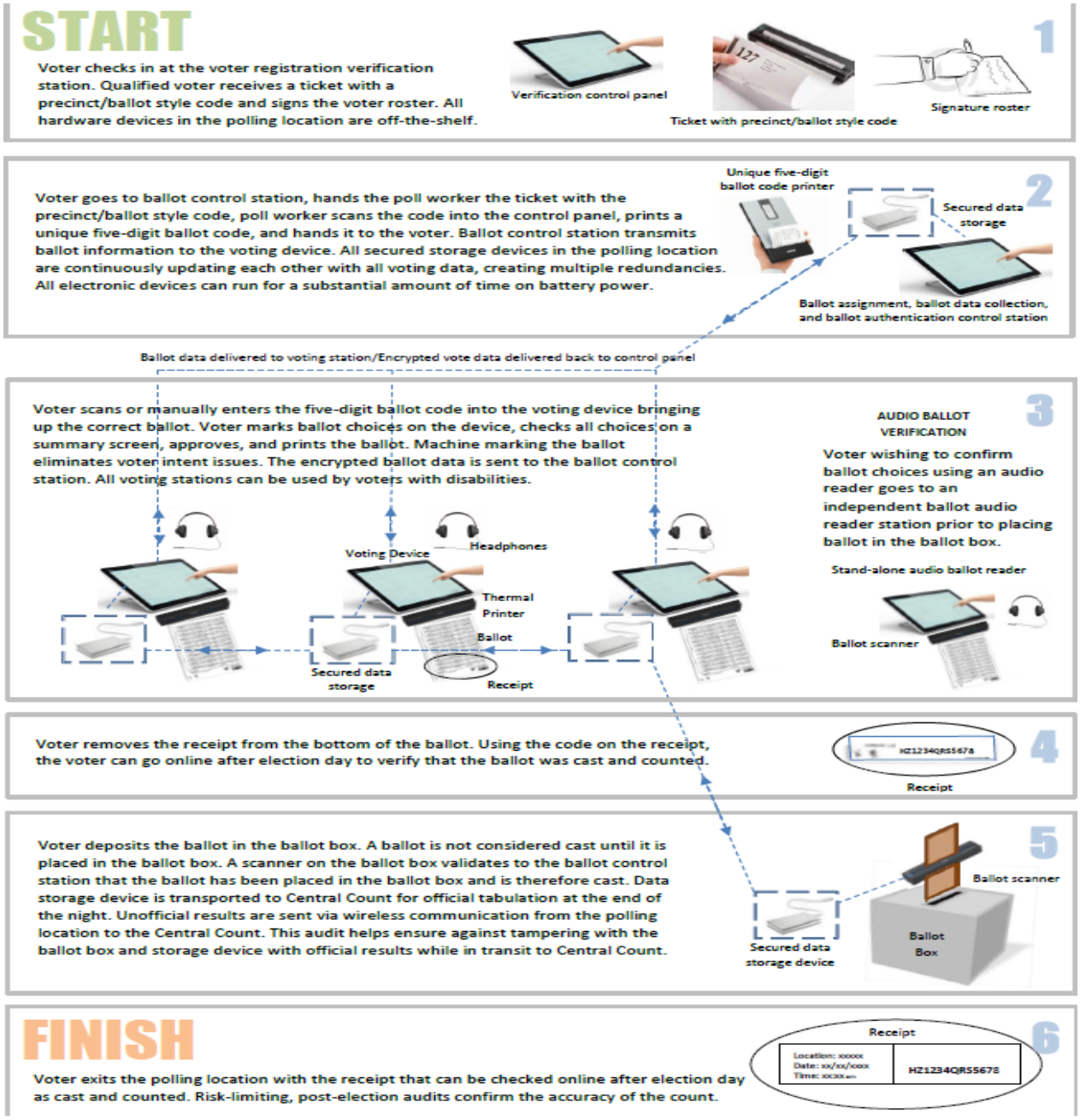
Based on the feedback they received from the citizen's panel and study group, County Clerk DeBeauvoir started working to create a voting system that fit the needs and desires of the county's voters. The STAR vote project was launched three and a half years ago, and is still in the early research stage, a Request for Information (RFI) was issued in June 2015 and they are now moving forward in that process. DeBeauvoir explains they want to make sure all details and bases are covered in the RFI before they start requesting (and spending) funding to get the system in place. There is a soft prototype of the system ready to be released at the same time as the RFI, but no specific computer software company/developer has been picked to work on the final software.

County Clerk DeBeauvoir is currently developing the STAR vote program solely through Travis County. DeBeauvoir said she would consider rolling the program out with another county, but has not yet determined which county she would partner with. Eventually, County Clerk DeBeauvoir would like the STAR system to be adopted throughout the state. Contrary to LA County, Travis County has spent little funding on the project thus far since they are focused on their RFI. Therefore, DeBeauvoir has not planned out how the pricing would be once other counties adopt the system, but states she wants to keep it as affordable as possible.

[6] Ars Technica. "Texas Supreme Court: No E-Voting Paper Trail Required." July 5, 2011. http://arstechnica.com/tech-policy/2011/07/texas-supreme-court-nixes-e-voting-lawsuit-before-trial/
[7] Texas Tribune. "Travis County Forges New Territory in Voting Machines." July 9, 2014. https://www.texastribune.org/2014/07/09/travis-county-forges-new-territory-voting-machines/

The following flowchart[8] illustrates how the STAR vote system, using COTS hardware as proposed, could work on Election Day:

Travis County STAR Vote System



[8] The Presidential Commission on Election Administration. https://www.supportthevoter.gov/files/2013/09/Dana-Debeauvoir-STAR-Voting-System-Diagram.pdf

V. Possible Benefits of Developing an Open Source Voting System

Innovation

The development of an open source voting system could open the door for local tech companies to work with the CCSF on this project; proponents argue that instead of being locked in a contract with one company, an open source system would encourage competition among companies in San Francisco and other nearby counties, providing a better system for a competitive price. The following chart[9] is a list of all approved systems in CA. Note that this list is from 2008, hence Sequoia and Premier/Diebold are still listed here, despite going out of business.

Voting Systems Approved for Use in California (as of October 14, 2008)

