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# Open Source and Electronic Voting: A New Strategy Toward Technical Procurement for Voting Systems

Andor Kesselman
*Claremont McKenna College*

# CLAREMONT MCKENNA COLLEGE

# OPEN SOURCE AND ELECTRONIC VOTING: A NEW STRATEGY TOWARD TECHNICAL PROCUREMENT FOR VOTING SYSTEMS

SUBMITTED TO

Professor Rick Worthington

AND

Professor John J. Pitney, Jr., Ph.D.

AND

DEAN NICHOLAS WARNER

BY

ANDOR SAMUEL KESSELMAN

for

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# ABSTRACT

Direct Recording Electronic Voting Systems (DRE) are some of the most popular forms of electronic voting and yet they are riddled with problems. Current voting systems are poorly designed and migration to newer software can be costly. Inadequate software solutions in voting systems have led to security flaws, bad tabulation, and partisan software design. As government proceeds into an increasingly sophisticated era of voting technology, it needs to consider a better platform.

This thesis explores the government procurement strategy associated with modern Direct Recording Electronic Voting Systems. The thesis argues that governments should adopt an open source solution (OSS) for future IT acquisition of voting systems. Adopting an open source solution not only provides practical advantages such as better software design, cheaper implementation, and avoidance of vendor lock-in, but also proposes that OSS provides a strong foundation for future IT policy. Open source's strength in transparency provides a key factor in voting system design. The thesis recommends that governments adopt a four part strategy for future OSS adoption with voting system.

**1)** Approve an independent, pro-OSS certification organization that works closely with the U.S Election Assistance Commission, National Institute of Standards and Technology, and other system organizations to create the optimal voting systems guidelines.

**2)** Update FAR requirements to greater accommodate open source procurement policy.

**3)** Assist local and state jurisdictions to acquire OSS for DRE machines.

**4)** Promote open source business strategy by hiring vendors for system integration and analysis

This thesis contends that these four policies will improve the electronic voting experience and allow for better future innovation and adoption IT strategies.

# ACKNOWLEDGMENTS

It has been a pleasure writing this thesis thanks to the wonderful support that I have had. First, thank you Professor Jack Pitney and Rick Worthington for the many meetings, emails, resources, and edits shared over the course of the semester. It was a great honor to work with such fine professors. This thesis would not have been possible if not for your help.

I would also like to thank my family members, specifically my Uncle Carl, my Uncle Arthur, my dad, and my mom for allowing me to brainstorm ideas off them. I wouldn't have had the idea of tackling the problem of electronic voting if it wasn't for my dad and Uncle Carl. Lastly, as immodest as this may seem I would like to thank myself for continuing to stick with this thesis with unwavering passion. I put this thesis over many other hobbies and I want to take a moment to acknowledge my hard work.

# INTRODUCTION

Direct Recording Electronic Voting Systems (DRE) are one of the most popular forms of electronic voting, yet they are riddled with problems.[1] Current voting systems have poor design and migration to newer software can be costly.

This thesis explores the government procurement strategy associated with modern Direct Recording Electronic Voting Systems. The thesis argues that government would be wise to adopt an open source solution (OSS) for future Informational Technology (IT) acquisition of voting systems. This paper contends adopting an open source solution not only provides practical advantages such as better software design, cheaper implementation, and avoidance of vendor lock-in, but also provides a level of transparency useful for voting systems. The thesis recommends that governments adopt a four part strategy for future OSS adoption with voting system:

> **1)** Approve an independent, pro-OSS certification organization that works closely with the U.S Election Assistance Commission, National Institute of Standards and Technology, and other system organizations to create the optimal voting systems guidelines.
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> **2)** Update FAR requirements to greater accommodate open source procurement policy.
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> **3)** Assist local and state jurisdictions to acquire OSS for DRE machines.
>
> **4)** Promote open source business strategy by hiring vendors for system integration and analysis

This thesis contends that these four policies will improve the electronic voting experience and allow for better future innovation and adoption IT strategies. OSS has the

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1 This is a live policy issue. The Presidential Commission on Election Administration recently recommended 19 reforms to the voting process as of January 2014.

potential to be constructive in facilitating innovation and organizing standards across voting systems. Though this thesis will not go into specific detail on implementation, the end of this thesis will address a mock organization called the Open Standards Voting Board (OSVB) which describes an independent, pro-OSS organization:

## ROADMAP

This thesis has five chapters. The first two provide context for the problems surrounding electronic voting systems. The first chapter explains the problem with voting systems, providing a brief introduction to electronic voting and the impact of policy design regarding such systems.

The second chapter describes open source software and intends to provide a more complete understanding of some of the advantages surrounding software solutions. Open source systems can be extremely powerful if utilized correctly. The chapter goes into detail about some of the software design associated with open source software, to understand how an open source platform would be possible under open source.

The third chapter provides information regarding adoption of voting software in voting systems. More specifically, it describe the various programs that certify, test, and audit electronic voting systems.

The last two chapters are the crux of this thesis. They describe the procurement process involving voting software and make policy recommendations for a pro-open source strategy.  The chapter provides insight to the decisions facing jurisdictions in the process of IT procurement. The chapter proposes a new and improved system for electronic voting using a prototype organization.

This thesis is to provide a plan for future IT procurement for voting systems. While this thesis focuses on the problem of electronic voting, the theories are intended to be relevant to a larger context within government IT strategy.

The next section will lay the groundwork for models that were heavily considered for the topic. The public value framework, metropolis model, and Salamon's New Governance framework were useful for developing a conceptual framework for policy design.

## PUBLIC VALUE FRAMEWORK

Public sector organizations need to balance fairness, accountability, and transparency in policy.[2] The public value framework has four drivers – administrative efficiency, service improvement for citizen engagement, and foundational values.[3]

These drivers are described by Rose and Persson, who in <u>Government Value Paradigms—Bureaucracy, New Public Management, and E-Government,</u> describe administrative efficiency as positive cost benefit represented by efficiency, effectiveness, and economy.[4] Persson and Rose believe that e-government is a mix of many methods of public management including traditional bureaucratic and new public management.

The current bureaucratic structure of public management is increasingly being accused of underperforming by advocates of the *new public management* (NPM) which seeks to improve performance, effectiveness, citizen centricity, and efficiency.[5]

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2 Leif Flak and Hellang Øyvind, "Assessing Effects of eGovernment Initiatives Based on a Public Value Framework" (n.d.).

3 Ibid.

4 Ibid.

5 Ibid. 47; Anders Persson and Goran Goldkuhl, "Government Value Paradigms--Bureaucracy, New Public Management, and E-Government," *Communications of the Association for Information Systems* 27 (July 2010): 27.

Because problems of efficiency, optimization, and effectiveness are similar to most businesses woes, often new public management focuses on bringing a "business" approach to public administration by emphasizing key business perspectives such as entrepreneurship, cost control, performance, and improved quality of services.[6]

Opponents of the model often criticize the NPM perspective as being too citizen-centric or argue that new public management reduces values of government. Proponents of NPM are customer centric, and perceive NPM structure as more competitive than traditional management frameworks.[7] NPM borrows many of the same ideas of a framework called reinventing government however it focuses in prompting subtle, incremental shifts toward democratic management.[8] For many advocates of the NPM model, E-Government could solve many traditional problems of governance.

According to Persson and Goldkuhl, E-Government represents a merger of several core values from NPM and traditional bureaucracy that focus on tenets such as equality, transparency, and rule of law.[9] Persson and Goldkuhl call E-Government a "a means to decrease the impacts of the dysfunctions of bureaucracy, a means of strengthening bureaucratic values, a way of building on NPM and taking it a step further and a step back from NPM and replacing it."[10]

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6 NPM have a distinct value system. For example, in 2006 the European Commission developed a framework called "EGep". Egep was created in 2006 to assess eGovernment services and is organized around three primary standards – efficiency, democracy, and effectiveness.; "eGovernment Economics Project (eGep) Measurement Framework Final Version." eGovernment Unit DG Information Society and Media European Commission, May 15, 2006; Flak and Øyvind, "Kristiansand, Norway," 249.
7 Ibid. 52
8 George Frederickson, "Comparing the Reinventing Government Movement with the New Public Administration" (Public Administration Review, n.d.).
9 Persson and Goldkuhl, "Government Value Paradigms--Bureaucracy, New Public Management, and E-Government," 57.
10 Ibid 57

This thesis proposal is not so bold as to suggest a complete restructuring of government or bureaucracy. In many contexts traditional bureaucracy is necessary to preserve government and social stability. I merely wish to expand on an area of public administration which I believe to be severely deficient.

## METROPOLIS MODEL

Crowd sourcing is different from traditional project models because of an emphasis on decentralization. The Metropolis Model perceives the "wisdom of the crowd," and relies on high management coordination and implementation to promote engagement and technological cohesion to be successful.  This model suggests that successful policy can rely on engaging and coordinating large numbers of people in a similar project. Successful adoption of peer production networks (networks that do not rely on markets, hierarchy, and contracts such as Wikipedia) within the context of E-Government requires dramatic changes in organizational structure, processes, and tools to support greater cohesion between developers and policy makers.[11]

## POLICY IMPLEMENTATION FRAMEWORK

Salamon's book on New Governance argues that the only coherent way to implement public policy in the modern era is to understand the dynamics between the private and public sector. Because policy makers have handed out discretion through contracting, complete control in the polity is impossible. Salamon argues that tools such

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11 Ibid. 84

as command and control are replaced with negotiation and persuasion.[12] Salamon stresses that public-private partnerships are crucial in policy. The prototype board proposed in this thesis relies on a similar relationship between the government and external vendors.

Salamon describes six goals for producing policy: effectiveness, efficiency, equity, manageability, and policy legitimacy.[13] In Salamon's world, these goals are at odds with each other within the polity by trying to be more effective (which is exclusively results oriented), policy makers naturally lose efficiency (which is cost oriented). Most successful policy embodies many or all of the six tools described by Salamon.[14] This thesis will not explain in detail each of this criteria due to the scope of the paper.

This thesis proposes that transitioning to open source can challenge the dynamics and tradeoffs Salamon describes. Through adoption of open source, we can gain efficiency and effectiveness. Moreover, Salamon's theories rely too heavily on traditional business models. Open source models can be a tool to engage policy makers; however they require policy makers to think outside the box. This paper will describe how OSS procurement can improve voting systems in many of the ways described by Salamon including efficiency, effectiveness, equity, and legitimacy.

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12 Lester Salamon, *The Tools of Government: A Guide to New Governance* (Oxford University Press, 2002), 15.
13 Ibid., 21–24.
14 Ibid., 22.

In The Whale and the Reactor, Langdon Winner proposes that artifacts have political qualities.[15] His book suggests a theory of technical politics – the theory that certain technologies are political phenomena in their own right.[16]

Winner's book provides the example of the low-hanging overpasses on Long Island created mid-20th century. The builder of the bridges, Robert Moses, built his overpasses according to specifications that would discourage the presence of buses on the parkway.[17] According to Winner, this had a negative effect on black immigration through the Long Island Bridge. Using the example of Robert Moses's bridge, Winner describes the idea that technological design can have political implications and that some technologies are naturally political by design. He suggests that motives can be expressed in the technology itself.

Like Moses's Bridge, voting system design is by nature political. Open source integration in voting systems will have political implications potentially in civic participation and the voting process. This thesis contends factors such as increased transparency of an OSS system will provide a better voting experience. Some of these improvements will be functional and others will be social or political. Each of these improvements will be addressed later in the thesis.

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15 Langdon Winner, *The Whale and the Reactor: A Search for Limits in an Age of High Technology* (London: University of Chicago Press, 1986), http://sciencepolicy.colorado.edu/students/envs_5110/whale_reactor.pdf.
16 Ibid., 21.
17 Ibid., 23.

LITERATURE ANALYSIS

Literature that was reviewed in this thesis mostly consisted of academic papers and government reports provided by online databases such as JSTOR, Academic Search Premier, and EBSCOHost. Many of the academic papers (particularly the ones involving electronic voting) use recent federal elections as a context for academic analysis. One of the potential weaknesses of this analysis is that federal elections only occur once every four years. The relatively small number of elections combined with the rapid pace of technological development means that many of the theories proposed in the papers are subject to drawing conclusions that may not have relevance for future elections. In addition to relying on a relatively small sample size and time frame, most of the research involves post-2000 dates. Many of the federal research programs and independent research programs did not get formed until after the debacle with the Bush-Gore elections. Federal programs such as the EAC and HAVA that support much of the research for electronic voting were not formed until 2000.

Federal reports were also used for quite extensively in this thesis. Many of the federal reports were extremely recent. The recentness of the reports was crucial for building a strong case in policy reform. Because the voting landscape and technology shifts at an extremely fast pace, it was important to get as up-to-date information on the election information as possible.

Finally, another challenge of this paper is that it ultimately recommends policy reforms in uncharted territories that require an understanding of many distinct fields. In particular, proposal of the OVSB was made by combining information on a variety of fields. The policy reform suggested requires having an understanding of many different

fields (voting systems, programming, and government). Because this topic involves a

broad range of distinct disciplines, it was a challenge to be knowledgeable and address

each of these disciplines.

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# 1. DRE VOTING SYSTEMS

## HISTORICAL CONTEXT

Covering past voting technology provides a context for understanding modern DRE systems.

In the precolonial period, voting took place "*via voce*" – in public and out loud.[18] Because the electorate was so small, via voce voting was manageable. As America moved toward independence and the population grew, states and local governments adopted a variety of different forms of ballot counting such as printed ballots, bean, and corn.[19] Pre and early colonial voting was relatively simple though voters were subjected to the public pressure of voting in certain directions, as well as voter fraud and lack voter privacy.[20] Toward the end of the nineteenth century, America adopted the secret or "Australian" ballot that is essentially a government printed paper ballot.[21] The adoption of a secret ballot created problems including bribery, fraud, and counting irregularities. [22]

Older systems such as lever systems were widely used until more recently. Up to 2000, election officials adopted other technologies including optical scans, levers,

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18 Paul Herrnson et al., *The Study of Electronic Voting: The Not-So-Simple Act of Casting a Ballot* (Washington D.C: Brookings Institution Press, n.d.).
19 Ibid.
20 Douglas Jones, "Douglas W. Jones Illustrated Voting Machine History," *Part of the Voting and Elections Web Page*, accessed February 6, 2014,
http://homepage.cs.uiowa.edu/~jones/voting/pictures/#before.
21 Herrnson et al., *The Study of Electronic Voting: The Not-So-Simple Act of Casting a Ballot*, 8.
22 Ibid.

and electronic. [23] Each of these systems became  increasingly complex in hardware and software. Older systems were riddled with problems of security, access, and expediency.  By the mid-1970s voting systems began to  incorporate computing power. The increasing complexity and power of such voting systems had  challenges, including that the evolution of Direct Recording Electronic machines (DRE) into full computing  machines capable of doing far more than simply counting votes.

By the late 1990s, DRE became increasingly incorporated in state and local elections.[24] DRE machines were designed to be utilized with touch screen interfaces. Figure 1 on the next page shows the adoption rates of different types of voting mediums over the last 30 years.

**DRE VOTING MACHINES**

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DRE machines are becoming more relevant in our voting system, as governments acquire new DRE machines. In 2012, DRE machines accounted for 39% of the vote.[25] The most popular form of voting equipment is a paper ballot with an optical scan (56%).[26] Because I expect growing demand of DRE machines as governments try to consolidate tallies and standardize the voting process, this thesis will focus on DRE technology.

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23 Ibid., 9.
24 Ibid., 10.
25 "Voting Systems & Use: 1980-2012 - Voting Machines - ProCon.org," *ProCon.org*, last modified 2014, accessed April 14, 2014, http://votingmachines.procon.org/view.resource.php?resourceID=000274.
26 Ibid.

