

ACCURATE: A Center for  
Correct Usable Reliable  
Auditable and Transparent  
Elections

2006 Annual Report

**ACCURATE** 



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## Overview

This past year was a mid-term election year, and was thus a very busy and productive year for ACCURATE. Our co-Principal Investigators (co-PIs) were involved in many aspects of the election, including serving as election judges, working on post-election analysis and auditing, poll worker training and observing international elections. A listing of our center co-PIs is found in Appendix A of this report.

ACCURATE co-PIs have provided formal feedback to the Election Assistance Commission (EAC) on their Voluntary Voting System Guidelines (VVSG), tested voting systems in several states and multiple countries, helped design voting technology legislation, and testified before committees of local, state, and the federal governments. Center activities have been featured in the New York Times (front page), the Washington Post, Newsweek, Time Magazine, and on NPR and CNN, as well as many other media outlets. We are particularly proud that one of our co-PIs, David Dill, was named an ACM Fellow in 2006 “for contributions to system verification and for leadership in the development of verifiable voting systems.”

We held our first workshop in February, 2006 in Menlo Park, California, hosted by SRI. The workshop was a great success with ACCURATE members presenting their work and advisory board members and invited elections officials giving several talks on current issues in voting. In August, we held our first public workshop called, Electronic Voting Technologies (EVT) in Vancouver. The program chairs were Dan Wallach and Ron Rivest, and the event was a great success with 10 refereed papers and a keynote address by Walter Mebane. There were approximately 120 attendees. EVT 2007 will take place on August 6 in Boston and will be co-chaired by co-PI David Wagner and former EAC Vice Chair Ray Martinez.

ACCURATE researchers have been extremely productive. In our first year and a half, we have worked on 32 different research projects in the areas of systems, cryptography, verification, policy, and usability and accessibility. Many of these efforts have led to innovations that will improve these various aspects of voting systems. In addition, much of the research has broader applicability to other systems. To date, ACCURATE has produced 27 refereed technical publications, with many more pending and in preparation.

Education is a core component of the ACCURATE center. To date, 9 college courses covering electronic voting were taught or co-taught by our co-PIs, and several new ones are planned. The courses have engaged students in the democratic process, taught them about the hot issues, and provided them the opportunity to solve some problems related to elections and technology. ACCURATE has provided funding for 18 graduate students and 12 undergraduates.

The ACCURATE center engages in an unusually large amount of outreach for a research center due to the important applicability of our work to actual elections. The outreach activities can be broadly categorized into three areas, namely, working with election officials and participating in elections; post-election auditing and analysis; and raising

awareness of security and other issues via hearing testimony and working with the press. Our far reaching outlook has had a direct impact on many elections, and as can be seen from our detailed activities section below, many election officials and jurisdictions rely on ACCURATE for support.

Finally, our center advisory board welcomed three new high profile members, including California Secretary of State Debra Bowen, former EAC commissioner DeForest Soaries, and technology and disabilities expert Noel Runyan. A complete list of our external advisory board can be found in Appendix B of this report. Also, co-PI Brent Waters from SRI replaced Drew Dean.

## **Detailed Activities**

This section provides details on the 2006 center activities. ACCURATE has been very successful in pushing the state of the art in technology, usability, and policy research. Furthermore, given the practical importance of electronic voting, there has been an unusually large amount of outreach and contribution to the elections community. Finally, the problem of electronic voting provides a tremendous opportunity for educating students and involving students in research projects.

### ***Research***

ACCURATE's research goals are divided into 5 broad categories: System-Level Issues, The Role of Cryptography, Design for Verification, Relating Policy to Technology, and Usability and Accessibility. This section provides an overview of the research in these areas.

#### ***System-Level Issues***

This section describes the ACCURATE projects relating to system-level issues.

- We are studying electronic voting machine architectures in which the voting user interface is prerendered and published before election day. We are investigating how platform-independent formats can be used for describing the voting user interface, so that one could examine and try out the voting process on any computer, without having to acquire voting machine hardware. During the past year, we have successfully designed and implemented prototype software for a high-assurance touchscreen voting machine. The resulting software allows broad flexibility in the appearance of the ballot, includes a verifier that protects the machine against improperly formatted ballot definition files, and stores the votes in a tamper-evident, history-independent manner. All of this is accomplished in less than 300 lines of Python, which demonstrates the feasibility of the approach for significantly reducing the size of the trusted codebase (in comparison, the Diebold AccuVote TS contains over 31,000 lines of C++ running on top of the Microsoft Foundation Classes and Windows CE). This work was published at the 2007 Electronic Voting Technologies Workshop.