Company	Approval Date	Software and Other Components	Optical Scan Hardware Components	Accessibility Hardware Components
DFM 10 Chrysler Irvine, CA 92618		BC Win, v. 2.0 - 3.0	Mark A Vote	
Election Systems and Software 11208 John Galt Blvd Omaha, NE 68137	**Approved** June 30, 2008	UNITY Election Management System, v. 3.0.1.1 Election Data Manager, v. 7.4.4.0 ES&S Image Manager, v. 7.4.2.0 Hardware Program Manager, v. 5.2.4.0 Election Reporting Manager, v. 7.1.2.1 Audit Manager, v. 7.3.0.0 Model 100 Optical Scan Precinct Counter, v. 5.2.1.0 Model 650 Central Ballot Counter, v. 2.1.0.0 AutoMARK Information Management System, v. 1.2.1.8 AutoMARK Voter Assist Terminal, v. 1.1.2258	Model 100 Optical Scan Precinct Counter, v. 1.3 Model 650 Central Ballot Counter, v. 1.1	AutoMARK Voter Assist Terminal, v. 1.0 (A100) and v. 1.1 (A200)
	Original Approval April 21, 2006 **Reapproval** January 2, 2008	Unisyn Election Management System, v. 1.1, which includes: Ballot Generation, v.1.1 Election Converter, v. 1.1 Election Loader, v. 1.1 Vote Converter, v. 1.1 Vote Tabulation, v. 1.1	InkaVote Plus Precinct Ballot Counter with ADA unit, v. 1.10	InkaVote Plus Precinct Ballot Counter with ADA unit, v. 1.10
	Original Approval August 3, 2005 **Reapproval** December 6, 2007	UNITY Election Management System, v. 2.4.3 AutoMARK Information Management System, v. 1.0	Model 100, v. 5.0.0.0 Model 550, v. 2.1.1.0 Model 650, v. 1.2.0.0	AutoMARK Voter Assist Terminal, v. 1.0, with firmware v. 1.0
Los Angeles County 12400 Imperial Hwy Norwalk, CA 90650	**Original Approval** February 11, 2004 **Reapproval** January 15, 2008	MTS, v. 1.3.1	LRC 1000	
HART InterCivic 15500 Wells Port Dr Austin, TX 78728	**Original Approval** September 22, 2006 **Reapproval** December 6, 2007	Ballot Now, v. 3.3.11 BOSS, v. 4.3.13 Rally, v. 2.3.7 Tally, v. 4.3.10 SERVO, v. 4.2.10 eCM Manager, v.1.1.7	eScan, v. 1.3.14	JBC, v. 4..3.1 eSlate/DAU, v. 4.2.13 VBO, v.1.8.3
Premier Election Solutions Approved under the name **Diebold Election Systems** 1253 Allen Station Parkway Allen, TX 75002	**Original Approval** February 17, 2006 **Reapproval** October 25, 2007	GEMS, v. 1.18.24 Key Card Tool, v. 4.6.1 VC Programmer, v. 4.6.1	AccuVote-OS (Model D), v. 1.96.6 AccuVote-OS Central Count, v. 2.0.12 AccuFeed	AccuVote-TSX, with Ballot Station, v. 4.6.4 AccuView Printer Module Vote Card Encoder, v. 1.3.2
Sequoia Voting Systems 7677 Oakport Street, Ste 800 Oakland, CA 94621	**Approved** October 14, 2008	WinEDS, v. 4.0.116 WinEDS Extended Services Software, v. 1.0.47 WinEDS Election Reporting Software, v. 4.0.44 Memory Pack Reader (MPR), v. 3.01	Optech 400-C/WinETP, v. 1.16.6 Optech Insight Plus, APX K2.16, HPX K1.44	
	Original Approval March 20, 2006 **Reapproval** October 25, 2007	WinEDS, v. 3.1.012 Card Activator, v. 5.0.21 HAAT Model 50, v. 1.0.69L Memory Pack Reader (MPR), v. 2.15	Optech 400-C/WinETP, v. 1.12.4 Optech Insight, APX K2.10, HPX K1.42 Optech Insight Plus, APX K2.10, HPX K1.42	AVC Edge Model I, v. 5.0.24 AVC Edge Model II, v. 5.0.24 VeriVote Printer

Notably, the CCSF (along with several cities in Alameda County) has a ranked-choice voting (RCV) system in place, meaning voters can choose several candidates—the first being their top choice, second, and so forth—in order to avoid a run-off election. Currently, Dominion systems only allow voters to choose 3 candidates for a ranked-choice ballot despite the fact most elections contain many more candidates than that. Furthermore, San Francisco Charter code

[9] California Secretary of State's office. http://votingsystems.cdn.sos.ca.gov/oversight/county-vsys/vote-sys-appr-in-ca-08-10-14.pdf.

13.102[10] states: "(b) The Mayor, Sheriff, District Attorney, City Attorney, Treasurer, Assessor-Recorder, Public Defender, and members of the Board of Supervisors shall be elected using a ranked-choice, or 'instant runoff,' ballot. *The ballot shall allow voters to rank a number of choices in order of preference equal to the total number of candidates for each office; provided, however, if the voting system, vote tabulation system or similar or related equipment used by the City and County cannot feasibly accommodate choices equal to the total number of candidates running for each office, then the Director of Elections may limit the number of choices a voter may rank to no fewer than three."*

If the source code for the election software were open source, then CCSF could customize the software so the RCV process is more effective, and voters could vote the entire ballot down instead of just three candidates, as the current system offers. There is precedence for this task: the city of Portland, Maine, introduced a ranked choice voting process in the 2011 mayoral race. Their system allows voters to cast votes for all the candidates in a mayoral race—about 15 candidates, and according to FairVote, an independent organization dedicated to increasing voter turnout and election reform, voter turnout was 50% higher than expected in that 2011 mayoral race[11]. These are, however, the views of one independent organization in regards to one specific election and should not be viewed as a trend. To put this into context, a 2012 San Francisco LAFCo study on RCV elections showed that, on average, voter participation only increased by 2.1% in RCV elections compared to non RCV elections. The increase in voter participation was higher in Supervisorial races, whereas the participation rate was not noticeably higher in City-wide elections (Mayor, Sheriff, District Attorney, etc). However, the results were more difficult to discern in City-wide elections since—due to "a legacy of incumbency"—there were no occasions where LAFCo could compare an open seat election for the same offices under RCV to an open seat election under the Run-Off system[12]. Efforts are now underway in Maine to expand ranked choice voting for state, gubernatorial, and federal elections.

Precedent

The CCSF stands from a point of advantage since several projects are well underway. The CCSF could draw upon the research and systems being developed in other counties to further expedite the production of this system. Additionally, if the CCSF opts to partner with an existing company, the work is already in progress. CAVO, for example, is one of several groups that have been working towards an open source voting system, and claim they only need one to two years

[10] San Francisco Charter. http://www.amlegal.com/nxt/gateway.dll/California/charter_sf/articlexiiielections?f=templates$fn=default.htm$3.0$vid=amlegal:sanfrancisco_ca$anc=JD_13.102

[11] FairVote.Org. http://www.fairvote.org/reforms/instant-runoff-voting/where-instant-runoff-is-used/ranked-choice-voting-in-portland/

[12] "The Voting Process, Including Ranked Choice Voting for Local Offices in the City and County of San Francisco." . San Francisco Local Agency Formation Commission. July 23, 2012

to complete an open source voting system. OSET estimates they need 18 months to complete their system, and the VSAP project in Los Angeles County is currently in their software development phase. Travis County has a prototype of the STAR Vote system as well.

Cost-effectiveness

If the CCSF shares the cost of development with other counties through a consortium model, San Francisco and Alameda County (the cities of Oakland, Berkeley, and San Leandro specifically) would need customized election software to accommodate the ranked choice voting process. While the exact pricing has not been discussed, it is to be assumed that each county would pay extra to have the system customized as such. However, based on a consortium model, two or more counties could split the cost for a RCV system, or any other specific changes a county would need.

Ideally, this system would be fiscally beneficial. The San Francisco Department of Elections purchased the current machines in 2008, and estimates the county would need to purchase new machines by 2017. Instead of purchasing large, expensive voting machines that need to be switched out every decade, the voting system could run on commercial off the shelf (COTS) hardware or industrial hardware components. COTS hardware entails products that can be easily found at any electronics store—iPads, tablets, scanners, etc. One problem with using COTS hardware is that ongoing technology changes could mean underlying source code would also need to change, which requires recertifying either part of, or the entire system with the new changes in COTS hardware. Industrial hardware components consist of parts and products that cannot necessarily be found at a commercial electronics store, but are sold by software and technician companies. Hardware that can be easily found, such as touch screen tablets, scanners, printers, etc, could be purchased in bulk and utilized for election purposes. COTS hardware, similar to proprietary hardware, will eventually term out and require replacement over time. However, proponents argue that COTS hardware will be much cheaper to replace over time, as opposed to consistently purchasing new machines from a proprietary company. The following chart displays detailed license and maintenance fees for Dominion systems, a breakdown of the cost of various Dominion hardware components:

Cost towards voting machines from Dominion: licensing fees and maintenance[13].