Availability of Voting Systems in US Presidential Elections by Percentage of Voters
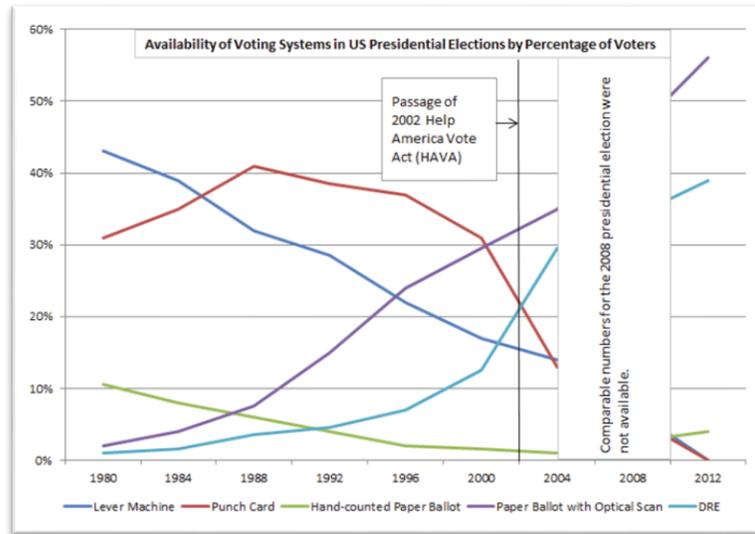
FIGURE 1 DISPLAYS THE HISTORY OF VOTING TECHNOLOGY EQUIPMENT TO 2006.
NOTICE THE CONTINUAL GROWTH IN DRE MACHINES.[27]

DRE machines were introduced by Shoup and Microvote companies that distribute voting systems.[28] The first systems represented a classic lever machine with push buttons replacing levels, lights replacing X marks, and 35mm film replacing the mechanical wheels that counted votes.[29] Since then, the displays have been replaced with sophisticated touch screen technology that represents a full ballot interface.[30]

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27 "Voting Systems & Use: 1980-2012 - Voting Machines - ProCon.org." Graph taken from the report on procon.org

28 Melanie Volkamer, *Evaluation of Electronic Voting* (Center for Advanced Security Research Darmstadt: Springer, 2008).

29 Charles Stewart III, "Voting Technologies," *Annual Review of Political Science* 14 (March 21, 2011): 353–378.

30 Ibid.

FIGURE 2 THIS IS AN EXAMPLE OF A NEWER DRE MACHINE. THE INTERFACE IS NOW GRAPHIC AND IS TOUCHSCREEN.[31]

Voting sites may choose DRE equipment for a number of reasons. DRE machines are the only voting system that enables individuals with disabilities such as blindness to vote secretly and privately.[32] DRE machines can reduce error rates in ballots and make the counting process more efficient and timely.

DRE machines store data locally. Data transference requires physical transference of storage within devices as the machines are not networked.[33] DRE machines store e-votes in local memory and originally did not create a paper trail. Recent reforms have advanced a voter-verified paper audit trail.[34] The voter-verified paper audit  trail (VVPAT) and various other changes DRE systems have

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31 Mark Clayton, "Voting-Machine Glitches: How Bad Was It on Election Day around the Country?," *The Christian Science Monitor*, November 7, 2012, http://www.csmonitor.com/USA/Elections/2012/1107/Voting-machine-glitches-How-bad-was-it-on-Election-Day-around-the-country.
32 Lisa Schur, *Reducing Obstacles to Voting for People with Disabilities*, VTP Working Paper (MIT: Rutgers University, June 22, 2013), http://vote.caltech.edu/content/reducing-obstacles-voting-people-disabilities.pg 1
33 Volkamer, *Evaluation of Electronic Voting*, 22.
34  Ibid.

attempted to improve voter accuracy and the audit process. Paper trails are a live debate in Congress. In the 113th Congress for example, they sought to rectify this issue by amending HAVA to require a permanent paper record for voting systems. [35] Bill H.R. 260 was aimed at reducing federal spending and the deficit by terminating taxpayer financing of presidential elections. It is currently being referred to committee.[36] Bill H.R. 1994 is titled <u>Excellence and Innovation in Language Learning Act</u> and died in committee. [37]

DRE machines are subjected to primarily two issues. These concerns dropped the use of DRE machines from 38% in 2006 to only 33% in 2010.[38]  Recently DRE equipment has become more popular with 39% of ballots cast using DRE machines in 2012.[39]  The first issue with DRE machines is that it hard to spot tampering. Because viruses and bugs can hide under the software, tampering of code or infected systems can be difficult to identify. Second, opposition to DRE machines believes that they are more prone to error than paper ballots with optical scans. Later, this thesis will identify "residual rates" of voting. It will demonstrate that the concern for residual rates should be minimal as evidence suggests DRE machines grossly reduce error rates. [40]

DRE machines can do much more than  count votes. DRE's are vulnerable to hacking like any computer, which makes  security valuable. Traditionally, DRE

35 Kevin Coleman and Eric Fischer, "The Help America Vote Act: Overview and Issues" (Congressional Research Service, October 21, 2013), https://www.fas.org/sgp/crs/misc/RS20898.pdf.
36 "To Reduce Federal Spending and the Deficit by Terminating Taxpayer Financing of Presidential Election Campaigns and Party Conventions and by Terminating the Election Assistance Commission. (H.R. 260) - GovTrack.us," accessed April 22, 2014, https://www.govtrack.us/congress/bills/113/hr260.
37 "Excellence and Innovation in Language Learning Act (2011; 112th Congress H.R. 1994) - GovTrack.us," *Govtrack.us*, accessed April 22, 2014, https://www.govtrack.us/congress/bills/112/hr1994.
38 Stewart III, "Voting Technologies."
39 "Voting Systems & Use: 1980-2012 - Voting Machines - ProCon.org."
40 Eric Fischer and Kevin Coleman, *The Direct Recording Electronic Voting Machine (DRE) Controversy: FAQs and Misperceptions*, CRS Report for Congress (CRS Web: Congressional Research Service, December 14, 2005).

computers are programmed to store the e-votes in local memory which can be accessed to tally election results.[41]

States test out DRE machines however they do not test to the level of scrutiny that the context requires. Because DRE machines are proprietary machines, manufacturers require confidentiality agreements. Testing takes place on the state and federal level but the results are not publicly available.[42] This thesis proposes that an open source platform for DRE systems would provide an adequate level of scrutiny and transparency that one should expect in a voting election system.

DRE machines have reduced the residual vote rates for voting systems (The votes that are uncounted because over votes for one or more offices, wrongly marked notes or other errors). In the presidential elections for example, punch cards had a 6.33% rate of error in Florida. After Florida adopted DRE machines for the 2004 election, the residual rate dropped to 0.56%.[43] Chapter 3 will discuss individual state tests for auditing and testing systems in more depth.

This thesis proposes that OSS adoption for DRE can solve problems regarding acquisition costs, transparency, and software auditing. Moreover, OSS has the potential to create a superior piece of software for voting machines. OSS integration into DRE machines will improve efficiently improves the voter experience.

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41 Ibid.
42 Ibid. 7
43 Ibid. 14

# THE 2000 ELECTION

The 2000 election dramatized the importance of efficient voting machine systems. Bush won Florida, and the presidency, by a mere 537 votes.[44] From a technological implementation perspective, the 2000 elections were controversial because of a large variance of performance affected by poor electoral voting systems within different districts in Florida.

Demographic and technological differences affected the reliability of voting systems. As an example, voters in Gadsden County had a 68 times greater chance of having their votes invalidated than adjoining Leon County. Gadsden, Florida's only black majority county, relied on unreliable voting technology while Leon County used modern voting technology.[45] Paul Schwartz, a professor of Law at the Brooklyn Law School did extensive analysis of the 2000 elections in an effort to evaluate certain systems. He looked at the residual rates – a rate that indicates how many votes were discarded, invalid, and spoiled as a percentage of the total vote. See appendix for Schwartz's complete breakdown of residual rates for different technologies. The appendix will show various tables and metrics used in a post-2000 evaluation of voting systems to determine the reliability of certain voting technologies. Technology such as punch cards in Florida had high residual rates which may have impacted some voting jurisdictions results.

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44 Padmananda Rama, "Obama Campaign Invokes '537' To Get Out The Vote : It's All Politics : NPR," *NPR*, last modified October 24, 2012, accessed April 14, 2014, http://www.npr.org/blogs/itsallpolitics/2012/10/24/163555295/obama-campaign-invokes-537-to-get-out-the-vote.
45 Paul Schwartz, "Voting Technology and Democracy," in *Voting Technology and Democracy*, vol. 77, New York University Law Review, 2002, 1, www.paulschwartz.net/pdf/votingtech.pdf.

Many election administrators describe the voting status as a "one size does not fit all" problem.[46] Although every district has unique voting challenges, often many of the problems are similar.[47]

Florida's use of punch cards increased error rates, which is one reason why the results were so controversial. The most controversial aspect of the 2000 elections was the "butterfly" ballot whose confusing design led to a high error rate. The butterfly ballot was so aptly named because the two columns were labeled with the names of candidates. Confused voters may have mistakenly punched holed Buchanan for Gore. [48]

The use of outdated technology with poor implementation strategy haunted the 2000 elections.[49] This case shows why governments need to develop reliable voting systems. Efficient and properly run election systems require more than technological reform. Although technology plays a significant part in voting system reform, voting systems depend largely on effective interplay of people, processes, and technology involving all levels of government.[50]

After the 2000 elections, policymakers began to realize the importance of assisting states in technological voting system adoption. Congress passed the Help America Vote Act (HAVA) to assist in upgrading voting systems. From a federal

46 Vivian B. Wilcox, *Steps to Manage Voting System Environments*, eBook Collection (EBSCOhost (New York: Nova Science Publishers, Inc, 2009), accessed March 9, 2014, http://web.b.ebscohost.com/ehost/ebookviewer/ebook/bmxlYmtfXzM1NzM1N19fQU41?sid=4825d317-6d2a-4379-bd44-5ba7a9dbc7f2@sessionmgr111&vid=1&format=EB&rid=1.
47 Robert Bauer et al., *The American Voting Experience: Report and Recommendations of the Presidential Commission on Election Administration*, January 2014, 9.
48 Schwartz, "Voting Technology and Democracy," 11.
49 Brian L Fife and Geralyn M Miller, *Political Culture and Voting Systems in the United States : An Examination of the 2000 Presidential Election* (Westport, Conn: Praeger, 2002), 1.
50 Wilcox, *Steps to Manage Voting System Environments*, 2.

perspective, issues such as standardization of data became prominent after the 2000

elections. Laws covering issues such as banning certain devices or recognizing how

to count ballots became prevalent. Between 2000 and 2003, states considered 5,378

new laws regarding voting systems.[51] In 2012, there were a total of 47 measures that

dealt with voting system reform and in 2013 there were a total of 43 pieces of

legislation.[52]

HAVA requires one voting machine in each precinct to accommodate

disabled votes. DRE systems are the only system that allows this functionality.[53]

This had led to the general growth of DRE systems in elections. DRE systems

began to be implemented in numerous states including Georgia which initiated a

statewide implementation of DRE systems in November 2002.[54]

## THEMES OF CONSIDERATION IN VOTING TECHNOLOGY

System analysts generally divide the election process into three parts –

preparation, polling, and counting.[55] In the preparation stage, elected officials prepare

the ballots. This stage includes the mapping of political district, ballot choice styles,

and voting locations. After preparation, poll workers sign in voters to make sure each

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51 Traugott et al., "The Impact of Voting Systems on Residual Votes, Incomplete Ballots, and Other
Measures of Voting Behavior" (presented at the Midwest Political Science Association, Chicago,IL, 2005).
52 "2011-2014 Elections Legislation Database," *National Conference of State Legislatures* (State Net,
n.d.), accessed April 14, 2014, http://www.ncsl.org/research/elections-and-campaigns/2011-2013-elections-
legislation-database.aspx. Data was obtained by searching topics: Voting Equipment/Technology-Selection
& Standards; Voting System Testing/Security/Storage in their respective years.
53 Fischer and Coleman, *The Direct Recording Electronic Voting Machine (DRE) Controversy: FAQs and
Misperceptions*, 4.
54 Ibid.
55 Ka-Ping Yee, "Building Reliable Voting Machine Software" (Philosophy in Computer Science,
University of Waterloo, 1998).

voter  is given a single ballot at the polling place. Finally, after the polling, records are counted either at the place or the central  election office.

Schwartz breaks  down the voting election system process into three elements.

- Voting Technology – This is the hardware and software of  voting systems. Examples include punch cards, optical scanners, and DRE machines.

- Public Institutions and Personnel that manage technology – This element refers the  organizational context for technology management. State and local environments for adoption are extremely important in  successful acquisition of DRE technology.

- Different laws that shape section, maintenance, and design of technology –  Various statutes can affect the adoption and acquisition of DRE machines. In general, the Obama administration has been a proponent of  passing pro-OSS adoption laws as recognized by the Open Government  Initiative.[56]

Schwartz says that the implementation of voting systems rely on heavily on external policies. In the case of OSS, political policies such as the federal stance on OSS acquisition can have a significant impact on the implementation of technological systems.

Voting is intended to be built on five principles involving freedom, equality universal access, directness, and secrecy. OSS system adoption can apply these

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56 "Open Government Initiative," *Whitehouse.gov*, n.d., http://www.whitehouse.gov/open.

principles to voting systems better than proprietary software. There are three primary dimensions of any election form – the medium used to hold the  ballot, the environment where people cast their vote, and the point of time in which vote casting is enabled.[57]

In a later section of the thesis, I will describe facets of software that are evaluated as well as go into more detail about specific facets of the voting process which are can  be improved through the use of open source software.  Historically, the five issues listed above  have been the primary challenges with voting technology.

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57 Volkamer, *Evaluation of Electronic Voting*, 24.

# 2. INTRODUCTION TO SOFTWARE SOLUTIONS

## PROPRIETARY VS. OPEN SOURCE SOFTWARE (OSS)

Software solutions in public policy typically come in two distinct flavors – Open source and proprietary software. OSS and proprietary software represent the different methods of distribution of software, and each has advantages and disadvantages. OSS typically is used in governments with growing demand for citizen engagement with budget constraints.[58] Governments have been increasingly interested in understanding the open source platform despite challenges in cloud integration. [59]

When an organization or entity creates software, the organization can either reveal his code and create an "open" software or may hide the code and "close" the software.[60] OSS integration complements the proprietary hardware of the actual system. This chapter will begin by briefly describing the differences between open and proprietary software and conclude by describing the different software process development models available to vendors.

## PROPRIETARY SOFTWARE

Closed or proprietary software gives the creator of the software full rights to determine distribution and development. Traditional proprietary vendors such as Microsoft distribute software in "binary" form – digital code essentially encrypted to

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[58] Mark Bohannon, "What's Ahead for Open Source in Government" (Opensource.com, September 4, 2013), http://opensource.com/government/13/9/trends-open-source-government-2013.
[59] Ibid.
[60] Delmer Nagy, "Understanding Organizational Adoption Theories through the Adoption of a Disruptive Innovation: Five Cases of Open Source Software" (College of Business: University of South Florida, 2010).

prevent engineers from being understanding the mechanics of the software.[61] With the

protection of intellectual property laws, proprietary companies try to maintain control

over the distribution and implementation of the product.[62] Intellectual protection of

software distribution has the consequence of encouraging investment within the

proprietary community.

Proprietary and open source software cannot co-exist within a given piece of

code. The proprietary form relies on copyright laws to maintain complete control over

source code. In contrast, open source uses "copyleft" licensing, which forces free

distribution of code of any software that includes the any other copyleft code.[63]

Proprietary software typically has high consumer usability as well as strong

documentation and support channels.[64] Moreover, proprietary software benefits a single

vendor's responsibility for the product, which is an advantage when a problem appears

and the vendor can fix it. Proprietary software excels in a few other areas such as

software usability.[65] It has value over OSS in areas of low usability or low network

benefits. They thrive in areas of low network effects or when OSS does not provide a

comparable product.

Vendors use "Vendor lock-in" (VLI) to retain customers and prevent migration.

VLI refers to the situation when a customer depends on a vendor for products and

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61 Robert Hahn, *Government Policy Toward Open Source Software: An Overview* (United Kingdom: AEI-Brookings Joint Center, 2002), http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1411617.
62 Ibid.
63 Jonathan Zittrain, "Normative Principles for Evaluating Free and Proprietary Software," *The University of Chicago Law Review* 71, no. 1 (Winter 2004), http://www.jstor.org/action/viewCitation?doi=10.2307%2F1600520.
64Ravi Sen, "JSTOR A Strategic Analysis of Competition between Open Source and Proprietary Software," *Journal of Management Information Systems* Vol. 24, no. 1, M.E. Sharpe, Inc. (Summer 2007): 235.
65 Ibid.

services to the extent that switching to a new technology does not make sense.[66] Software

vendors can lock in government using several methods: 1) Designing a system

incompatible with software by other vendors; 2) Using proprietary standards or a closed

architecture that lacks interoperability with other applications 3) Licensing software

under exclusive conditions.[67] The strategy can reduce government bargaining power and

gives proprietary vendors a competitive advantage.[68]

For instance, when you first start running Windows 8, you set up a Microsoft

account. Microsoft uses the account to connect to the account to your computer using

cloud technology.  The VLI occurs when you go to a laptop without Internet access,

where you have to open a local account and set up everything again.[69] Another example

is Apple. Apple forces VLI by only allowing programs and hardware to work within their

ecosystem. Once a user has adopted the Apple ecosystem, it can be costly to change.

VLI reduces flexibility or adaption to new technology. In the context of electronic

voting systems, VLI can reduce opportunities of migration to better systems while

simultaneously reducing incentives for software performance users must wait until a

function or program is "financially viable" before being integrated into any system.[70]

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66 Kevin Xiaoguo Zhu and Zach Zhizhong Zhou, "Lock-In Strategy in Software Competition: Open-Source Software vs. Proprietary Software," *Information Systems Research* 23, no. 2 (June 2012): 536–545.
67 Ibid.
68 Ibid.
69 "Vendors Just Can't Stop Trying to Lock Us All In: EBSCOhost," accessed February 28, 2014, http://web.a.ebscohost.com/ehost/detail?vid=3&sid=859fa2bd-3a17-4b1b-8021-1d696fadc787%40sessionmgr4003&hid=4212&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#db=aph&AN=85135589.
70 Edward Corrado, "The Importance of Open Access, Open Source, and Open Standards for Libraries," *Issues in Science and Technology Librarianship* (Spring 2005), http://www.istl.org/05-spring/article2.html.

In open source software (OSS) code is transparent and accessible to everyone. This means that anyone can read, modify, copy, and even fork (take an existing project and start their own project) a piece of software.[71] Open source is typically built under the General Public License (GPL), which restricts ownership of code. Under the GPL, code must be freely redistributed, completely accessible, and allow for modifications and
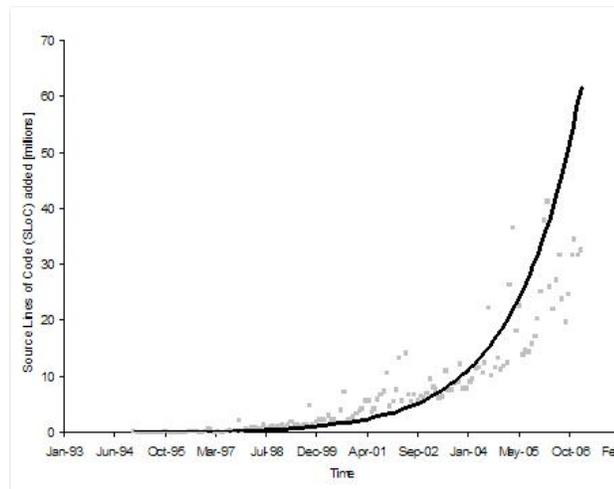
FIGURE 3 GROWTH OF LINES OF SOURCE CODE

ADDED (MILLIONS) [73]

derived works.[72] The ability to fork code reduces VLI within almost any given system. According to the Open Source Initiative, open-source software must be freely distributed, allow access to source code, and not restrict modifications.

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71 Stephen Weber, *The Success of Open Source* (Massachusetts: Harvard University Press, 2004), 64. According to the Open Source Definition, the complete description of Open Source is it must have :
1. Have free Redistribution
2. Allow access to Source Code
3. Allow modifications and derived works
4. Maintain integrity of authors source code
5. Not discriminate against fields, endeavor, persons, or group
6. Lack specific license to a product

Open Source relies on a unique economy of peer production.[74] In *The Wealth of Networks*, Yochai Benkler says that peer production systems are economies centered on information, cultural production, and manipulation of symbols (brand recognition). Benkler argues that peer production networks are decentralizing the economy.[75] He defines this new economy as the "networked information economy which relies on decentralized action to coordinate distribution".[76] Benkler theorized that as the computer networks continued to expand, so would the power of the information network.[77]

Potentially one key criterion in any open source project is that it must be freely distributed among the population without bias. Because of networking, and lack of restrictions, downloading and sharing OSS is easy. Free distribution means that installing OSS can be made considerably cheaper.

Public policy is increasingly recognizing the value of open source production. On his first day of office, President Obama signed the Memorandum on Transparency and Open Government encouraged of open source software in government.[78] Acquisition of OSS in government has both technological and political functions. In 2010, CSIS found

7.  Not restrict other software
8.  Must be technology neutral

"The Open Source Definition | Open Source Initiative," accessed January 24, 2014, http://opensource.org/osd.

73 Amit Deshpande and Dirk Riehle, "The Total Growth of Open Source | Software Research and the Industry," last modified 2008, accessed March 5, 2014, http://dirkriehle.com/publications/2008-2/the-total-growth-of-open-source/.

74 Ibid. This graph shows the growth in source code from January of '93 to February 2008.

75 Ibid.

76 Ibid.

77 Ibid., 4. Benkler and many other experts on OSS technology believe in the power of the crowds. The larger the communities, the greater ability for the community to notice/fix bugs, creates code, and do a multitude of other tasks that would be important for creation of OSS.

78 "About Open Government | The White House," accessed February 27, 2014, http://www.whitehouse.gov/open/about.

364 open source policy initiatives.[79] Through technology, OSS can provide exemplary

reliability, performance, and scalability at significantly lower costs.[80] Despite the code

being open, the defense department utilizes OSS in for a variety of functions including

mapping, military training, and modeling.[81] Open source software has potential across a

wide variety of governmental functions that tackle internal and external problems.


## BLENDING MODELS

One business model that has recently been growing in software development

involves a hybrid strategy between open source and a traditional business models. These

hybrid models combine the advantages of OSS while retaining control and

differentiation.[82] Client Shared Source for example is a model where vendors share code

only with clients.[83] Other models use dual licensing, which uses the GPL for only part of

the code.[84] Essentially, these "open source vendors" create revenue from three sources--

the product itself (for legal reasons), operational comfort, or consulting service.[85]

79 James Lewis, "Government Open Source Policies" (Center for Strategic and International Studies, March 2010), http://csis.org/files/media/csis/pubs/070820_open_source_policies.pdf.

80 David Wheeler, "WhyOpen Source Software / Free Software (OSS/FS)? Look at the Numbers!" (2007), http://www.dwheeler.com/oss_fs_why.html.

81 U.S. Department of Defense, "Open Source Software FAQ," accessed January 16, 2014, http://dodcio.defense.gov/OpenSourceSoftwareFAQ.aspx#Q:_What_are_some_military-specific_open_source_software_programs.3F.

82 Joel West, "How Open Is Open Enough?: Melding Proprietary and Open Source Platform Strategies," *Elsevier* 32, no. 7 (July 2003), http://dx.doi.org/10.1016/S0048-7333(03)00052-0.

83 Mikko Riepula, "Sharing Source Code with Clients," *IEE Computer Society* (August 2011), http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5750002.

84 Ibid.

85 Dirk Riehle, "The Single-Vendor Commercial Open Course Business Model," *Friedrich-Alexander-University of Erlangen-Nürnberg*, Springer-Verlag 2010 (November 24, 2010).

Software development requires strong coordination among many developers. Despite the growing complexity of software, hundreds of thousands of OSS projects exist, with many thousands of developers contributing to the project. There are many models of process management in software design.  Some of the models are *prescriptive* while others are *descriptive* models of the process model. *Prescriptive models* describe how software management should be done while *descriptive* models represents how something is actually done.[86] Dr. Dieter Rombach describes the quality of the product as function of process and context.

$$\text{Quality} = f\,(\text{Processes, Context})^{87}$$

Proprietary developers and OSS developers require different forms of software process models. For example, the waterfall method is much more tailored to proprietary software development while the iterative enhancement model is highly relative to an open source strategy.  In electronic voting software, iterative models are superior to sequential/time based models like the waterfall model. Iterative models provide enhanced feedback mechanisms necessary for improved electronic voting software. In building an electronic voting system, using a Unified Development Model would probably lead to the best final product. Though this thesis will only describe the waterfall, iterative, and unified models of development, there are many others that are commonly used in programming.

86 Münch Jürgen, Armbrust Ove, and Kowalczyk Martin, *Software Process Definition and Management* (Springer, 2012), http://reader.eblib.com.ccl.idm.oclc.org/(S(jiclccbscrtqc53nhgn2zyvd))/Reader.aspx?p=972560&o=568&u =m707cPx2EsphZoH0FEhQTA%3d%3d&t=1393346390&h=E14F6EB8E305264D8A61C1087226DE3D F5D56681&s=21425586&ut=1738&pg=1&r=img&c=-1&pat=n#.
87 Ibid., 24.

*Waterfall model*
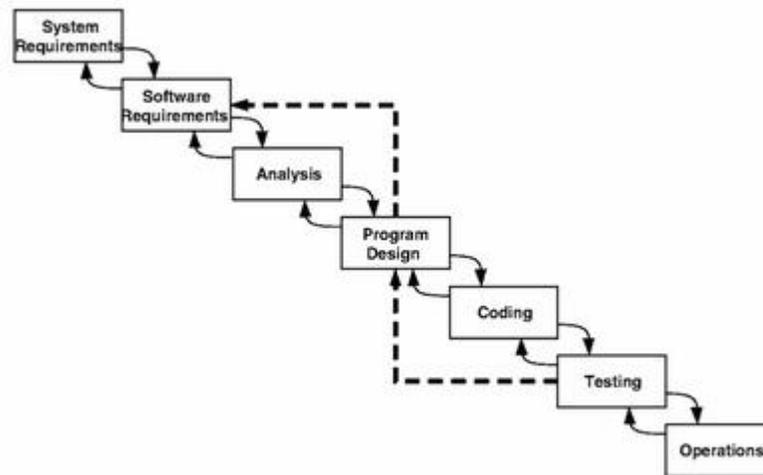


**Fig. 2.3** Waterfall model as described by Royce, with iterations

FIGURE 4 THE WATERFALL PROCESS DELEGATES TASKS OUT FROM THE BEGINNING BY HAVING CLEAR REQUIREMENTS OVER PROGRAM DESIGN AND REQUIREMENTS FROM THE START. IT CAN BE EXTREMELY USEFUL FOR SMALL SCALE PROJECTS THAT ARE REALLY DEFINED [89]

The waterfall model is a prescriptive model described by Winston Royce in 1970.[88] The model posits that products can be created on levels of abstraction and integration in reverse directions.[89] According to Jurgen et. al, adhering to the sequential order of activities is difficult even if interaction in neighboring activities is allowed. The waterfall method has the advantage of relatively little problems in development.[90] It weaknesses lie in its lack of flexibility. Because often the context and criteria for software development changes drastically, the waterfall model is rarely applied strictly to software creation. In large scale projects, the waterfall method is less suitable.

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88 Ibid.
89 Ibid., 25. Figure is a prescriptive process model of software.
90 Ibid.

*Iterative Enhancement Model*

The iterative enhancement model was described by Basili and Turner in 1975.[91]
Each iteration adds functionality to the software. The first iteration develops the core
parts of the complete system, the second iteration and third iteration increase
functionality.[92] Advantages include improved feedback mechanisms and flexible
involvement. The problem with incremental development is its flexibility, which can
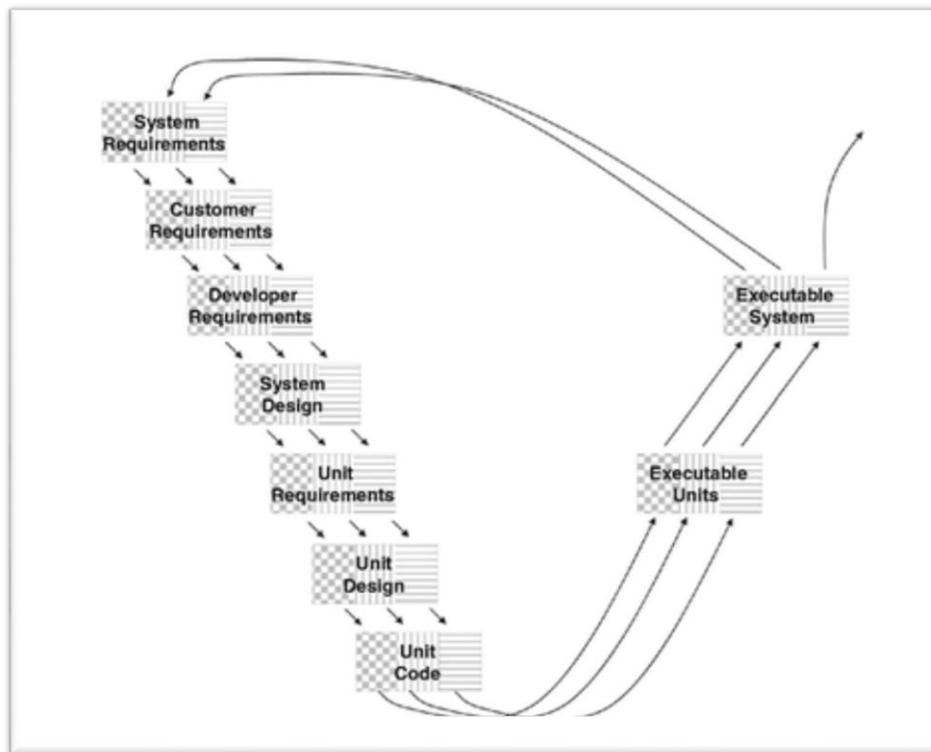


FIGURE 5: ITERATIVE PROCESS CAN BE EXTREMELY FLEXIBLE AND USEFUL ON LARGER SCALE
PROJECTS WITH LESS DEFINITIVE GOALS. ONE OF THE GREATEST RISKS WITH SUCH A
STRATEGY IS INCREASED COSTS.[95]

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91 Ibid., 26–27.
92 Ibid.

often lead to unknown costs and can get increasingly difficult to work with. [93] Other

models such as the two listed above are also commonly used in software design including

the prototyping model, the spiral model, and the incremental commitment spiral model.[94]

*The Unified Process Model*

Often in programming, software developers use the unified process. It is a generic

process framework for software development that consists of generic phases and

activities that can be adapted for organizations.[95] It can use both the waterfall models and

supports iterative development strategy within certain phases. The Unified Process relies

on UML (Unified Modeling Language) to describe the system and its requirements.[96]
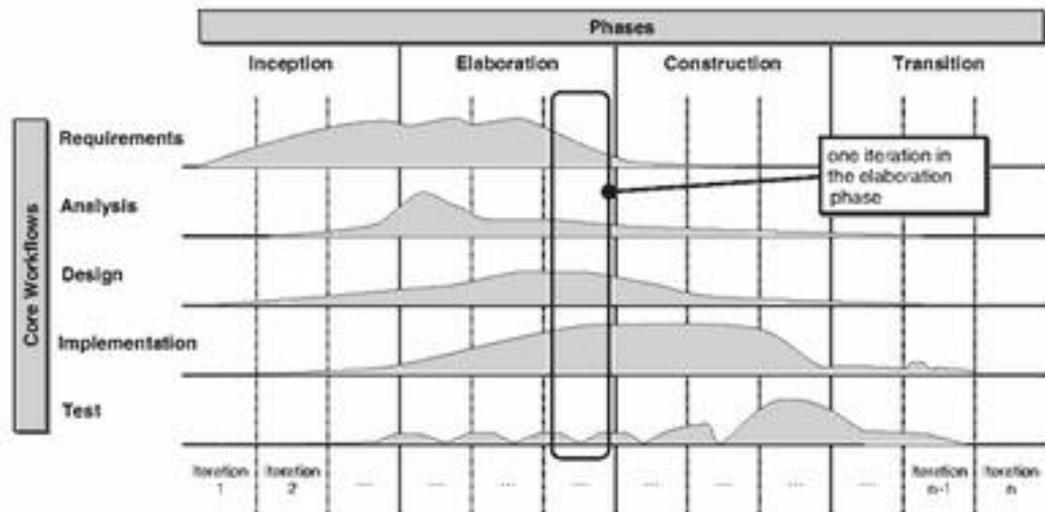


FIGURE 6 THE UNIFIED PROCESS MODEL MELDS BOTH ITERATIVE AND WATERFALL

STRATEGIES INTO ONE COMPLETE STRATEGY. THIS MODEL COULD BE EXTREMELY

EFFECTIVE IN LARGE SYSTEM DESIGN SUCH AS ELECTRONIC VOTING.[99]

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93 Ibid., 28.
94 Ibid., 32.
95 Ibid., 33.; Ibid., 26. Figure is a prescriptive process model of software
96 Ibid., 33.