Annual Maintenance & Licenses Fees

Annual Maintenance & Fees	Quantity	2008	2009	2010	2011
Edge 2 - Parts and Repairs	610	Included	61,000.00	61,000.00	61,000.00
VVPAT - Parts and Repairs	710	Included	21,300.00	21,300.00	21,300.00
HAAT- Parts and Repairs	610	Included	30,500.00	30,500.00	30,500.00
400-C - Parts and Repairs	5	Included	30,000.00	30,000.00	30,000.00
Insight - Parts and Repairs	610	Included	61,000.00	61,000.00	61,000.00
Licenses Fee WinEDS Application		Included	112,500.00	112,500.00	112,500.00
Licenses Fee RCV Application		Included	70,000.00	70,000.00	70,000.00
Total			386,300.00	386,300.00	386,300.00

Transparency

In addition to improvements on the ranked choice voting experience, a new open source system could increase transparency. The ability to monitor the source code allows the public to ensure the system is running correctly, and this could also improve the auditing process. If any concerns were raised about a recent election or polling results, it would ideally be easier to double check and ensure the systems did not malfunction. While it is true that not anyone could comprehend the source code, the option to have an informed, capable individual analyze the code provides an increased sense of transparency from the current system. The proprietary system does not allow the public to analyze the code, and election results are difficult to obtain since they are private information. Consequently, political scientists and researchers are limited in the scope of their work since they cannot easily obtain detailed election results they may want, but are not available based on the priority nature of the current system. If the voting system is open source, the results would be public, allowing more opportunity for political research. The revised CAVO proposal explains: "Once the polls close, the tabulation routine with the recorded votes would be terminated and the tally sheet printed. One would be posted at the polling place and one would go in the Ballot Box with the ballots. Any number of tally sheets could be printed and distributed to anyone upon request. The tally sheet would also exist in electronic form."[14] Additionally, "Once all the ballots have been uploaded to master spreadsheet, results are calculated and the spreadsheet is published so anyone can download and check."

Security

While there is no definitive proof that open source systems are more secure than closed-source, there is definitive proof that closed-source systems are still vulnerable to tampering. The findings from Secretary of State Bowen's top-to-bottom review provided evidence of this, and voting

[13] Provided by Director John Arntz, San Francisco Department of Elections.
[14] CAVO proposal (attached as Appendix A)

system experts have also weighed in with the same analysis. Open source advocates state the transparent nature of open source voting systems has a spillover effect into the security aspect; the more transparent a system is, the more secure it is.

Minimal Paper Use

Proponents—specifically CAVO—also argue that the CCSF has an opportunity to save money, go green, and provide more inclusive elections by eliminating the need for pre-printed ballots. It should be noted that print-on-demand could cause other logistical issues that would need to be reviewed and possibly addressed before this could be implemented. This is especially relevant in the area of language accessibility. Currently, ballots are printed in several languages, partly resulting in ballots that are three to five pages long. This not only uses an exorbitant amount of paper, but also takes up considerable storage space since ballots must be kept for 22 months from the date of an election (only in the case of a federal contest; state and local contests must be retained for six months from election date). The CCSF is also limited in how many languages can be included on preprinted ballots due to document spacing. In the November 2015 election CCSF will use a two language ballot which may address parts of this issue, but by having a print-on-demand system CCSF would not have to over-print ballots to make sure there are enough of each language at each polling location, and thereby have less to recycle after the election is over. Regardless of whether the city would adopt a touch-screen ballot marking device or maintain a paper ballot as the marking device, a voter could check in with a poll worker, request a ballot in a specific language, and then have the ballot printed onsite (whether it is printed after recording all the choices on a touch screen tablet or the paper ballot is printed to be marked by the voter). Since the software would be developed for the CCSF, more languages could be included for voters to choose from, unused paper ballots would be eliminated, and fewer pages would be needed for the printed ballots. Lengthy paper ballots would, however, still be necessary for vote-by-mail recipients (more than half of voters now VBM). The CCSF would also need to consider what kind of delay (if any) this would put on the voting system: how much longer would it take for each person to check in and have their ballot printed, whether it is before or after casting their ballot?

VI. Project Feasibility/Technicalities

A. Timeline

The previous model for voting system approval required federal certification by the Elections Assistance Commission (EAC) before reaching the Secretary of State's office. The process of federal certification could take anywhere from 6 months to 2 years, and would then require more time at the Secretary of State's office for finalized state approval. With the passage of SB 360 in 2013, counties no longer need to go through federal certification to approve new voting systems, and can submit proposals directly to the Secretary of State's office for certification. While vendors no longer need to provide EAC certification to the Secretary of State's office for approval of a new system, the vendors still must provide the same type of testing reports that were obtained when EAC approval was needed. Since this is a new law, it is difficult to ascertain the exact amount of time the certification process would take; however, the Secretary of State's office estimates the process would take anywhere from 6 to 18 months.

Other counties have had difficulty keeping up with their timeline. VSAP started their project in 2009, but does not expect to have a complete voting system until 2018—in which case they will do a soft rollout, indicating the system will not be employed at every single polling place. In comparison to their original proposal, they are running three years behind schedule. Travis County started this project three years ago, but is still in the early research phase.

Several of the software experts LAFCo spoke with emphasized the need to "phase in" this new voting system; there is too much at stake to safely and accurately overhaul the entire proprietary system and replace it with a brand new prototype all at once. In 2004, a computer malfunction in the San Francisco election temporarily paralyzed the vote tallies under the new ranked choice voting system.[15] As a result, the votes were not ranked properly. Incidents such as these are a reminder that careful, precautionary steps should be taken to ensure the system runs smoothly. Director John Arntz explained that the same voting system does not have to be in place for every precinct; thus there is an option of phasing in and testing out a new open source voting system in one or more precincts before deploying it throughout the entire county. However, these experimental systems must still be approved by the Secretary of State's office at least nine months before being phased in.

B. Budgeting

Budgeting is a particularly ambiguous area. The estimated cost of hardware to run an election should be fairly easy to determine, but the cost to develop software for the system is still

[15]Los Angeles Times, "San Francisco Officials Repair Voting Glitches." November 6, 2004. http://articles.latimes.com/2004/nov/06/local/me-sfvote6

undetermined. CAVO quoted the total cost of development at $4 million dollars, while OSET quoted the total cost at $18 million, along with the acquisition of another dozen staff members. The VSAP project in LA County has spent $1.2 million on the initial research and planning stages, and will spend another $15 million on the production phase, and Travis County does not yet have an estimate on how much will be spent towards their STAR system. All of the above cost quotes are not always for the exact same thing; which goes to show the difficulty of creating an accurate budget for the creation of a new system at this time. Regardless, the voting systems must be replaced soon and the CCSF will have to spend money on new machines in the following couple of years, hence this is the ideal time to discuss which route to take.

CAVO is one organization that has submitted a detailed proposal, complete with budgeting costs. Aside from the software development costs, CAVO estimates the total polling place costs for 570 polling places in the CCSF to be $1.96 million. This includes **only** the polling place costs (the voting booth and BMD, ballot box, and monitor) and does not cover the scanners for VBM ballots, nor does it cover the staffing costs, such as the project manager, maintenance, etc. According to CAVO's proposal, the cost of 10 scanners for VBM ballots and a computer system to tabulate those ballots would be an additional $43,500. The cost of staffing is not covered in the proposal. Therefore, in addition to the initial cost to develop the system's software, the CCSF and DOE would also have to consider the initial polling place costs compared to what they spend with the current system, along with the staffing costs discussed on page 24 of this report. More insight would be necessary to see when the operation costs level out over the next few elections.