UML program relies on use cases to describe system requirements.[97] The Unified Process Model relies on strong and complete use case documentation to create stable form. Finally, the Unified Process model is iterative and incremental.[98] The figure on the previous page shows the various stages of the Unified Model Class. The Unified Process if a popular life cycle model.[99]

# HOW OPEN SOURCE DEVELOPMENT DIFFERS FROM PROPRIETARY DEVELOPMENT STRATEGIES
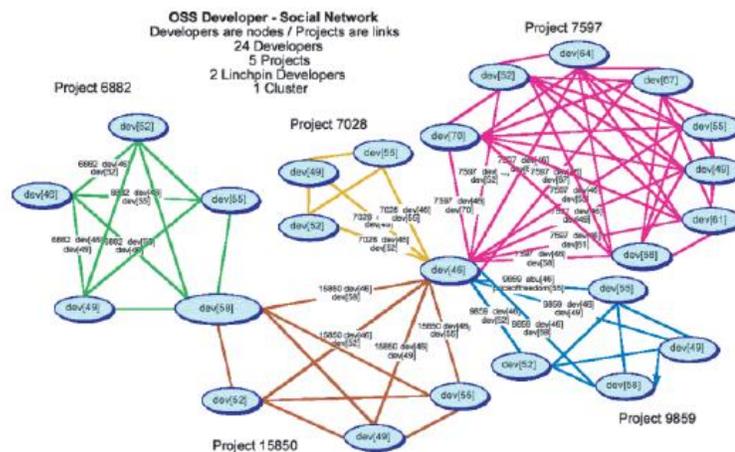


FIGURE 7 OSS DEVELOPER NETWORKS CAN BE EXTREMELY ROBUST AND DIFFICULT TO MANAGE. ONE OF THE MOST CRUCIAL PARTS OF ANY PROJECT IS HIGH LEVELS OF COORDINATION AMONG ASYNCHRONOUS COMMUNICATION MEDIUMS.[100]

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97 Ibid., 34.
98 Ibid.
99 Ibid., 35. The Unified Process Model is an example of a lifecycle model commonly used.

The OSS development process differs from traditional development strategies because of the unique nature of OSS development. OSS projects deal with unpaid employees without strict adherence to any schedule or regime for development processes.[100] OSS development is unique because it relies on coordinating projects
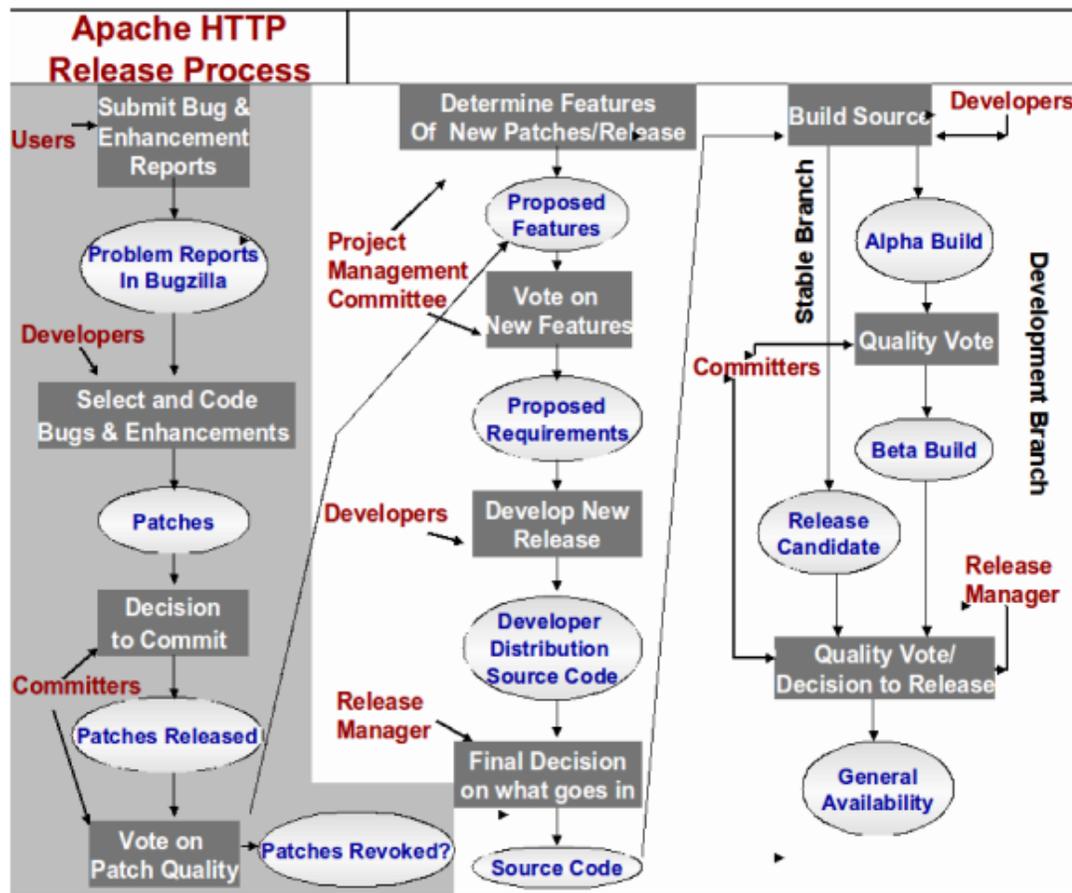


Figure 27. Process flow graph for Apache HTTP server release process

FIGURE 8 THIS DIAGRAM SHOWS THE VARIOUS ROLES GIVEN TO CONTRIBUTERS TO THE APACHE PROJECT. THE APACHE PROJECT IS A WIDELY USED WEB SERVING TECHNOLOGY.[100]

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100 Scacchi et al., "Guest Editorial Understanding Free/Open Source Software Development Processes," *Wiley InterScience* 11, Software Process Improvement and Practice (2006): 95–105.

through asynchronous systems.

Katzy and Crowston's competency rally theory identifies four capabilities a virtual organization must process to succeed.[102] The study argues that while these are obvious factors relevant to every context, they pose particular problems for virtual organizations.[103]

Figure 7 and Figure 8 model the communication networks in open source development. Figure 7 shows the network of developers contributing to open source projects. In Figure 7, it describes a social network that links 24 developers in five projects through two key developers into a larger open source project community. In the model provided by Scacchi, developers are connected through focused nodes into larger projects.[104] In this specific diagram, two developers are responsible acting as the central node to connect individual developers with community projects.

Figure 8 describes the contributors of typical open source project. In the case of Apache, individuals start out as end-users (such as web administrators) and then proceed to developer status, committer status, project management committee status, Apache membership status, to finally the board of directors. When a developer reaches the committer status, the developer can accept or modify code in the Apache project. The

101 Chris Jensen, André Van Adviser-Hoek, Andre. Discovering and Modeling Open Source Software Processes. University of California, Irvine, 2010.; There are various models available to describe the Open Source Development Process including DEMO, ARIS, ADONIS, IBM Rational Method Composer, OSSAD, SPEARMINT, and Eclipse modeling framework; For more information about Open Source Modeling please check out: Philip Huysmans, Kris Ven, and Jan Verelst, "Using the DEMO Methodology for Modeling Open Source Software Development Processes," *Information and Software Technology* 52, no. 6 (June 2010): 656–671.
102 Kevin Crowston, "Open Source Softwar E Pr Ojects as Virtual Organizations: Competency Rallying for Softwar E Development", n.d., http://crowston.syr.edu/sites/crowston.syr.edu/files/iee2002.pdf. 7 Capabilities consist of: Identification and Development of Individual Competencies, identify market opportunities, marshal competencies, and manage short-term cooperative effort.
103 Ibid., 8.;
104  Scacchi et al., "Guest Editorial Understanding Free/Open Source Software Development Processes," *100*

diagram below gives a more detailed description of the functions contributors within the

Apache project. As you can see from the diagram below, members vary on influence

within the project. From a policy perspective, understanding dynamics in software

creation helps government interact with open source vendors and comprehend how the

software development process works.
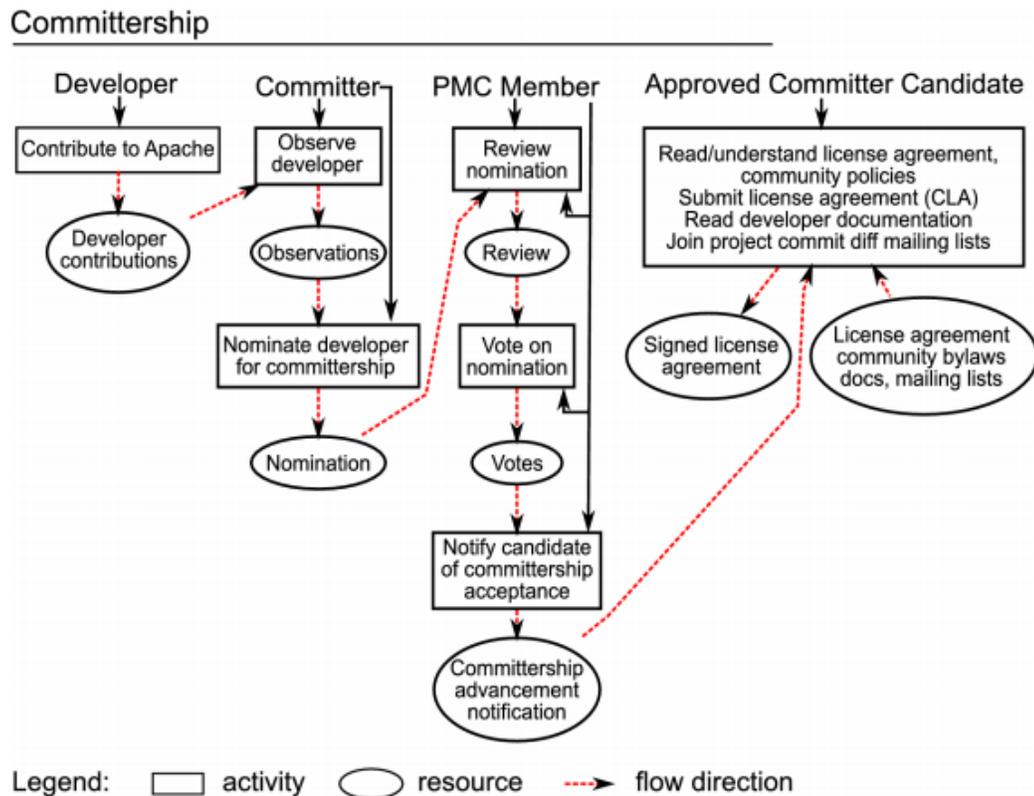


*Figure 28. Role migration process for committership in the Apache HTTP project*

FIGURE 9 IN THE APACHE PROJECT, EACH MEMBER HAS DIFFERENT ROLES AND POWER TO
IMPACT THE APACHE PROJECT.

PUTTING IT TOGETHER: WHY OPEN SOURCE DEVELOPMENT

PROCESSES MATTER IN ELECTRONIC VOTING

Choosing the right development framework and method is essential for electronic voting creating a dynamic and flexible voting system that has strong feedback loops with strong bug and glitch support. Based upon the requirements of electronic voting systems, supporting software needs to match a variety of requirements and adhere to a strict set of standards while remaining flexible and open to new information. That is why adopting a blend model similar to the unified process model would be optimal for electronic voting systems. The unified process model can be given strict direction from the beginning of planning, and at the same time it remains flexible to required changes. As problems or bugs appeared in the software, the unified process model would be capable of flexibly addressing program concerns.

Even more important is that process design can increase participation. Using open source processes will provide a level of transparency not currently available in voting systems. Open systems are often more productive than closed systems.[105] In the book Open Government: Collaboration, Transparency, and Participation in Practice, Lanthrop and Ruma recommend open standards to spark innovation and growth. Using their concept of open government, this thesis proposes that participation in open source systems will encourage more innovation.[106] Not only will the transparency increase system functionality, but it will also encourage political growth because voting systems

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105 Daniel Lathrop and Laurel Ruma, *Open Government: Collaboration, Transparency, and Participation in Practice* (O'Reilly Media, 2010), 15.
106 Ibid., 17.

are political artifacts.[107] Increasing the access to voting system design will have a positive

impact on system design and public participation in the voting process.

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[107] Winner, *The Whale and the Reactor: A Search for Limits in an Age of High Technology*. Because artifacts have political functions, increasing transparency will promote the growth of the political environment surrounding voting systems.

# 3. VOTING SYSTEMS IN AMERICA

## THE VOTING PROCESS

The US runs its elections unlike any other country in the world. As American politics is so unique, modern political science often focuses on American politics.[108] According to The Oxford Handbook of American Elections and Political Behavior, American politics is unusual because of the degree and ways in which sources of political power are split within and between branches of government.[109] Elections responsibility is entrusted to local officials in approximately 8000 jurisdictions. These local officials are in charge of managing the voting process and can be employed by various levels of government.[110] American voting systems are among the most decentralized voting systems in the world. Its locality is a unique feature within the American system.[111] The interesting structure of elections poses unique challenges that most countries do not have to deal with. Many of the administrative challenges are created by a lack of standardization and public support for voting systems. Because the voting process relies heavily on volunteers, quality of administration varies by jurisdiction and even polling place.[112] Polling places can vary greatly in wait times, limited resources, and long ballots.[113]  According to the report by the presidential commission on election

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108 Jan Leighley, *The Oxford Handbook of American Elections and Political Behavior (Oxford Handbooks of American Politics)* (Oxford University Press, 2012), 668.
109 Ibid.
110 Bauer et al., *The American Voting Experience: Report and Recommendations of the Presidential Commission on Election Administration*.
111 Leighley, *The Oxford Handbook of American Elections and Political Behavior (Oxford Handbooks of American Politics)*, 668.
112 Ibid.
113 Ibid.

administration, the most common complaint in all voting reform is resource limitations.[114]

It is because we have such a unique system that it is important to maximize every dollar

spent on voting elections and reform the election process to ensure fair voting. As it

currently stands, impaired voters still have difficultly at elections and registration

inaccuracies persist the voting process.[115]


## REFORMS TO THE VOTING PROCESS

In December of 2001, the House passed H.R. 3295, the Help American Vote Act

and the senate passed the Martin Luther King, Jr. Equal Protection of Voting Rights Act

in 2002 in early 2002.[116] HAVA was created to encourage states to upgrade antiquated

voting systems by authorizing 3.86 billion dollars over several fiscal years to make

federally mandated improvements.[117] HAVA specified numerous requirements of states

for the federal money such as providing voters with the ability to verify their votes before

casting a ballot.[118] HAVA was also responsible for the creating of the EAC.[119] In 2013,

the President's budget request included $11.5 million for the EAC of which $2.75 million

was transferred to the NIST and $1.3 million was for the Office of the Inspector General.