C. Legal Technicalities

A couple segments of CAVO's original proposal brought attention to California election code and laws. Several parts of the proposal needed to be changed in accordance with California election law; for example, CAVO initially proposed the following regarding vote tabulation: "Tally sheets would be transmitted to the City Hall counting center by a mobile phone registered for that polling place. For the 570 polling places, the counting center would have 570 cell phone numbers from which tally sheets are expected". This section of the proposal was not feasible, as according to Secretary of State Padilla's office, California election code does not permit the transmittance of official or unofficial results via mobile phone or any telecommunication system. Additionally, under California election code, voting systems cannot be electronically networked to anything, anytime. These conditions also rule out the possibility of mobile voting to be incorporated into the tabulation and reporting process. Mobile voting is defined as a wireless form of voting via telephone or internet—through an app, website, etc.

Representatives from CAVO were notified of these concerns and quickly made the appropriate changes to their proposal. However, this brings up additional costs to consider (staffing,

transportation costs to the central election center, etc). For any proposed voting system in California, these are important standards and stipulations to keep in mind.

D. Remaining Questions and Concerns

It is important to note that LAFCo nor any of the experts interviewed for this report are claiming that open source software is more secure than closed source software; there is no possible way to make that claim. To this point, however, the experts interviewed for this report stressed that open source software can be just as secure as closed source software, and dispute the notion that open source software is more vulnerable to attacks and tampering. Furthermore, proponents of the new system state the transparent nature of open source software could allow more eyes to spot any problems or evidence of tampering as opposed to closed source software.

Overhauling the current voting system and replacing it with a completely new open source voting system is no small feat. Even with the precedence of other counties, there are countless components of this system to consider and smooth out aside from the software and hardware. Several of the software experts we spoke with discussed intermediate steps to take instead of drastically switching the voting systems. One suggested compromise would be for the CCSF to keep their contract with Dominion, but only under the condition that Dominion releases their source code to the public. According to Professor Wagner's 2007 testimony, "most states do not receive or require access to voting source code… in California, three of the four major vendors have pledged that if California passes a law requiring source code disclosure to the public, they would abide by those provisions."[16] However, this is solely one expert's opinion, and Dominion was not part of the group of vendors who made that pledge. If Dominion denies the request to make their software open source, there is one more intermediate step the CCSF could take with the proprietary company. Dominion is releasing new voting machines with Auditmark technology, which digitally records images of each ballot and provides a written record of how the ballot was recorded by the tabulator. If the CCSF purchases voting machines from Dominion equipped with Auditmark, they could provide an increased sense of transparency and ability to audit. San Francisco Elections Commissioner Chris Jerdonek, states this option makes the proprietary system more transparent, but a proprietary system is still not preferable. Commissioner Jerdonek and other advocates argue that a public process—such as voting—should be overseen by a public system, not a proprietary system.

Another point of concern was raised about the hardware components of the proposal. Ryan Macias, from the Secretary of State's office, mentioned that identifying specific hardware for the system to run on (android, apple, specific printers, etc) would expedite the certification process at the state level. Additionally, Greg Miller from OSET stresses that having specific hardware

[16] David Wagner testimony http://www.cs.berkeley.edu/~daw/papers/testimony-house07.pdf

that is married to the software is crucial to creating a complete open source voting system; you cannot talk about one component without the other. Identifying specific hardware for the system to run on would provide a more stable base for developers to build and fine-tune the software, instead of developing a "one size fits all" software program.

Providing a ballot receipt and barcode is also a main component in several open source voting system proposals. Proponents state that this would increase transparency and security, as voters could look up their receipt later to ensure their ballot was counted correctly. Additionally, the bar code would serve as another step to ensure ballots are not counted more than once. The DOE has a legal obligation to protect voter identity and privacy, thus election officials from both the CCSF and Secretary of State Padilla's office have raised some concern about being able to track a bar code/identification number to a specific voter.

The DOE also raises several questions related to staffing costs. The following chart specifically breaks down the specialized staff provided by Dominion:

Election Services

Election Services		Price per Election
Service Oversight		
Services Management - Complete oversight of project per election		50,000.00
Pre-LAT - Plan, Test and Coordinate testing operations		65,000.00
Total Services oversight		**115,000.00**
Elections Preparation and Operation		
Ballot Layout and Production Management		30,000.00
DRE WinEDS Layout		30,000.00
Total Annual Election Preparation and Operations		**60,000.00**
Logistical Support		
Staffing - 10 Temps for 15 days per Election		65,000.00
Delivery to and collection from Polling Stations		94,000.00
Transportation		12,000.00
Total Annual Logistical Support		**171,000.00**
Election Day Support		
Election Day Field Response Team personnel	33 Temp Field	21,000.00
On-Site Technical Support Response Team	2 Technical Support	38,500.00
Central Processing Network Support	6 Personnel	63,000.00
Election Troubleshooting - On-Site Response Team	7 Personnel	24,500.00
Total Election Day Support		**147,000.00**
Consumables		**4,400.00**
Total cost of Services per Election		**497,400.00**

Cost for election services from Dominion: staffing, project manager, tech support, specialists, etc[17].

[17] Provided by Director John Arntz, San Francisco Department of Elections.

Currently, Dominion provides the CCSF with roughly 65 specialized staff members to assist in election services; not including poll workers, these staff members include a project manager, maintenance, technical support, ballot formatters, and supporting management personnel. If the CCSF terminates their contract with Dominion in pursuit of their own voting system, they would need to replace those 65 staff members and determine the logistics of hiring a new staff; these staff members are currently employed by Dominion, and therefore are only contracted workers for the CCSF when there is an election. If the CCSF owns their own voting system, they would have to consider whether these new staff members would remain as contracted workers from a separate organization, or be brought in house as either part or full-time employees of the CCSF. Additionally, LAFCo would request more information on how quickly and efficiently an open source voting system could accommodate a special election, compared to the proprietary system. LAFCo has not conducted extensive research on this topic for this report, but considers it a point for consideration if this project moves forward.

The Dominion voting machines and printed ballots are currently stored at Pier 48; however the DOE is losing that storage space due to upcoming development. In addition to the paper ballots the DOE is required to keep, these large machines take up a substantial amount of storage space, and the DOE is currently looking at affordable storage options in the city, which is not an easy task. Therefore, any new proposed system must consider minimizing storage space as an important factor.

VII. Concluding Remarks & Next Steps

A successful open source voting system is a large-scale, long-term project, comprised of various factors aside from the software and hardware itself. Many of the experts interviewed for this report stressed the importance of election auditing; in order for a truly secure election, election results must be audited—the creation of open source voting software will not suffice as a security measure on its own. The voting system must be discussed as a whole; system certification, maintenance, and staffing must be discussed simultaneously. Additionally, an open source system cannot be discussed with the software as a standalone component: the software must be married with specific hardware for best results.

In regards to concerns surrounding the vulnerability of open source software, there are several main points to take away. First, open source software would not be more vulnerable than closed source software; especially considering the public nature of open source software allows more people access to monitor the source code and spot flaws or evidence of tampering. Secondly, open source does not entail that anyone could implement changes in the source code whenever they please. While the code would be available to the public for interpretation and analysis, changes to the code would not be implemented until they were approved by the CCSF and certified by the Secretary of State's office. The certification process is time consuming: when the CCSF changed one line in the charter regarding ranked choice voting, the certification process took half of a workday. Changes towards the actual voting system take several months to process, so it would be best to limit the frequency of changes for logistical purposes.

The CCSF may not experience some of the drawbacks and hurdles other counties have encountered; since other counties have set a precedent, the CCSF would not need to conduct heavy initial user research (although LAFCo staff would suggest conducting some basic research to determine how San Francisco voters want their voting system to be), and there are several prototypes or outlines of open source voting systems to be adapted. The only thing the CCSF would need to customize or start from scratch is a RCV system, which should be an accomplishable task for computer software experts. LA County spent $150,000 for initial research, and another $15 million with IDEO to create the design of the ballot. If the CCSF draws upon their research and model, they would not need to spend as much in those areas—ideally, the only funds the CCSF will need to spend are the actual software program development, hardware components, staffing costs, basic voter research, and regular election costs (ballots, etc).

Although the CCSF may not have to spend as much as other counties have, the details around budgeting are undetermined and remain a concern. Figures from existing projects indicate that a

new open source voting system may not be cost effective in the initial stages. LA County currently contracts with ES&S to utilize the InkaVote system; similar to San Francisco, they own the tabulation system, so they only need to pay a maintenance fee, totaling roughly $1.7 million per year. This fee covers staffing and maintenance on the voting machines, as well as keeping skeleton staff on site at all times. In comparison, their contract with IDEO has cost $15 million, and there are no solid figures as of now on how much the new system will cost—total hardware costs for BMDs, staffing, maintenance, and the final production of the source code and software are still undetermined.

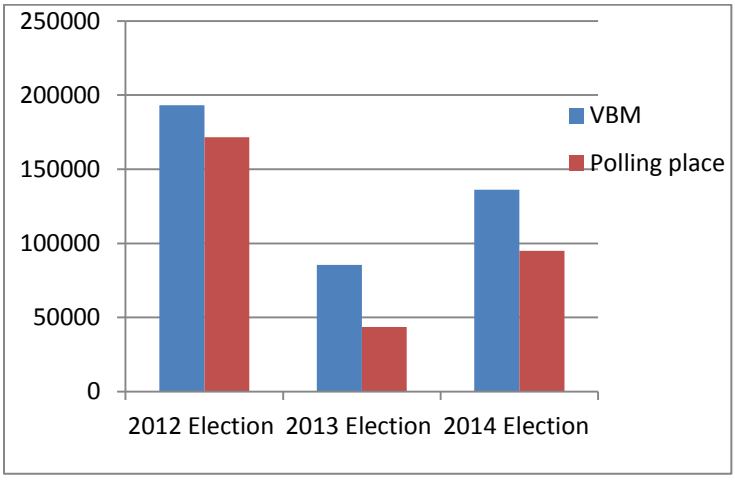
Although several organizations and voters advocate for mobile voting processes, LAFCo cannot recommend mobile and paperless voting proposals at this time; aside from the restrictions based on election laws, there is simply not enough evidence to suggest mobile voting (voting via internet connection through an app or website) would be as secure as a paper ballot, or a touch screen marking device with a paper ballot printout. The experts interviewed for this report also stressed the importance of having a paper trail for auditing purposes. As previously mentioned, this new system—if adopted—must be phased in as carefully as possible, hence mobile voting should not be a possibility until the new open source voting system has been completely phased in and fine-tuned.

If the CCSF creates their own open source voting system, the plan must also consider how to replace the previously mentioned election service staff provided by Dominion. CAVO raised two suggestions: 1) purchase just the election services from Dominion. The CCSF could still use vendors for support—but instead of buying hardware, software, and services, they could buy only the services, or 2) work with a company through CAVO. As a CAVO member or affiliate, the company would be CAVO certified, implying they would have some knowledge of the system and be able to provide adequate support during the election. LAFCo staff considers the probability of Dominion agreeing to send staffing for a system that is not their own unlikely. Additionally, although CAVO is available to develop the system for the CCSF, we recommend putting out a RFI in order to expand the CCSF's options (if the CCSF decides to create an open source voting system). The San Francisco/Bay Area is home to a plethora of tech companies, providing a wide range of options and valuable resources to develop the most effective open source voting system.

The new system should contain a thorough plan for VBM ballot tabulation. The majority of voters in San Francisco now VBM, so in order for a new system to be truly effective, the system proposal should have the most efficient and cost-effective method of tabulating these ballots. Having a plan for the VBM component as a short afterthought is insufficient; in addition to the CCSF, Alameda County voters also vote primarily by VBM ballots and have RCV, thus

Alameda County would be a good partner from the start. The following graph displays how San Francisco voters cast their ballot in the past three years:

How San Francisco voters cast their ballot in the past three elections



	2012	2013	2014
Vote by Mail	193,196 (53%)	128,937 (60%)	136,219 (59%)
In Person	171,679 (47%)	85,403 (40%)	94,995 (41%)

If the CCSF decides to keep their contract with Dominion—who is unlikely to make their software open source—they could, at the very minimum, request more transparent practices, using Auditmark technology provided by Dominion. The DOE is already looking at the option of purchasing machines with Auditmark technology, in the event that the CCSF renews their contract with Dominion. In conclusion, there are valid points both in support and opposition of developing this new voting system. Whether this open source voting project moves forward is a policy decision for the elected leaders of the CCSF. In any case, this proposal has raised important questions and concerns regarding how the city's elections are conducted.

VIII. Abbreviation Codes

BMD: Ballot Marking Device

CAVO: California Association of Voting Officials

CCSF: City and County of San Francisco

COTS: Commercial Off-the-Shelf

DOE: San Francisco Department of Elections

EAC: Elections Assistance Commission

GPL: General Public License a family of popular OSI-approved, copyleft open source software licenses (e.g. GPLv2 and GPLv3)

HAVA: Helping America Vote Act

LAFCo: San Francisco Local Agency Formation Commission

OSET: Open Source Elections Technology

OSI: Open Source Initiative

OVC: Open Voting Consortium

RCV: Ranked Choice Voting

RFI: Request for Information

STAR: Security, Transparency, Auditability, and Reliability

VBM: Vote-by-Mail

VSAP: Voting Systems Assessment Project

IX. List of Documents

1. FairVote. http://www.fairvote.org/reforms/instant-runoff-voting/where-instant-runoff-is-used/ranked-choice-voting-in-portland/

2. Fried, Jason, and El-Najjar, Ahmad. "The Voting Process, Including Ranked Choice Voting for Local Offices in the City and County of San Francisco." San Francisco Local Agency Formation Commission. July 23, 2012. http://www.sfbos.org/Modules/ShowDocument.aspx?documentid=41990

3. GNU Operating System. https://www.gnu.org/licenses/gpl-faq.html#DoesFreeSoftwareMeanUsingTheGPL

4. Lee, Timothy B. "Texas Supreme Court: No E-Voting Paper Trail Required." *Ars Technica*. July 5, 2011. http://arstechnica.com/tech-policy/2011/07/texas-supreme-court-nixes-e-voting-lawsuit-before-trial/

5. Okun, Eli. "Travis County Forges New Territory in Voting Machines." *Texas Tribune*. July 9, 2014. https://www.texastribune.org/2014/07/09/travis-county-forges-new-territory-voting-machines/

6. The Presidential Commission on Election Administration. https://www.supportthevoter.gov/files/2013/09/Dana-Debeauvoir-STAR-Voting-System-Diagram.pdf