114 Ibid., 10.
115 Bauer et al., *The American Voting Experience: Report and Recommendations of the Presidential Commission on Election Administration*.
116 Ibid.
117 *States, Territories, and the District Are Taking a Range of Important Steps to Manage Their Varied Voting System Environments*, Report to the Chairman, Committee on Rules and Administration, U.S Senate (United States Government Accountability Office, September 2008), 15.
118 *GAO-08-874*.
119 Ibid.

[120] In 2013, the budget request included $11 million for the EAC of which $2.75 million was transferred to the NIST.[121]

The Presidential Commission on Election Administration was established on March 28, 2013 to make recommendations on the voting experience including issues such as voting machine capacity and technology, voting accessibility, training and acquisition of poll workers, and design of polling places.[122] The EAC works with the NIST to create standards, accredit voting system test laboratories, and certify voting systems.[123] The report done by the commission recommended that the voting experience try to improve qualities such as quickness, accessibility, information, and tallying.[124]

Through proper software design and integration, I believe that noticeable improvements can be accomplished in all the criteria stated above.

According to the Presidential Commission on Election Administration this year, by the end of the decade many of the nation's voting machines bought with HAVA funds 10 years ago will need replacements.[125] Moreover, current machines do not fulfill the unique requirements of certain jurisdictions.[126] The report argues that reform must occur in the standards and certification process to foster adoption of off the shelf technologies

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[120] Coleman and Fischer, "The Help America Vote Act: Overview and Issues."

[121] Ibid.

122 Bauer et al., *The American Voting Experience: Report and Recommendations of the Presidential Commission on Election Administration*, 6.

*123 GAO-08-874*, 16.

124 Bauer et al., *The American Voting Experience: Report and Recommendations of the Presidential Commission on Election Administration*. Funding was provided under a continuing resolution, P.L. 112-175 until March 2013, which it was superseded by P.L. 113-6, the Consolidated and Further Continuing Appropriations Act, 2013.

Note: These are all the values proposed:

Be accessible and dependable, quick, have a simple ballot design, lend itself to efficient registration, have accurate tallying results, provide clear and informative descriptions, ensure timely collection, have well organized management, provide good guidance for those confused, accommodate those with disabilities as best as possible.

125 Ibid.

126 Ibid., 11.

and "software-only" solutions.[127] In 2007, newer standards were proposed by the

Technical Guidelines Development Committee of the U.S. Election Assistance

Commission (EAC) and the National Institutes on Standards and Technology (NIST).[128]

Unfortunately, lack of clarity in technology standards has resulted in stagnation within

the adoption of new technology.[129]

Presidential Commission on Election Administration agreed on 19

recommendations moving forward such as improving list accuracy, improving voting

technology equipment, and improving the collection and distribution of data. Many of the

recommended policies to achieve such goals stated in the report required large

technological reform in the voting process. The report suggests reforms such as online

voter registration, that jurisdictions should transition to electronic poll books, that states

should provide electronic ballots on their websites for overseas and military voters,  and

that there should be an adjustment of standards and certification process for voting

machines.[130] This thesis suggests that for a variety of reasons, open source technology is

ideal for reaching the goals of the presidential commission. The table below demonstrates

some of the fixes addressed through an open source platform described in the final

chapter of this thesis.

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127Bauer et al., *The American Voting Experience: Report and Recommendations of the Presidential Commission on Election Administration*.

128 Ibid., 12.

129 Ibid.

130 Ibid.  In the report, there were a total of 19 recommendations made to improve voting systems. Various reasons and justifications were given for each recommendation and given a more time, this thesis would address how each recommendation can be improved through OSS. An example would be of online voter registration, where OSS could assist in achieving the overall objectives of the report with a reduction in potential error, reduction in money, an increase in accuracy and currency of voter roles, and an improvement in voter experience. It should also be noted that OSS integration in many complementary systems to the DRE voting machines could significantly improve the voting experience. If for example early voting was expanded, it would reduce the stress and use of DRE machines at polling stations. This could indirectly assist in improvement of the election experience.

|  | **Recommendation for Improvement** | **OSS Solution** |
|---|---|---|
| Fix 1 | Maintain and improve voting technology equipment | Open Source Vendors |
| Fix 2 | Improve the collection and distribution of election data. | Open Standards/OVSB |
| Fix 3 | Improve transparency of the voting process | Open Code |
| Fix 4 | Improve list accuracy and enhance capacity of voter registration including voter security. | Open Source Development Processes |

## VOTING SYSTEM MANAGEMENT

The election process is a year-round process involving four stages of an election process. The voting process begins with voter registration. After voter registration, mail in ballots and early voting take place. Election Day voting is the third stage of the process. Finally, after the absentee, early voting, and Election Day votes are recorded,



Figure 4: Conceptual Depiction of a Voting System Life Cycle Model

Sources: GAO analysis of NIST, IEEE, and EAC publications.

FIGURE 10: VOTING SYSTEM ADOPTION LIFE CYCLE UP TO MANAGEMENT
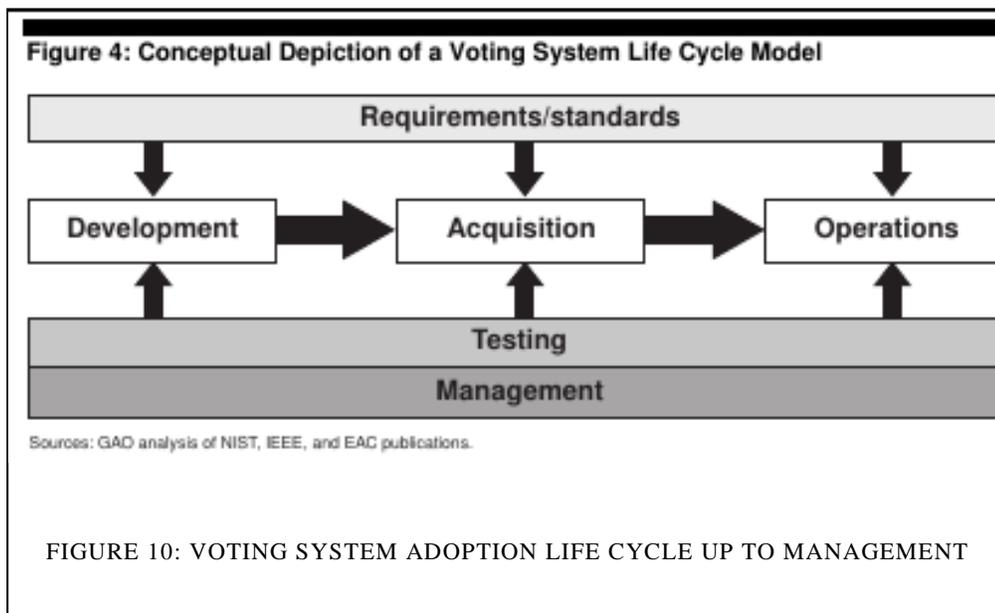
they are then counted and certified.[131]

Though it makes sense that OSS can improve each of these processes, this thesis will mostly analyze election day voting and vote counting and certification. This is because DRE machines typically involve these two stages of the voting process more than the other two. As mentioned in an earlier chapter, DRE machines are the only technology that can mark, cast, and tabulate results independent of another system.[132] As you can see from the figure above, the voting system life cycle is continuous and often simultaneous. Requirements are set, which then feed into the development, acquisition, and operation of voting systems. This process lends itself to a feedback system, with constant improvements to existing standards/processes upon the acquisition of new information.

## VOTING SYSTEM TESTING AND CERTIFICATION

Based upon Section 311 of HAVA, the EAC should periodically adopt standards for voting systems in the form of VVSG.[133] Section 231 also requires the EAC to provide testing and certification of hardware and software on the federal level.[134] The EAC program for testing provides voluntary voting system standards, voting system testing by accredited laboratories, and voting system certification.[135] Compliance with the VVSG is strictly voluntary; however, some states mandate participation to a varying degree.[136] On top of various federal standards adopted by states, states often require specific

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131 *GAO-08-874*, 11.
132 Ibid., 11.
133 *GAO-08-874*.
134 Ibid.
135 Ibid.
136 Ibid.

requirements and responsibilities for approving voting systems in an election. These include long-term system sustainability and life cycle costs. [137] Over time, states have become more involved in controlling the voting process within jurisdictions.[138] According to the report from the Government Accountability Office, "A few states and territories have become more active in identifying and resolving problems and a number have reported taking actions to overcome a range of challenges that many states and territories share."[139]

EAC staff classifies each state's requirement into four groups: 1) No Federal Requirements; 2) Requires Testing to Federal Standards; 3) Requires testing by federally accredited lab; 4) Requires federal certification [140]



**Figure 10: General Steps that States and Others Follow in Approving Voting System**

Approval timeline

**Involve public**

Members of the public are kept informed of voting system approval activities through one or more mechanisms, including public notices, public hearings, invitations to view or participate in approval activities, or periods for public comment.

| 1. Establish standards or criteria | 2. Evaluate documentation | 3. Test and examine results | 4. Make approval decision |
|---|---|---|---|
| Minimum system requirements (functional or performance) are established that must be met for a voting system to be approved. | Voting system documentation is evaluated to determine whether the system meets the standards or criteria. Documentation may include technical documentation, vendor business information, and test plans and results from accredited testing laboratories. | Voting systems are tested to determine whether they meet the standards or criteria. The results are examined to confirm whether the system successfully passed testing. | The results of voting system testing and documentation evaluation, including any recommendations, are reviewed and a decision is made regarding system approval. |

**Resolve problems**

Problems that arise as a result of the documentation evaluation or testing are resolved with the vendor.
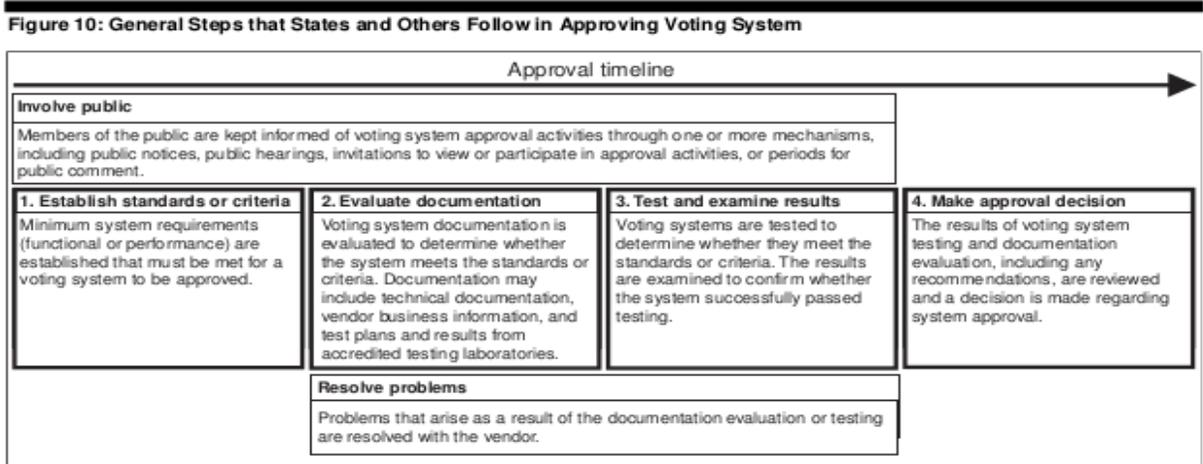
FIGURE 11THERE ARE FOUR STEPS TO APPROVING A VOTING SYSTEM. THE FIGURE ABOVE DESCRIBES THE APPROVAL PROCESS.[140]

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137 *GAO-08-874*, 4.
138 Ibid.
139 Ibid., 3.
140 Ibid., 4. Please see appendix for categories of state, territory, and district participation of federal voting standards.

As it currently stands, each state varies in its application of federal standards on voting technology. Please see the appendix in the back for a complete list of state categories in voting standards.

Managing the approval process is generally based upon four steps including testing of systems and making approval decisions.[141] Testing software can be done in a variety of ways and can vary state by state. Most software testing is done by local jurisdictions with the guidance from states however; several states also performed tests using state staff, vendors, or contractors.[142] The process can involve reviewing source code, function testing, or running mock elections.[143] Approval-related testing falls into eight categories including software comparison, regression testing, security testing, security review, volume testing, accessibility testing, function testing.[144]

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141 This is the full process for approval decisions:
1) Establishing standards or criteria
2) Evaluation of documentation
3) Testing systems to state standards and examining results
4) Making approval decisions
142 *GAO-08-874*, 6.
143 Ibid., 39.
144 Ibid., 42.

The table below describes the seven types of testing:[145]

| Type of Testing | Purpose of Testing |
| --- | --- |
| Certification (Fed) | To verify compliance of system with federal standards prior of system acceptance |
| Certification/Approval State | Validate compliance with state standards prior to election |
| Acceptance | Verify the equipment delivered by a vendor meets state or local requirements before election. |
| Readiness (logic/accuracy) | Verify if equipment is functioning properly by comparing predictable outputs to input |
| Security | Defining and testing security of voting equipment |
| Election Day Parallel | Verify the performance of equipment through random selection |
| Post-election audit | Review election records to confirm correct conduct of election or uncover problems. |

System approval can be reexamined and reviewed if (1) changes to the system affect accuracy, efficiency, or capacity. (2) Receive a request for re-examination by state electors. (3) Otherwise deem it appropriate.[146] Systems are revoked for a variety of reasons. Many of the reasons for system rejection involve a software modification that causes noncompliance with state requirement.[147]

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145 Ibid., 20.
146 Ibid., 27.
147 Ibid., 28.

As of 2009, twenty states did not have federal requirements, ten states only required testing to federal standards, thirteen states required testing by a federally accredited laboratory, and twelve states require the federal certification for testing voting systems.[148] The reality that barely over 20% of states require federal certification for their voting systems demonstrates the difficultly of decentralized voting. This thesis will briefly describe four states' requirements for voting standards to illustrate the difficulty of decentralized voting.

**Arkansas (No Federal Requirements) -** Arkansas requires that voting systems are HAVA compliant; however, it does not have regulations regarding the federal certification process. The certification process involves voting systems approved by the State Board of Election Commissioners. Applications are accepted by the board for persons requesting an opportunity to present their voting system for use in Arkansas. The board examines the system and files a report with the office of the Secretary of State stating the "accuracy, efficiency, and capacity" of the proposed voting system.[149] After approval the board does not need to approve the voting system again.[150]

**Oregon (Requires Testing to Federal Standards) -** Oregon requires that voting system testing be consistent with the rules in the FEC publication *Performance and Test Standards for Punchcard, Marksense, and Direct Recording Electronic Voting (2002).*[151] Once a system is approved by the secretary, it may be used for conducting elections.

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148 "State Requirements and the Federal Voting System Testing and Certification Program" (EAC, 2010), 5, http://www.eac.gov/testing_and_certification/.
149 Ibid., 10.
150 Ibid.
151 Ibid., 45.