7. San Francisco Board of Supervisors Resolution No. 460-14 (2014) http://www.sfgov2.org/Modules/ShowDocument.aspx?documentid=2333

8. Romney, Lee. **"**San Francisco Officials Repair Voting Glitches." *Los Angeles Times***.** November 6, 2004. **http://articles.latimes.com/2004/nov/06/local/me-sfvote6**

9. San Francisco Charter Code, Article XIII, Sec. 13.102: Instant Runoff Elections. http://www.amlegal.com/nxt/gateway.dll/California/charter_sf/articlexiiielections?f=templates$fn=default.htm$3.0$vid=amlegal:sanfrancisco_ca$anc=JD_13.102

10. Top-to-Bottom Review. California Secretary of State's Office (2007) http://www.sos.ca.gov/elections/voting-systems/oversight/top-bottom-review/

11. Verified Voting. https://www.verifiedvoting.org/resources/voting-equipment/sequoia/optech-400c/

12. Wagner, David. Testimony before the U.S. House of Representatives, Elections Subcommittee. March 15, 2007. http://www.cs.berkeley.edu/~daw/papers/testimony-house07.pdf

13. California Secretary of State's office. http://votingsystems.cdn.sos.ca.gov/oversight/county-vsys/vote-sys-appr-in-ca-08-10-14.pdf.

Appendix A: CAVO Proposal

The following is the open source voting system proposal from CAVO.

Revised March 16, 2015 to eliminate use of cell phones to transmit data

AN OPEN SOURCE VOTING SYSTEM FOR SAN FRANCISCO

SUMMARY: This presents an approach towards a voting system for the City and County of San Francisco utilizing open source voting software and off-the-shelf hardware components. The San Francisco Department of Elections could staff with temporary election hires, or contract with an election company for trained personnel. Voters at polling places would cast their votes on tablet touchscreens, print and confirm their ballot. A poll worker would scan the ballot and deposit in a ballot box, which would be designed to enable scanning and recording the votes. Once the polls close, poll workers would deliver the ballot box with the scanned totals and all its printed ballots to the central counting facility where the scanned totals would be added to the vote counts and sampling and other due diligence security measures could take place.

The City would save the costs of a vendor providing hardware and software every election, and require only staffing support. One-page polling place ballots showing a voter's actual votes on inexpensive multipurpose paper would offer about $400,000 savings in pre-election printing costs for each election. Multi-page preprinted ballots on heavy stock paper would be required only for those registered to Vote By Mail.

This report addresses the polling places, the City Hall counting center, additional verification of voting, AC power and batteries, ranked choice voting and the Open Voting Consortium and "Dechert Design" work on open source voting systems. Once developed, open source software would be free. Equipment costs for the system described below would total about $2 million. This may be compared with the $400,000 savings in pre-printed ballots for each election, and the costs of Dominion Election Systems services.

Links are provided for potential off-the-shelf hardware to give a sense of current availability and costs, but are not intended to be prescriptive. More detailed analysis would naturally be required before going forward with equipment purchases for an open source voting system.

John Arntz, San Francisco Director of Elections, has been very helpful in providing information about the current situation and the last election, which is much appreciated.

BALLOTS

The number of cards printed is based on the number of permanent vote-by-mail (VBM) voters and the total number of registered voters in the City.

Every permanent VBM voter receives a ballot for each election, and these ballots require several cards to cover all offices and propositions. Currently there are around 232,000 permanent VBM voters. For last fall's election, half the VBM voters received a four-card ballot, and others a five-card ballot (an average of 4.5 cards a voter) which means over one million VBM cards. The unit cost for a VBM ballot card is around $.33 since VBM ballots require more handling than cards for the polls, for a cost of around $345,000.

For the polling places, cards are printed for about 75% of all registered voters for those casting ballots at the polls. The current San Francisco registration count is 433,386, and 75% of this number is 325,000. Using the 4.5 cards per voter average, around 1.5 million ballot cards were printed for the polls. The unit cost for a ballot card printed for use at the polls is around $.27, and the total cost was around $400,000.

The total pre-printed cards for both types of voters was around 2.4 million in the last election.

POLLING PLACES

Each of San Francisco's about 570 Polling Places would have about six Voting Booths with privacy partitions, voting tablets and printers, and a Ballot Box with number of votes displayed on a monitor.

The Voting Booth

Voting Booth hardware would include a touchscreen tablet and printer. Optimally, both would be battery powered to guard against power failures, and connect mechanically by USB or equivalent for security, without any wireless capability that could open the door to outside interference.

The cost of a touchscreen tablet depends largely on make and screen size. There are many possible choices, and an easily replaceable battery would be important. While a 7-inch tablet would be feasible, a 10-inch tablet with zoom-able interface would be more readable for people with poor eyesight, and require less scrolling. An audio interface could be implemented on the same tablet.

The battery-powered printer and battery-powered tablet should be able to go all day without recharge, but spare charged batteries should be on hand. Voting booths might average 30 to 60 voters, depending on turnout, each printing their one-page ballots after making their selections. These printers have a duty cycle of 500 to 1000 pages per month in business use, so this would be light duty.

The voting booths could have foam board partitions costing about $5 per booth. The booths might look something like this:
http://www.openvotingconsortium.org/blog/2009-oct-08/california_democratic_council_voters_enjoy_ovc

The ideal window would not require paging, and have the entire ballot on one screen no matter how many (zoom-able) contests. The print might be very small in some cases, but the contest title should always be clearly readable, e.g., if there were 10 candidates for US House, the print may be too small to read the names but by tapping on the contest title, the text would zoom up. Once a selection is made, it would zoom down. The selected candidate name would be readable while the unselected candidates may not. The entire ballot and the choices made, and the un-voted contests, would be readily seen on one page. This may be more easily done with a 10-inch tablet than with a 7-inch tablet, and warrants further investigation.

After making all selections, the voter would click the Print button and exit the Voting Booth, giving the ballot to a poll worker to scan and deposit in the Ballot Box (see Scanning Ballots, below)

Voting Booth Costs

For cost estimating purposes, Amazon sells in volume and their margins are low.

The printer decision is much easier than the tablet. The Open Voting Consortium has used the HP battery powered printer in its demos for about 4 years. Below is an HP link and links for a Canon printer and battery. As indicated above, links demonstrate availability of equipment and costs but are not recommendations regarding selection.

$300 HP Printer http://www.amazon.com/HP-Deskjet-Printer-Battery-Included/dp/B000B658NC/ref=sr_1_2?ie=UTF8&qid=1422054349&sr=8-2&keywords=hp+portable+printer+battery+powered

$170 Canon Printer http://www.amazon.com/dp/B00NV9LL9Q/ref=sr_ob_10?ie=UTF8&qid=1422054627&sr=8-10

$83 Battery for Canon Printer http://www.amazon.com/Canon-LK-62-Rechargeable-Lithium-Ion-Battery/dp/B00161RTYM/ref=pd_bxgy_e_text_z

Tablet costs keep coming down. Current low-priced options include:
$50 7-inch Tablet http://www.amazon.com/dp/B00MXXJLTS?psc=1#productDetails
$110 10-inch tablet http://www.amazon.com/Dragon-Touch-A1X-Pre-installed-TabletExpress/dp/B00LM5WU96/ref=sr_1_8?s=electronics&ie=UTF8&qid=1422944529&sr=1-8&keywords=kitkat+tablet

The tablet should have a stand or cradle. There are many off-the-shelf options:
https://www.google.com/#q=tablet+cradle

$13 Akron Tablet Stand http://www.amazon.com/Arkon-Travel-Android-Tablet-Samsung/dp/B000CKVOOY/ref=sr_1_5?s=electronics&ie=UTF8&qid=1422934599&sr=1-5&keywords=tablet+cradle

Costs for each Voting Booth would total about $475, based upon $300 printer, $110 tablet, $15 tablet stand, $5 partitions and a 10% ($45) contingency. Six Voting Booths per Polling Place would total about $2850.