Voting machines are submitted to the Secretary of State for examination. The Secretary of state can enlist the help of no more than three individuals to examine the system. The assistants are experts in one or more of the fields of data processing, mechanical engineering, and public administration. After completing the examination, the Secretary of State will approve or reject the voting system.[152]

**Arizona (Requires Testing by a Federally Accredited Laboratory) –** Arizona requires that systems are HAVA compliant and approved by a laboratory that is accredited by the EAC. Arizona does not have regulation regarding the federal certification process and the Secretary of State appoints a committee of three people to test different voting systems. The committee submits recommendations to the Secretary of State who makes a final decision on which voting systems to adopt.[153]

**California (Requires Federal Certification)**[154] **–** In California, the Secretary of State adopts the regulations for the certification of voting systems in CA but cannot certify DRE equipment without federal qualification. In California's voting platform, the Secretary of State accepts applications for persons or companies requesting an opportunity to present their voting system for use in California. The Secretary of State will complete an examination of the voting system and send a report to the Governor and the Attorney General. Before approving a system, the Secretary of State will hold a public hearing to give interested parties the opportunity to express their opinions on the voting system. The Secretary of State then files a report approving a system within thirty days of examination.

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152 Ibid.
153 Ibid., 9.
154 Ibid., 11.

State voting policies have a few deficiencies in the approval process. First, it is clear that they lack adequate testing. Many states only allow three people to assist the Secretary of State in the approval process. Open source can provide a solution to this problem because as software gets increasingly complex, it is important to have a large body of testers and approvers. Open source is powerful at allowing a large body of specialists and experts collaborate together which is why an open source platform should be used in voting requirements.[155]  In due time, open source projects like TrusttheVote will prevail as the best software solution for voting systems.

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[155] Rarely in a project like Linux does anyone know everything about the system.  Often in large open source projects contributors specialize in parts of code or specialize in certain perspectives or approaches toward software improvement. This can be extremely powerful in voting systems, where understanding the system may require a large body of expertise in multiple areas.

# 4. PROCUREMENT AND ACQUISITION STRATEGY OF

# OSS IN GOVERNMENT

## HOW PROCUREMENT WORKS IN GOVERNMENT

In 1974 the Office of Federal Procurement Policy was created to create uniform

and centralized procurement regulations.[156] Around that time, Congress approved the first

set of Federal Acquisition Regulations (FAR), which set guidelines for federal

government agencies and served as a benchmark for state regulation.[157] After multiple

revisions of FAR, the Clinton administration initiated a "Reinventing Government"

model that attempted to align government procurement decisions with private business

efficiency models.[158] This perspective is similar to the new public management model

discussed in the introduction. Over the years, more "business-like" reforms were

introduced to Congress including the Federal Acquisition Streamlining Act and the

Federal Acquisition Reform Act of 1995.[159] Today, government continues to pursue a

more "business-like" platform for software acquisitions. The attempt to reform IT policy

is a bill currently being evaluated by the Senate named the Federal Informational

Technology Acquisition Reform Act (FITARA).

Of all level of governments, local governments are in the best position to drive

procurement reform because they are more "streamlined".[160] Former Oregon CIO and

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157 Ibid.
158 Marco Lansiti, "Government IT Procurement Processes and Free Software," *Public Contract Law Journal* 41, no. 2 (Winter 2012): 197–232.
159 Ibid.
160 Justine Brown, "Bringing Innovation to Procurement," *Government Technology*, last modified March 4, 2014, accessed March 26, 2014, http://www.govtech.com/budget-finance/Bringing-Innovation-to-Procurement.html.

procurement director Dugan Petty said that "Because local governments are more streamlined, it's often easier for them to make decisions and to move on an innovative path than it is for states or the federal government".[161] Several local governments are making major reforms in procurement strategy including New York City's strategy to reduce procurement cycle times, improve customer service, and employ strategic sourcing to leverage spending.[162]

Unfortunately, many procurement policies are outdated. [163] Petty said the modern procurement process "begins to break down in areas where you have to evaluate something other than price."[164] Current procurement strategy "not only makes the system difficult to navigate, it also stifles innovation and creativity".[165] Government procurement policy has many problems including a risk-averse orientation.[166] This has resulted in the system favoring larger vendors that have had experience with governmental IT projects.[167] This has led to government procurement strategy missing out on some innovative solutions in IT strategy.

Government procurement works in a bidding like process given guidance by various Defense Federal Acquisition Regulations (DFARS) procedures. A government puts out a request for proposal (RFP) a type of bidding solicitation in which a company

161 Ibid.
162 Ibid.
163 Ibid. Now that procurement is digital, there are a lot of factors in strategy that weren't previously considered. Most notably, OSS present a significant challenge to traditional procurement strategies.
164 Ibid. Quote is from Dugan Petty, former Oregon CIO and procurement director who serves as senior fellow for e.Republic's Center for Digital Government Brown, "Bringing Innovation to Procurement."
165 Ibid.
166 Richard Walker, "State CIOs Say Procurement Problems Hobble Innovation - InformationWeek," *InvormationWeek*, last modified October 15, 2013, accessed March 26, 2014, http://www.informationweek.com/government/open-government/state-cios-say-procurement-problems-hobble-innovation/d/d-id/1111936?.
167 Brown, "Bringing Innovation to Procurement."

announces that funding is available for a particular project. The RFP outlines the bidding

process, contract terms, and provides guidance for how the bid should be formatted and

presented.[168] Companies then compete for project by placing bids on the project's

completion on aspects such as total cost of ownership, transparency, security, and ease of

use.[169]

## FITARA

Government has slowly been realizing the importance of proper IT acquisition

procedure. All levels of government spend over $80 billion on IT products and services;

IT procurement is a very costly and significant part of government operations.[170] The

Federal Informational Technology Acquisition Reform Act (FITARA) was introduced on

March 18, 2013 and attempts to address some of the larger issues of strategic sourcing

within government.[171] FITARA represents a bipartisan measure introduced by House

Oversight and Government Reform Committee Chairmen Darrell Issa.[172] As the bill

stands, it is has been passed by the House and is waiting to be passed by the Senate.[173]

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168 "Request For Proposal" (Investopedia, n.d.), accessed March 26, 2014,
    http://www.investopedia.com/terms/r/request-for-proposal.asp.
169 Francis Buono et al., *Government Procurement of Software: Providing Policies for Ensuring the Greatest Possible Return on Investment in Troubled Economic Times*, Bloomberg Law Report (Bloomberg Finance L.P, 2009), No. 23, Vol. 3, accessed March 25, 2014,
    http://www.willkie.com/files/tbl_s29publications%5Cfileupload5686%5C3029%5Cgovernment%20procurement%20of%20software%20provident%20policies%20for%20ensuring.pdf.
170Michael Hardy, "House Passes FITARA | Federal Times | Federaltimes.com," last modified February 25, 2014, accessed March 25, 2014,
    http://www.federaltimes.com/article/20140225/ACQ02/302250009/House-passes-FITARA.
171 "Federal Information Technology Acquisition Reform Act (H.R. 1232) - GovTrack.us," *Govtrack.us*, accessed March 25, 2014, https://www.govtrack.us/congress/bills/113/hr1232.
172 "Washington: House Passes Bipartisan Federal IT Reform," *LexisNexis* (Washington, February 25, 2014), accessed March 25, 2014,
    http://www.lexisnexis.com/lnacui2api/results/docview/docview.do?docLinkInd=true&risb=21_T19513638830&format=GNBFI&sort=BOOLEAN&startDocNo=1&resultsUrlKey=29_T19513638834&cisb=22_T19513638833&treeMax=true&treeWidth=0&csi=400469&docNo=1.
173 "Federal Information Technology Acquisition Reform Act (H.R. 1232) - GovTrack.us."

FITARA would reform the current framework of information technology. FITARA stipulates that CIO's participate in the budget planning process related to IT and that the CIO would have consultation with the chief financial officer and budget officials.[174] FITARA also gives authority to provide collaboration centers tasked with the development requirements of intergovernmental acquisitions of commodity IT.[175]

FITARA is perhaps the most significant change to IT procurement strategy since the Informational Technology Management Reform Act of 1996.[176] FITARA represents recognition of merit-based acquisition policy in government. Sec. 5506 of the Bill suggests that software acquisitions should be based on performance and value, free of preconceived preferences based on how technology is developed, and include in consideration of proprietary, open source, and mixed source software technologies.[177]

While the government focus on IT procurement reform in FITARA suggests a positive step in technology policy, it still falls short of perfect by remaining too government centric. Specifically, the bill fails to adequately promote OSS adoption strategies. The bill stipulates light recommendations that government should prefer open source solutions. Government needs to more than lightly recommend OSS adoption. They should seek out OSS solutions in a manner consistent with the prototype organization described in Chapter 4.

174 Ibid.
175 Ibid.
176 Hardy, "House Passes FITARA | Federal Times | Federaltimes.com."
177 Issa and Connolly, *Amendment to the Rules Committee Print of H.R. 1960 Offered by Mr. Issa of California and Mr. Connolly of Virginia.*, 2013, f:\VHLC\061013\061013.432.xml.

# PROCUREMENT OF VOTING TECHNOLOGY: HOW IT WORKS

State governments are in charge of most election policy and procedures.[178] Nevertheless, states usually have decentralized election administration so that details are carried out at the city or county levels.[179] This structure can create variations in a jurisdiction's capacity.

Acquisition can also be delayed due to the desire to meet federal system requirements.[180] Decisions to upgrade systems or purchase new systems can be postponed by states if they feel the federal government is going to come out with new guidelines.[181]

# ORGANIZATIONAL OSS ADOPTION THEORIES

Adoption of OSS technology can be a difficult undertaking. OSS is a "disruptive" technology.[182] While most software follows traditional stages of adoption (listed below), OSS provides unique requirements for a different adoption cycle. There are a variety of factors that can be identified to impact adoption of OSS technology including technical knowledge, administrative intensity, internal communication, vendors, technical communities, and innovation characteristics.[183]

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*178 GAO-08-874*, 9.
179 Ibid.
180 Ibid., 30.
181 Ibid.
182 Nagy, "Understanding Organizational Adoption Theories through the Adoption of a Disruptive Innovation: Five Cases of Open Source Software," 6.
183 Ibid., 1–2.

The traditional adoption process has five traditional stages. [184]

| Adoption Stages |
| --- |
| Awareness |
| Interest |
| Adoption |
| Routinization |
| Infusion |

The first stage is awareness of an innovation. A buyer may hear of a new technology without procuring it. Next, the buyer evaluates the innovation to determine if the innovation is the correct fit. When the organization actually adopts the software it decides how it intends to apply the new technology.[185] Once the technology has been adopted, it becomes assimilated into the regular work processes.[186] For the case of voting systems, once the OSS has been introduced into all the DRE machines, it has reached the assimilation stage. Finally, the last stage of any adoption cycle is infusion. The infusion process for DRE software is important because it sets the precedent for future software adoption in government processes.[187]

In the case of OSS, there are a variety of different model cycles. Grand et al. proposes four stages of adoption including software as an end product, complementary asset, design choice, or business model.[188] For most local governments, OSS adoption of voting technology would most likely be acquired as a complementary asset. With a

184 Nagy, "Understanding Organizational Adoption Theories through the Adoption of a Disruptive Innovation: Five Cases of Open Source Software," 6.
185 Nagy, "Understanding Organizational Adoption Theories through the Adoption of a Disruptive Innovation: Five Cases of Open Source Software."
186 Ibid., 7.
187 Ibid., 8.
188 Ibid., 9.

complementary asset, an organization needs to integrate software with hardware.[189]

Grand et. al identifies unique characteristics of OSS adoption in their research which are
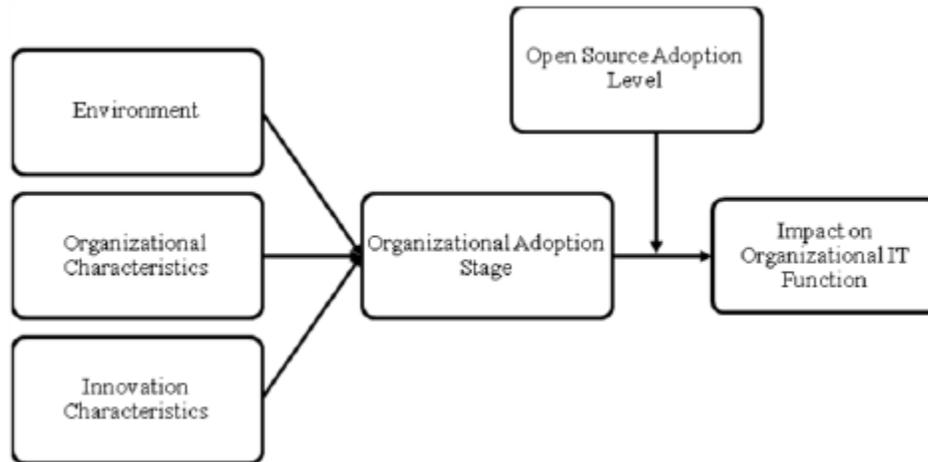
represented in the figure below.[190]



*Figure 12 Grand et al. characteristics of OSS adoption strategy*

Delmer Nagy's dissertation on OSS adoption cites a number of studies related to

OSS adoption strategy.[191] Many of his references would be relevant to OSS adoption,

Katz and Shapiro (1986) and Attewells (1992) work on vendor relations is relevant to the

current issue with OSS adoption in voting systems. Katz and Shapiro's Network

Externalities theory posits that technology vendors can influence adoption of innovation

in many ways. First, vendors sponsor a technical standard that determines how

innovations integrate and work together.[192] Secondly, vendors impact technology

adoption through support systems for technology. Because they control the support

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189 Ibid., 10.
190 Ibid., 11.
191 Nagy, "Understanding Organizational Adoption Theories through the Adoption of a Disruptive Innovation: Five Cases of Open Source Software."
192 Ibid., 14.

structures for their software, they can impact how software interacts with their customers.[193] Because of the large role that vendors have on system design and acquisition policy, careful procurement of software is extremely important in optimizing policy.

The other important theory related to OSS adoption is Attewell's theory of technical knowledge and know-how (1992). Attewell's theory is important to understanding the value proposition OSS vendors present in OSS adoptions. The theory argues that specific knowledge about an innovation has marketable value.[194] OSS voting systems will work largely because developers for the vendor will be able to provide expertise on the specific software acquired by a government.  Nagy combines Attewells theory with other research to create a hybrid model of open source adoption.


## IMPORTANT FACTORS OF CONSIDERATION IN OSS ADOPTION

OSS adoption in voting machines possesses a unique challenge to government procurement strategy. Nontraditional business models such as open source software challenge traditional procurement strategy because of initial costs.[195] As mentioned in chapter two, enterprise software licenses are much more predictable in costs and maintenance. Free software is different in that it carries with it nontransparent costs that traditional costs estimates may not accurately identify.

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193 Ibid.
194 Ibid., 15.
195 Lansiti, "Government IT Procurement Processes and Free Software."

As commercial software, General Public License (GPL) software is compatible with government acquisition processes.[196] The software can be provided to contractors and be modified for use by the government. Once the contractor has prepared a modified version of the GPL software, the modified version must be delivered to the program that originally set the contract.[197] Because of how the GPL license operates, the GPL is the only set of terms under which the contractors can legally deliver modified versions of the GPL code.[198]

GPL software can be modified by combining it with existing government funded software.[199] Sometimes, software may bear a government purpose rights legend or other restrictive markings that prevent government from altering source code or modifying code in any way. [200] In this case, written permission from the software owner is required before modifications can be made.[201]

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196 Scott Michel et al., "Government Computer Software Acquisition and the GNU General Public
       License", October 2011, accessed March 25, 2014,
       http://www.softwarefreedom.org/resources/2011/government-acquisition-and-gpl.pdf.
197 Ibid., 8.
198 Ibid., 9.
199 Michel et al., "Government Computer Software Acquisition and the GNU General Public License."
200 Ibid., 10.
201 Michel et al., "Government Computer Software Acquisition and the GNU General Public License."