Consumables including paper, black ink cartridges, and spare batteries would be ongoing but minor, perhaps $10,000 per election.

Some work should be done to figure attrition rate for tablets, based on some desired life span, perhaps 10 years. Enough spares should be purchased to cover lost, stolen, damaged or broken equipment. Printers should hold up fine as long as they are stored properly and not abused, with about a 10-year life.

Scanning Ballots and the Ballot Box

The voter would give the poll worker at the Ballot Box their ballot, and the poll worker would scan the ballot barcode and deposit the ballot in the Ballot Box. The ballot count would display on a monitor, and increment as each ballot counted, with ballot an audible beep. If the poll worker scanned the same ballot a second time for some reason, the ballot count number would not increment and the display would say "ballot already counted." The tabulation of votes would not be displayed on a screen. Once the polls close, the tabulation routine with the recorded votes would be terminated and the tally sheet printed. One would be posted at the polling place and one would go in the Ballot Box with the ballots. Any number of tally sheets could be printed and distributed to anyone upon request. The tally sheet would also exist in electronic form.

Ballot Boxes with the data files and tally sheets would be delivered to the City Hall counting center by the poll workers. The data could be extracted from the tally sheets and integrated in a matter of minutes after the poll workers arrive. The Ballot Box data files, paper ballots and tally sheets could be checked to ensure they all match. Before announcing results, some checking could be done to ensure that all have come in as expected and been counted.

Ballot Box and Monitor Costs

The Ballot Box would be a lockable custom computer with low-power/battery-powered system inside.

A small system board would be mounted in the upper right (or upper left) rear corner.... something like the following, which is about $100 not counting the battery which would be about $50.

$100 Pico-ITX System Board (in quantity)
http://www.embeddedworks.net/empc572.html?gclid=Cj0KEQiA6JemBRC5tYLRwYGcwosBEiQANA3IB3Prz8ZiPBFHBQyo96TC35BxyXT6tVdsQ98lHlNblQwaAv4Y8P8HAQ

The system board would be mounted so that the HDMI (or mini HDMI) port would be accessible from outside the Box (rear or side). The Box would also have a hole for a 2D barcode scanner's USB cable. It would have a clamp

inside so that once the cable is routed into the Box, it would be clamped into place and could not be pulled out while the Box is locked. Perhaps the 2D barcode scanner would stay connected all the time depending on whether the 2D barcode scanner might have other uses between elections.

$200 2D Barcode Scanner http://www.amazon.com/Motorola-DS4208-SR-Handheld-Omnidirectional-Barcode/dp/B00MMXO9WI/ref=sr_1_1?ie=UTF8&qid=1422941954&sr=8-1&keywords=2d+scanner+usb

The top lid of the Ballot Box would be hinged with a lock. The Box would have a slot in front for depositing the ballots (see Open Source Consortium Demonstration at LinuxWorld, below, with link to LinuxWorld video).

For startup with the Ballot Box open, a keyboard and mouse would be attached and some secure media with the election data and software would be loaded. When all is checked and ready, the keyboard and mouse would be removed, the barcode scanner plugged-in and the Box closed and locked.

Any monitor with DVI or HDMI could be used (presumably plugged into its own UPS power). The Ballot Box would be in a safe location and continually monitored and staffed. The monitor would display the ballot count in a large font which could be seen from anywhere in the room. Anyone in the room should be able to witness that a ballot was scanned and deposited and that the display number increased by one.

$100 20-inch monitor http://www.amazon.com/Dell-Computer-E2015HV-20-Inch-LED-Lit/dp/B00M1C47EU/ref=sr_1_14?s=electronics&ie=UTF8&qid=1422942632&sr=1-14&keywords=computer+monitor

When the polls close, the Ballot Box would be unlocked and a printer from one of the Voting Booths plugged into the system board for printing the tally sheets (multiple copies of one tally sheet, letter or legal sized). The barcode scanner would be unplugged and keyboard and mouse plugged-in. The Ballot Box data files and tally sheets would be delivered to the City Hall counting center and added to the overall vote counts.

The Ballot Box could be made for around $300 (not counting barcode scanner and monitor which may be available from City inventory), with $50 battery and $100 system board. A $200 barcode scanner and $100 monitor would bring the cost to $600.

Total Polling Place Costs
With six Voting Booths at $2850 and the Ballot Box, Monitor and Phone at $600, total costs per Polling Place would be about $3450. With 570 Polling Places, 570 x $3450 = $1,966,500.

CITY HALL COUNTING CENTER

The City Hall counting center would not need anything purpose-built or dedicated to handle polling place ballots -- just ordinary computers, printers, and scanners. However, representative equipment and costs are indicated below if new purchases are considered.

The tally sheets would have the precinct data encoded in a bar code, and much of the vote would be accumulated by scanning the bar codes on the tally sheets for other than ranked-choice votes. Ranked choice votes are more complicated, and discussed under Ranked Choice Voting, below.

The election materials from the polling places should come in sealed Ballot Boxes and sealed Envelopes. The counting center checks everything in, uploads the tally sheet information and electronically tallies all the polling place votes, and compares numbers. The Ballot Box would have the electronic file and voted paper ballots. The Envelopes should have the:
- test ballots

- tally sheets
- media with which the Ballot Box computer and the Voting Booth tablets were loaded
- USB stick or other media on which the results were copied from the Ballot Box
- chain of custody data with signatures
- signatures of witnesses

Spot checks include:
- comparing number of voted paper ballots from a polling place with number reported in the tally sheet
- check individual ballots to ensure only a single representation exists in the tally sheets and master spreadsheet.
- check tally sheet against corresponding range of cells in master spreadsheet
- manual recount of votes from a polling place and check against tally sheet
- scan some individual ballots and run software to verify that the text matches the bar code representation.

The last check is important because there's a persistent question: "How do we know the bar codes are right?" The short answer is: "This is verified at the counting center before the results are published."

Once all the ballots have been uploaded to master spreadsheet, results are calculated and the spreadsheet is published so anyone can download and check.

Vote By Mail Ballots could be scanned with 10 new off-the-shelf high-speed flat bed scanners using open source software to tabulate the votes. These new scanners could replace four older Dominion Voting System's Model 400-C scanners originally costing about $75,000 per scanner, and would provide a much faster VBM count.

Canon $4239 scanner http://www.scantastik.com/hardware/canon-scanners/canon-dr-g1100-scanner.html

An inexpensive but powerful PC—8-core, 4 GHZ processor with 16GB RAM and SSD—could run (open source) Linux to process the scanned images. The following represents a possible hardware configuration, if an existing Department of Elections computer were not used.

Computer configuration
$400 Acer 1440p monitor 27 inch
$100 Radeon HD 7770 video card
$175 AMD FX 8350 8-core processor 4GHZ
$180 ASUS SABERTOOTH 990FX system board
$130 Corsair 16GB RAM
$80 Corsair CX Series 750 watt power supply
$105 Crucial MX100 256 GB SSD

$1,170

Add any case, mouse, keyboard from stock or buy these new (~ $100)., and then assemble and install Linux and other free open source software.

monitor
http://www.amazon.com/Acer-K272HUL-bmiidp-27-inch-Widescreen/dp/B00JB6HCIC/ref=sr_1_1?ie=UTF8&qid=1423551782&sr=8-1&keywords=acer+1440p+monitor

Video card
http://www.amazon.com/Sapphire-DL-DVI-I-SL-DVI-D-PCI-Express-11201-12-20G/dp/B009O7YZA6/ref=sr_1_3?ie=UTF8&qid=1423551843&sr=8-3&keywords=radeon+7770

Processor
http://www.amazon.com/AMD-FD8350FRHKBOX-FX-8350-8-Core-

Processor/dp/B009O7YUF6/ref=sr_1_1?ie=UTF8&qid=1423551916&sr=8-1&keywords=amd+fx+8350

motherboard
http://www.amazon.com/ASUS-SABERTOOTH-990FX-R2-0-Motherboard/dp/B008YDJHWM/ref=pd_sim_pc_4?ie=UTF8&refRID=1214NWP9Q5NKZ44ZQGVJ

RAM
http://www.amazon.com/Corsair-Vengeance-Desktop-Memory-CMZ16GX3M2A1600C10/dp/B006EWUO22/ref=sr_1_1?s=electronics&ie=UTF8&qid=1423551990&sr=1-1&keywords=corsair+ram

Power supply
http://www.amazon.com/Corsair-Modular-Bronze-ATX12V-EPS12V/dp/B00ALK3KEM/ref=sr_1_1?s=electronics&ie=UTF8&qid=1423552039&sr=1-1&keywords=corsair+750+cx+750

SSD
http://www.amazon.com/Crucial-MX100-2-5-Inch-Internal-CT256MX100SSD1/dp/B00KFAGCWK/ref=sr_1_1?s=electronics&ie=UTF8&qid=1423552103&sr=1-1&keywords=crucial+mx100+256gb

The 10 high-speed flat bed scanners at $42,390 and computer at $1,170 would cost about $43,500.

ADDITIONAL VERIFICATION OF VOTING

There are some options to provide additional voting verification if desired.
1) Before giving their ballot to the poll worker at the Ballot Box, the voter could use an audio ballot verification station to put on headphones and scan the ballot's bar code, verifying their votes by listening to the votes read back. This would be a further check on the votes recorded on the ballot. Equipment would include a computer, and roughly $25 for headphones and another $200 barcode scanner.

2) One-person one-vote at the polling place can be verified by witnesses at the polling place. When the ballot is scanned with the Ballot Box' barcode reader and inserted in the Ballot Box, the number of the votes increases on the monitor, and protocol could call for others in the room to announce the number and applaud. The poll workers could thank the voter and hand out an "I Voted" sticker. Everyone in the room would see that one person cast one ballot, and that voter would be recognized and applauded.

AC POWER AND BATTERIES

While assuming AC power connection normally, there would be a requirement for cases where no power is available. This would mean having spare tablets on hand and external chargers available.
If no AC power were available, for example, you could start with 10 units (for 6 Voting Booths) charged-up, booted-up, and ready to go. Poll workers would have to check the units from time-to-time. When the charge on a tablet drops below, say, 25%, the poll worker would swap out with a charged unit. Then they'd connect the discharged unit to a portable charger (these are readily available and cheap). Printers should have no problem getting through the day on a single charge, and it's a simple matter to swap the battery in case one does run out of juice.

Having a user-replaceable battery would be highly advantageous. Most tablets do not have user-replaceable batteries, and this could be a problem. It could make the difference between getting 10 years service out of the tablet, and having to replace them all in 3 years.

There may be an issue if the tablet sits for a year unused with the battery inside. Probably the battery will completely lose its charge and, if it sits for long like that, it may be damaged. If batteries are to be stored, they're supposed to be stored with some charge -- uninstalled.

http://batteryuniversity.com/learn/article/how_to_store_batteries

Battery problems have plagued DREs (Direct-Recording Electronic Voting Machines) for many years. One of the worst scenarios would be to spend a lot of money on tablets and find that the batteries are all bad after one year. If the batteries are not user-replaceable, it could be that battery replacement would cost nearly as much as buying all new tablets.

Before making a large purchase of tablets, the battery issues should be thoroughly understood. It may depend on the specific battery technology and the specific circuitry in the tablet, which may vary from tablet to tablet. The issue may be mitigated with some maintenance routines. For example, perhaps an employee would have tables set up so that 50 units (or some magic number) each day would be taken from storage and set up to run for a while then charged for a while. Continually cycling through the inventory would provide confidence that the units can hold a good charge.

RANKED CHOICE VOTING

The data from each ballot is needed, even for a preliminary count, and the file with the polling place data should include all the ballots represented in XML/EML format (tagged text). A range of cells would be dedicated for each precinct so that anyone with a printed copy of the original tally sheet could check to see the same results in the spreadsheet.

All of the data from the polling places would be uploaded to one master spreadsheet (a script would run to extract data from each precinct PDF file and plug the data into the spreadsheet). Each ballot would be represented in one row with the unique identifier in the first column and the choices for each contest represented in however many columns it takes. The spreadsheet would not have any formulae; rather, a computation routine would be run once all the data is uploaded.

OPEN VOTING CONSORTIUM & THE "DECHERT DESIGN"

Alan Dechert presented the "Dechert Design" approach for open source voting to the SF Elections Commission on September 16, 2009, as well as providing much of the information in this report. This link to the Commission's Minutes leads to links to the documents submitted at that time.
http://sfgov2.org/archive.aspx?dept=305&sub=314&year=2009&dtype=319&file=111410

Alan Dechert demonstrated the "Dechert Design" approach for open source voting at the August 2008 LinuxWoirld Conference and Expo in Moscone Center.
http://www.openvotingconsortium.org/blog/2008-aug-29/success_at_linuxworld

Appendix B: Vendor Staffing

Breakdown of specialized staff from Dominion, provided by John Arntz, Director of the San Francisco Department of Elections.

- Project Manager – the contract requires the PM to be available five (5) days a week during normal business hours for eight (8) weeks prior to the week before the election. One week prior to and until the election is certified, Project Manager is available 24 hours a day, 7 days a week. In actuality the PM is consistently on-site nearly daily from mid-August through mid-December for a November election and from mid-March to the end of June for a June election. Off-peak, the PM visits both the Department's main office and its warehouse a few times a month.

- All personnel, materials, equipment and programming necessary to accomplish all aspects of the L&A testing of each component of the System, which is conducted every election. Typically 12 people for approximately 30 days.

- All personnel and new equipment and materials required to perform preventative maintenance of each component of the System, which is conducted annually. Typically 10 people for approximately 14 days.

- Sufficient, experienced technical support personnel on Election Day to troubleshoot and repair individual components of and the System. The election day personnel include at least 33 personnel (3 per District for 11 Districts) to troubleshoot and make repairs at the precinct level, a minimum of four (4) personnel at the Central Processing Network center at City Hall, a minimum of two (2) at warehouse for repairs, and a minimum of two (2) high-level technical specialists at the Department.

- Ballot Formatting – the vendor provides personnel to format ballots before each election. This involves at least one person and requires approximately one month's time to complete the ballots for multi-card elections.

- System Issues – there is no set number of personnel and their associated time for this item. Still, whenever there are equipment or system issues that Department personnel cannot resolve, we ask that the vendor's engineers review such issues and then propose explanations as well as solutions.

- Supporting Management Personnel – all activities that the vendor undertakes for SF include the support and organization of resources and personnel of management personnel who seldom visit the county.