# 5. A NEW STRATEGY

Because technology acquisition is increasingly becomes cheaper for governments and because open source software has become such a complete product over the recent years, federal policy needs to reform its funding and priorities in election reform.

Since the passage of the Help America Vote Act in 2002, government has authorized over $3.65 billion in payments to the states for improving administration of federal elections.[202] Some $1.6 billion have been spent on voting systems (since 2008) and 355 million on voter registration systems. This money can and should be allocated more efficiently through intelligent policy design integrated with OSS.

Current voting systems still have much room for improvement. Between the 2008 elections and the 2012 elections, considerable reforms have taken place. The Pew Index shows that overall performance has improved by 4.4 percentage points in a study taking into consideration polling locations, availability of voting information tools online, rejections of voter registration, problems with registration or absentee ballots, rejection of military and overseas ballots, voter turnout, and accuracy of voting technology.[203]

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202 *How States Are Using Federal Funds to Carry Out the Help America Vote Act (HAVA)*, NASS Report on State HAVA Spending for the Improvement of Election Administration, April 2010, 3.
203 Stephanie Bosh, "Pew Index Shows 40 States Improved Election Performance in 2012 - The Pew Charitable Trusts," last modified April 7, 2014, accessed April 11, 2014, http://www.pewstates.org/news-room/press-releases/pew-index-shows-40-states-improved-election-performance-in-2012-85899543004.

Government needs a new strategy of IT procurement that uses the open source movement to provide better voting software with greater flexibility. The software adopted by government should reduce residual rates, increase security, and also adapt to a dynamic technology environment. In addition, adopting a newer open source strategy to IT procurement will improve transparency of the voting process.[204]
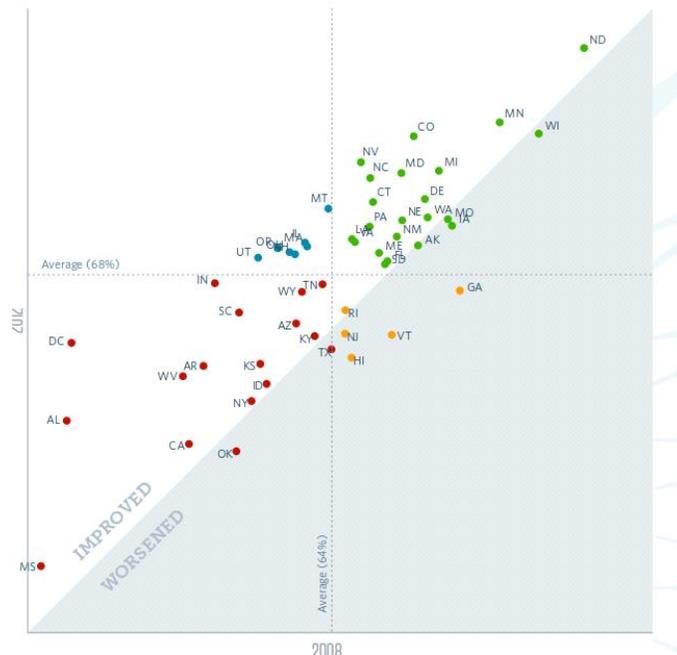


FIGURE 13 FIGURE SHOWS EACH STATES IMPROVEMENT OVER THE YEARS IN VOTING TECHNOLOGY USING PEWS UNIQUE METHODOLOGY OF SCORING VOTING EXPERIENCE. OVER THE YEARS STATES LIKE NORTH DAKOTA HAS IMPROVED THE MOST. THE MIDDLE OF THE X AXIS IS LABELED 2008 AND THE MIDDLE OF THE Y AXIS IS LABELD 2012.[206]

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204 This graph as well as other data on election performance can be found at pewstates.org at the url http://www.pewstates.org/uploadedFiles/Flash_Library/PCS/Interactives/ElectionsPerformanceIndex/templ ate.html#overview

Governments need to reevaluate their approach in IT policy. FITARA's reforms do not represent the radical reform to IT procurement requires for future IT policy. FAR has demonstrated itself to be an outdated procurement guideline that has difficultly addressing the growing open source market. It is clear that an OSS approach is a more optimal strategy toward addressing voting systems. This section will recommend a new four-part plan for government that introduces open source adoption in future voting system certification and acquisition.  Because of the limited scope of this thesis, it will not go into depth about the specific implementation of such a plan. The plan is:

**1)** Approve a public and independent, pro-OSS certification organization that works closely with the EAC, NIST, and other system organizations to create the optimal voting systems guidelines.

**2)** Update FAR requirements to greater accommodate open source procurement policy.

**3)** Assist local and state jurisdictions to acquire OSS for DRE machines.

**4)** Promote open source business strategy by hiring vendors for system integration and analysis

The first part of this four part strategy recommends that government explore the option of distributing power and control of voting authorization to an independently run pro-open source organization to create guidelines similar to the Voluntary Voting System Guidelines (VVSG). The organization would be the basis for voting system approval within the United States. This open source organization should work closely with the EAC and other voting organizations to ensure alignment of voting goals between the EAC and the newly created organization. For arguments sake, this thesis will address a mock organization called the Open Source Voting Board (OVSB).

The organization needs to be as open as possible and allow for public input into voting standards. The organization itself should be run on a platform that models open source by charging nothing for its services and remaining free and open for community input. The community would be involved in primarily two parts of the OVSB. First, it would be directly involved in creating open standards. These issues could vary from technical issues to usability issues. The second way the community would be involved with the OVSB would be indirectly through the open source vendors. Through open source vendors, developers would be networked with the OVSB.

There are a few advantages that such an organization would provide. The first advantage such as system would provide would be the system allows for wider participation in standardizing the voting process. Community involvement would help cater to public support and improve public participation in democracy. Moreover, an independent body could react faster to specific requirements and challenges to voting standards because they are more streamlined.[205] Finally, a public approval system for OSS would free resources used by the EAC and allow the EAC to use the money to fund local governments. User participation in technical design is crucial for successful technology design. According to Peter Asaro of the Beckman Institute, "A given technology will only be empirically and politically successful if it is able to survive a dialectic of design and use. While it is possible to get a technology "right" the first time

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205 Brown, "Bringing Innovation to Procurement." See quote from Chapter 4 for more information regarding the streamlined nature of local governments in technology policy.

around, the best guarantee of a technology's success is to subject it to successive

redesigns informed by user reactions."[206]

The second part of the plan is to update the FAR requirements to accommodate

open source acquisition. This part of the plan is a crucial step for OSS adoption in voting

systems and aligns closely with the Open Government Initiative proposed by President

Obama. FAR's challenge in recognizing the value and costs of open source policy is a

problem that needs to be addressed moving forward. Though this thesis suggests an open

source solution be adopted on a case by case basis, government needs to adjust FAR

requirements for future IT procurement. As outlined earlier, there are a plethora of

advantages to Open Source Software that are often not identified in contemporary

procurement policies.

There are many ways to optimize purchasing strategy. One way government

procurement strategy optimizes choices is by comparing the net benefits (difference

between all present and future costs and benefits).[207] The purchasing option with the

highest net benefit represents the optimal purchase.[208] One of the challenges with open

source procurement is that the total ownership costs can be difficult to estimate. In

addition, there are many intangible benefits to open source are impossible to estimate as

well. FAR requirements should attempt to recognize that traditional software

procurement strategy is not suitable for open source solutions, and that a new policy

regarding open source software needs to be created.

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206 Peter Asaro, "Transforming Society by Transforming Technology: The Science and Politics of Participatory Design*," last modified October 1, 1999, accessed April 22, 2014, http://www.cybersophe.org/writing/PD.html#5.1.
207 Lansiti, "Government IT Procurement Processes and Free Software."
208 Ibid.

With improved FAR requirements and freed up resources from the EAC, HAVA funds need to continue to assist local and state governments in adoption of OSS. As systems continually need to be upgraded, HAVA should use the freed up resources to assist poorer local governments in transitioning to newer voting technology.

Finally, government needs to promote open source strategy by hiring approved open source vendors from the OVSB for system integration and analysis. This policy is essential for rewarding participation in open government voting systems. While this facet of the plan can be applied specifically to the case of electronic voting it also has large implications for a larger macro policy of adopting and promoting open source business models in government.

## HYPOTHETICAL CASE OF NEW VENDOR RELATIONS

This section will present a prototype of the first reform suggested in this thesis. The first reform of the thesis suggests that the EAC work closely with an independent organization that assists with creating standards, auditing, and approve voting systems. This case is a preliminary survey of how the current standards board could be improved upon. It is not intended to be detailed in description and is not necessarily how implementation would be realized. The diagrams below are intended to give a brief idea of such a system as I describe in my recommendations. It relies on the creation of an independent agency that assists the EAC in election reform. This mock organization is called the Open Vendor Standards Board (OVSB) and evaluates voting systems. The OVSB can approve systems and will rate systems with a positive orientation toward open source standards. In the OVSB, open source platforms will receive higher ratings than proprietary systems.

The OVSB will be an independent mock organization funded through donations

and commission made by assisting vendor-government contracts. Vendors submit code to

the OVSB for approval. The OVSB will rate and approve various software using

standards created closely with the EAC. Local governments then use OSVB standards to

procure software and make more informed choices about voting technology.

An analogous organization to the OVSB would be something similar to the World

Wide Web Consortium (W3C). The W3C is an international community where member

organizations, a full time staff, and the public work together to develop web standards. [209]

Like the W3C, the OVSB would work together with the public to develop open standards

for voting systems. Unlike the W3C however, the OVSB would have additional

responsibilities such as approving voting systems and facilitating a network between

governments and vendors.

The OVSB has a business model. The OVSB can make money through

networking and commission. When a local government desires to implement certain

software in their voting systems, the OVSB will assist in providing the necessary

networking for vendors for the government to implement the project. The vendor receives

the contract from the government and the OVSB receives a fee from the vendor to fund

further research and work.

The OVSB's standards entail a pro-open source policy. On the rankings, open and

more transparent code gets rated higher. Rankings would include factors such as

transparency, security, usability, and cost. While all vendors can submit their code to the

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209 "About W3C," *W3C*, last modified 2012, accessed April 23, 2014, http://www.w3.org/Consortium/.

OVSB, the OVSB will rank and recommend open source code whenever possible.

Governments would contact the OVSB to be networked with the appropriate vendors for

assistance in system integration. The diagrams below show the interactions between the

OVSB, NIST, EAC, and the vendors.

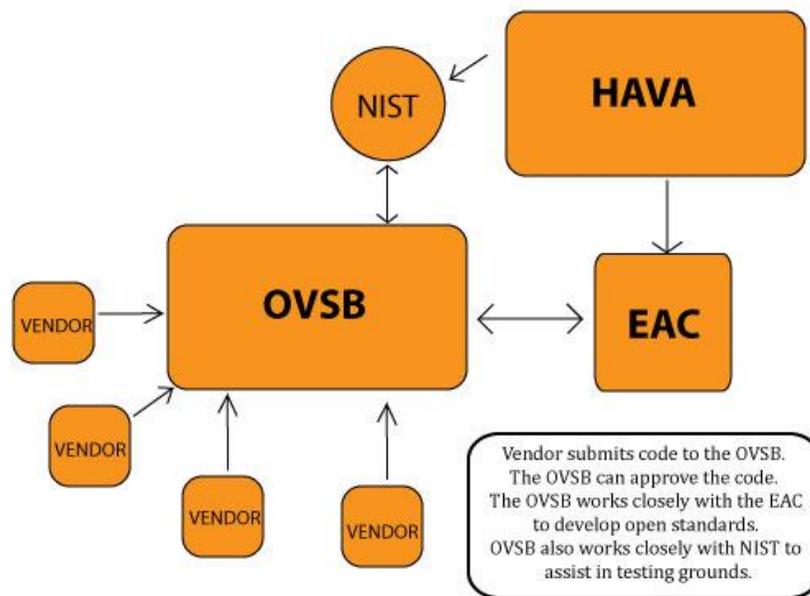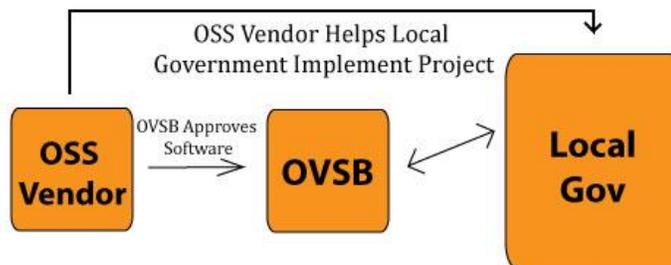**Open Vendors Standards Board (OVSB) Flow Diagrams**



FIGURE 14



FIGURE 15

The OSVB and the EAC work closely to create open standrads. The open source community can submit code to the OVSB or assist in developing standards for the OVSB.
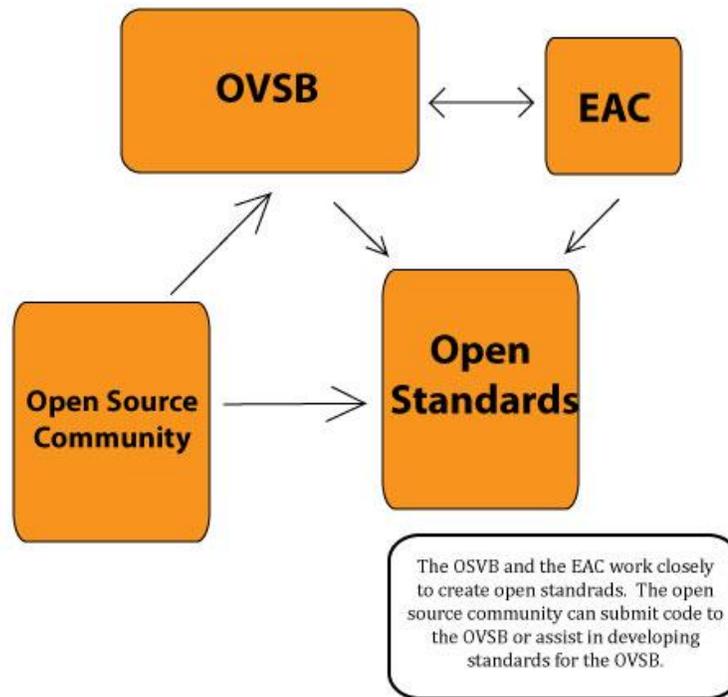
FIGURE 16

Enacting such a system would accomplish three goals. First, it would allow the EAC to better allocate funding to assist governments. Less government money will be spent on administration within the EAC as many administrative tasks would be consumed by the OVSB. Second, the OVSB would create a superior set of standards that are agreed upon by the entire community. This would add legitimacy to the voting process and increase civic participation.[210] Finally, the OVSB would promote a network between vendors and local governments. This would encourage open source participation and facilitate better software solutions for voting systems.

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210 One can look at the W3C's success at open standards to see that the OVSB would be successful at engaging citizens in voting reform. For more information on the W3C's involvement in open participation please visit the url http://www.w3.org/participate/.

There a variety of critics to open source adoption within voting systems. Critics primarily address security and usability concerns.[211] These concerns are frequently sighted in open source systems and have been addressed countless times in research. These concerns should not demotivate open source adoption in voting systems.

The issue of security is one of the most frequently cited arguments against open source. By providing code to everyone, you also provide access for hackers to breach security holes and modify programs. Opponents of open source adoption argue that this creates weaker security.

Though it may seem counter-intuitive, transparency increases security within OSS design. By allowing people to see the code, security holes are easily detected and fixed quicker than any proprietary system. The director of the Linux Foundation Jim Zemlin commented on the topic of security in open source:

"If there were a backdoor in Linux, you'd know it. The whole world can see every line of code in Linux. This is one of the reasons Linux is more secure than other operating systems and why open-source software overall is a safer than closed software. The transparency of the code ensures it's secure."[212]

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211 Dave Roberts, "California Experiments with Open-Source Voting | CalWatchDog," *Calwatchdog*, last modified March 28, 2014, accessed April 12, 2014, http://calwatchdog.com/2014/03/28/california-experiments-with-open-source-voting/.
212 J O'Dell, "Linux Chief: 'Open Source Is Safer, and Linux Is More Secure than Any Other OS' (exclusive) | VentureBeat | Dev | by J. O'Dell," last modified November 26, 2013, accessed April 22, 2014, http://venturebeat.com/2013/11/26/linux-chief-open-source-is-safer-and-linux-is-more-secure-than-any-other-os-exclusive/.

It is the nature of software that almost no software is 100% bug free. There are glitches, bugs, or hacks in almost every system. The difference is that with open source, the community can identify the bugs and address them while in a proprietary setting a company may never identify the bug or may choose to hide the bug. This can hinder security patches.  As an example, Microsoft doesn't report all security vulnerabilities that it fixes in its software. [213] Adobe also does not report internal vulnerability fixes.[214] Proprietary companies are not incentivized to admit security problems within their code. This can make code much more insecure than open source. Open source is an ideal platform for voting systems because it forces security flaws to be addressed and identified. This makes it much harder for invisible bugs or glitches to impact voting machines.

The second criticism commonly associated with open source is usability concerns. Current systems are not at a high quality of usability or accessibility.  This can have a negative impact on the voter experience. According to the Gregory Miller, co-executive director and chief development officer of TrustTheVote, "Current voting machines are not high in quality of usability or ideally engineered for maximum disability accessibility. Many are also poorly designed in terms of ease of administration, leading to instances of election dysfunction labeled as "operator error" by voting machine vendors."[215]

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[213] Tom Sanders, "Microsoft Official Admits to Quiet Security Patching | PCWorld," *PC World*, last modified May 27, 2010, accessed April 22, 2014, http://www.pcworld.com/article/197410/Microsoft_patch.html.

[214] Ibid.

[215] Alex Wilhelm, "Meet TrustTheVote, A Project To Make Voting Open Source And Transparent | TechCrunch," *TechCrunch*, last modified April 14, 2014, accessed April 22, 2014, http://techcrunch.com/2014/04/14/meet-trustthevote-a-project-to-make-voting-open-source-and-transparent/.

The OVSB will assist in combating usability concerns with open source. As explained, the OVSB has a rating system that accounts for factors such as usability. The OVSB would address usability concerns within the rating system providing a better score to a more usable product. Though this does not necessarily solve poor usability problems within any software, it does provide clarity of potential usage problems of software for governments as they make management decisions.

## CURRENT MOVEMENT TOWARD OPEN SOURCE ADOPTION

An open source strategy for electronic voting is not necessarily a novel concept. The idea of open source voting began in 2006 when John Sebes and Gregory Miller created the Open Source Digital Voting Foundation.[216] After a six year battle with the IRS, they have finally been able to publish open code online.

Government has been blocking foundations such as OSDVF from reforming the voting process.[217] Finally, government is in the position to adopt new open source software. States such as California are experimenting with open source voting after realizing they were spending tens of millions of dollars on ineffective voting machines.[218] Various reports indicate that HAVA funds are not spent effectively.[219] Audits indicate a need for an improved strategy in fiscal spending. According to the audit, despite counties

216 Robert McMillian, "Open Source Voting Machine Reborn After 6-Year War With IRS | Enterprise | WIRED," *Wired*, last modified August 6, 2013, accessed April 12, 2014, http://www.wired.com/2013/08/osdv/.
217 Ibid.
218 Roberts, "California Experiments with Open-Source Voting | CalWatchDog."
219 Elaine Howlde, *It Must Do More to Ensure Funds Provided Under the Federal Help America Vote Act Are Spent Effectively* (California State Auditor, 2012 2011).

receiving $252 million since 2003 to replace their voting systems, nearly a fifth indicated

they are using outdated voting systems.[220]

Senator Alex Padilla (D) authored Senate Bill 360 to revamp the state's voting

systems without the need for federal approval. According to Senator Padilla, "In

California there's a patchwork of different technologies to develop … for each of the 58

counties by at least a half-dozen vendors. Currently counties only partially own the

systems, which serve as the accuracy and transparency of the hardware and the software

that they use in voting. Election equipment is subject to licensing agreement which means

that counties at times additionally rely on vendors for system maintenance and

repairs."[221] The bill SB360 authorizes counties to implement pilot voting systems. The

District of Columbia has also launched its own version of open-source on-line voting

software developed by the Open Source Digital Voting Foundation. [222] The open source

system provides overseas voters with an identification number to login online and send a

ballot.[223]

The Open Source Digital Voting Foundation is paving the way for open source

voting. Its leading project right now, TrusttheVote, is an open source solution headed by

the Open Source Election Technology Foundation to electronic voting.  The TrusttheVote

Project has a mandate to make demonstrative progress by the 2016 national elections in

delivering applicable, actionable, and useful results. So far, the project has had impact on

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220 Roberts, "California Experiments with Open-Source Voting | CalWatchDog."
221 Ibid.
222 Rob Pegoraro, "Faster Forward - D.C. Launches Test of Open-Source Online Voting," accessed April
12, 2014, http://voices.washingtonpost.com/fasterforward/2010/06/dc_launches_test_of_open-sourc.html.
223 Ibid.

voter registration, voter information, ballot design, ballot tabulation, election results

reporting and analysis, and some auditing.[224]

States have been hesitant to move toward open source in the past for a multitude

of reasons. Besides a natural orientation toward proprietary software in government, there

has not been a strong and well-funded open source project open for voting systems until

very recently. This thesis proposes that states should take more aggressive measures in

adoption of open source technology, that the benefits of open source voting systems far

outweigh the current proprietary solutions, and that open source voting is the best method

to guarantee transparency of the democratic process that runs American elections.

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224 "The TrustTheVote Project » The Project," *Trustthevote.org*, accessed April 12, 2014,
https://www.trustthevote.org/background.

# CONCLUSIONS

Open source adoption provides a number of advantages such as transparency. Factors such as transparency will have a positive effect on the development of voting systems. As Winner suggests in his book <u>The Whale and the Reactor</u>, voting machines can have political and social implications. Increasing transparency surrounding the development of voting systems will create better voting software that identifies with core values of the voting process. As governments continue to move toward transparent voting systems, open source provides the most direct solution to increase visibility in the voting process.

Open source's crowdsourcing strategy is the optimal way to create better standards and code. Utilizing the power of the crowd creates the capacity to deal with bugs better, optimize functionality, and inspire innovation among voting systems. From a technical approach, crowdsourcing is optimal to troubleshoot bugs, identify security flaws, and address usability issues among the public. From a design perspective, programmer Eric Raymond compared the development process to a bazaar where everyone can join and contribute creating a "inspiring, creative, and democratic atmosphere".[225] In Raymond's bazaar model, democratic discourse leads to the best solutions accepted for source code.[226] As Raymond suggests, open source is ideal for inspiring innovation within the voting process.

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225 Guido Hertel, Sven Nidner, and Stefanie Herrmann, "Motivation of Software Developers in Open Source Projects: An Internet-Based Survey of Contributors to the Linux Kernel," *Open Source Development* 32, no. 7 (July 2003): 1159–1177.
226 Ibid.

As government moves toward more sophisticated voting methods including remote voting, government needs to ensure an intelligent platform for policy design. My research advocates that open source is the best platform to provide quality elections. Even more powerful however, open source will provide the transparent foundation necessary for future innovations in election reform.

The beauty of an open source solution to voting systems relies on a harmony between the processes of designing elections to the actual elections themselves. It is this alignment of design that provides clarity in the benefits of open source. This alignment provides the voting process with the legitimacy that Americans deserve. In conclusion, open source needs to be proactively pursued in voting systems to provide a better, safer, and more honest voter experience.

# APPENDIX I SCHWARTZ RESIDUAL RATES

## TABLE A[27]
### FEEDBACK IN FLORIDA:
### "RESIDUAL RATES" IN FLORIDA BY VOTING TECHNOLOGY

| VOTING SYSTEM | COUNTIES | TOTAL VOTES FOR PRESIDENT** | ALL BALLOTS*** | RESIDUAL BALLOTS NUMBER | % |
|---|---|---|---|---|---|
| Optical (precinct) | 26 | 2,055,755 | 2,072,927 | 17,172 | 0.83% |
| Lever machine | 1 | 62,013 | 62,570 | 557 | 0.89% |
| Punchcard (central) | 24* | 3,571,616 | 3,717,544 | 145,928 | 3.93% |
| Optical (central) | 15 | 264,873 | 280,813 | 15,940 | 5.68% |
| Paper/hand | 1 | 3,826 | 4,084 | 258 | 6.32% |
| TOTALS | 67 | 5,958,083 | 6,137,938 | 179,855 | 2.93% |

Optical (precinct) means marked ballots are tabulated by machines at precinct level.
Optical (central) means marked ballots are tabulated by machine at a central elections office.
Punch card (central) means punch card ballots are tabulated by machine at a central elections office.
*Uncertified figures from three counties result in unofficial statewide totals.
**Includes all 10 presidential candidates on Florida ballot, plus valid write-ins.
***Includes absentee ballots, which tend to increase the number of residual ballots.

## TABLE B
### UNDERVOTES VERSUS OVERVOTES*

| VOTING SYSTEM | NO. OF COUNTIES | *MIAMI HERALD* TABULATIONS | | | |
|---|---|---|---|---|---|
| | | UNDERVOTES | Percentage of Total | OVERVOTES | Percentage of Total |
| Optical (precinct) | 26 | 5,686 | 37.15% | 9,620 | 62.85% |
| Lever machine | 1 | 133 | 70.37% | 56 | 29.63% |
| Punch card (central) | 24 | 54,217 | 38.43% | 86,878 | 61.57% |
| Optical (central) | 15 | 1,050 | 6.74% | 14,520 | 93.26% |
| Paper/hand | 1 | 25 | 11.79% | 187 | 88.21% |
| **Totals** | **67** | **61,111** | 35.44% | **111,261** | 64.56% |

*These results are drawn from the Miami-Herald, Knight Ridder and USA Today sponsored examination of the Florida undervotes. The examination itself was carried out by BDO Seidman, LLP, Certified Public Accountants. The results for all 67 Florida counties are posted online at http://www.miami.com/herald/special/news/flacount/docs/100973.htm (last visited April 23, 2002). Partial results from the study are also found in Miami Herald Report, supra note 21, at 222-301.

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[227] Schwartz, "Voting Technology and Democracy," 633.

# APPENDIX II PROCUREMENT PROCESS



Disposal

Life Cycle Sustainment

Low-Rate Initial Production

System Capability and Manufacturing Process Demonstration

Integrated System Design

Technology Development Phase

Material Solution Analysis Phase
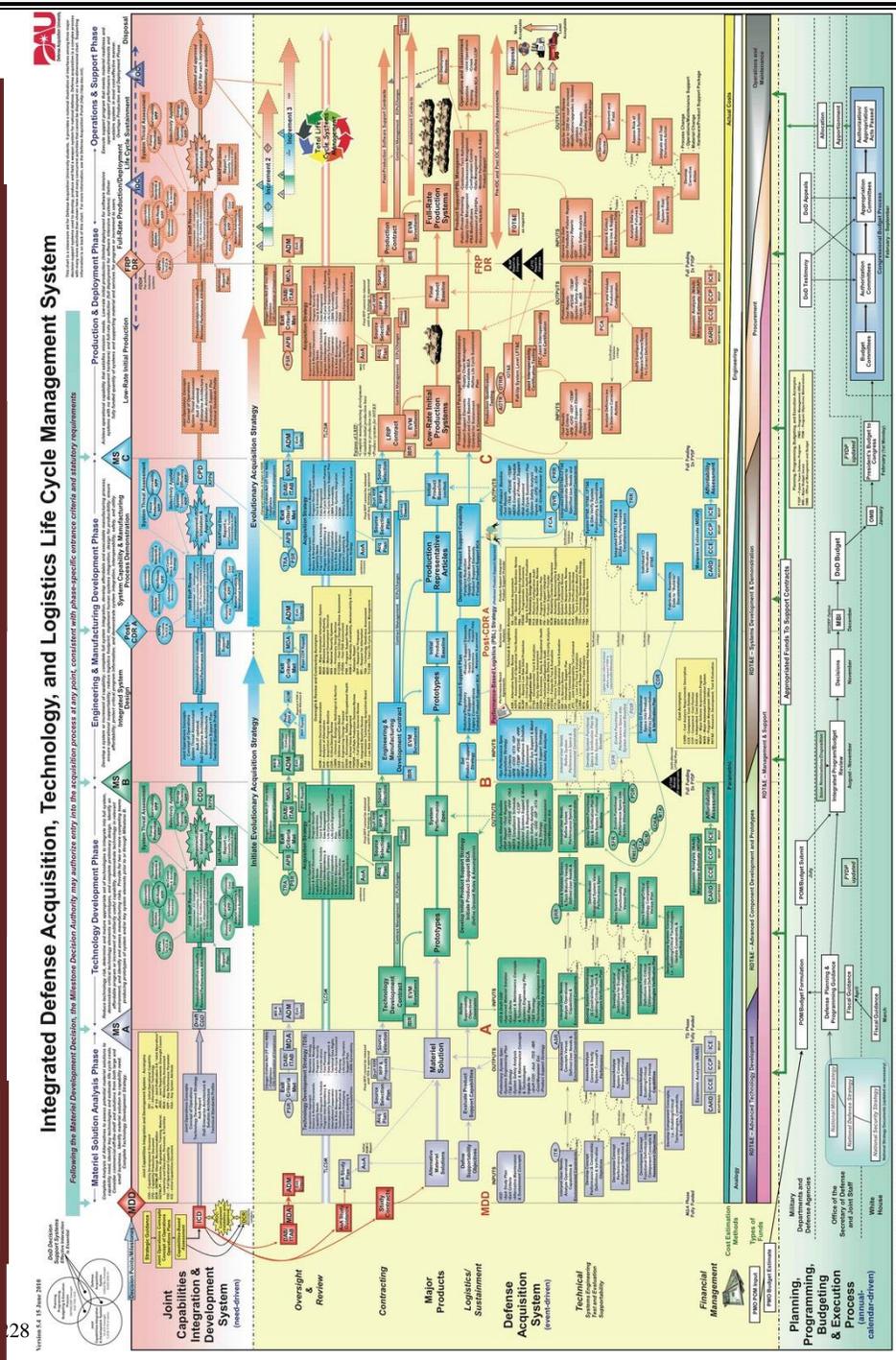
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# APPENDIX III STATE TESTING

| 1.) No Federal Requirements | 2.) Requires Testing to Federal Standards | 3.) Requires Testing by a Federally Accredited Laboratory | 4.) Requires Federal Certification |
|---|---|---|---|
| **20** | **10** | **13** | **12** |
| AK | CT | AL | CA |
| AS | DC | AZ | CO |
| AR | IN | IL | DE |
| FL | KY | IA | GA |
| GU | MN | LA* | ID** |
| HI | NV | MA | NC** |
| KS | NY | MD | ND |
| ME | OR | MO | OH |
| MI*** | TX | NM | SC |
| MS | VA | PA | SD |
| MT | | RI* | WA |
| NE | | UT* | WY |
| NH | | WI* | |
| NJ | | | |
| OK | | | |
| PR | | | |
| TN | | | |
| VT | | | |
| VI | | | |
| WV | | | |

\* Statutes/regulations require testing by an independent testing authority or NASED accredited laboratory according to standards adopted by either the FEC or EAC.

\*\* Statute allows for either NASED or EAC certification.

\*\*\* Statutes/regulations prescribe testing by an independent testing authority accredited by NASED, with no mention of Federal standards.

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[229] "State Requirements and the Federal Voting System Testing and Certification Program," 5.

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