- We are analyzing security requirements for electronic voting systems. Our requirements are organized in a hierarchical fashion; the requirements tree breaks down the fundamental goals of one vote per authorized voter, fairness, accurate casting, accurate counting, privacy, coercion prevention, and verifiability into detailed subgoals. The responsibility for each subgoal can be assigned to components of the voting system, such as human election workers, voting hardware, or voting software. Setting out responsibilities in this way is a necessary step in evaluating voting software to see if it correctly upholds the necessary security commitments.
- We have completed the design, fabrication and testing of a new and simplified data diode (unidirectional data channels designed to be placed between computer systems). In addition, we have begun to build a demonstration system showing how data diodes can be used to protect the security of an election management system while allowing direct connection between the election management system and a possibly insecure web server used to publish election results.
- We have initiated a study of pre-election Logic and Accuracy testing procedures. We have observed the process in Alameda, Marin, and Contra Costa counties. Also, we interviewed elections officials in Alameda and Marin counties. We are working to study how the effectiveness of these procedures may be enhanced for new election technology.
- We have implemented an instant-runoff vote tabulation system for The University of Iowa Student Government; this was a pilot project, but it was used in their Spring 2006 election for the president of the student body. Building on this experience, we have completely redesigned the student election system in order to create a general open-source framework to support complex tabulation rules for ranked-choice ballots. Our framework separates the basic algorithm for a multi-round instant runoff election from the specifics of the conduct of each round and from the specific tie-breaking rules, and it produces sufficient audit data that outside observers can review the results and independently verify that the vote tabulation was done correctly.
- We participated in a USACM-sponsored study of statewide voter registration databases. We also participated in a study sponsored by the Brennan Center for Justice on the security of electronic voting.

### ***The Role of Cryptography***

One of the areas of research that is critical to ACCURATE is in the area of Cryptography. The following are cryptography-related projects within ACCURATE:

- We have studied improved mix net design that can yield shorter proofs, using bilinear maps. Mix nets are the basis for cryptographic voting methods. We also have developed some new techniques for searching encrypted data, which enables the database to locate all records satisfying a specific predicate without revealing

other information in the database. This could be generally useful for doing targeted searches of data while protecting privacy.

- Implementations of cryptographic algorithms, such as AES, are obviously critical to the foundations of computer security. In collaboration with Profs. Warren Hunt and J Moore at the University of Texas, we have constructed a program verification system for Java programs based on ACL2 (a lisp-based theorem-prover) and STP (an efficient decision procedure for bitvectors developed in Prof. Dill's group). The system is based on a partial implementation of the Java Virtual Machine in ACL2, and a subset of the Java Modeling Language for annotating programs with assertions. We have written a formal specification of AES based on the IFIP standard, and have verified that encryption and decryption are inverses for all keys. We are currently working on verifying the correctness of encryption, including the correctness of key expansion. We expect that this procedure will be largely automatic, and that a proof of AES can easily be adapted to other widely-used symmetric key encryption algorithms.
- We are working on a paper design of a simple protocol for cryptographic key management in voting systems, which grew out of our voting system project class from the Spring, 2006 quarter. We are using model-checking techniques to verify the protocol, using the Murphi model checker. Unlike most other approaches to verification of cryptographic protocols, we are simultaneously modeling and checking reliability issues, including manual recovery from system failures of various kinds, along with the usual verification that the protocol has specified security properties under a black-box cryptography model.
- We designed a new cryptographic tool that provides the necessary security properties for a DRE vote storage system. In particular, our system provides tamper-evidence while maintaining complete voter privacy. In this context, tamper evidence means that an audit will detect if stored votes were modified or deleted. Voter privacy means that the layout of ballots on the storage medium reveals no information about the order in which ballots were cast. Moreover, the system does not require any special hardware. Our approach is based on a new cryptographic primitive we call History-Hiding Append-Only Signatures. We describe two constructions for this tool and discuss how to make use of it in a DRE.
- We developed a collection of cryptographic software that will make new primitives available to practitioners. The software is now available at the website <http://acsc.csl.sri.com/>.

### ***Design for Verification***

One of the novel concepts in our ACCURATE grant proposal was the idea that systems can be designed for verification. That is, that verification is one of the key properties of a voting system, and it should be designed for, just as performance and scalability are often

designed for in computer systems. This section describes our research into verifiable voting systems.

- We are investigating techniques to aid verification of specific properties in voting machines. We published at Usenix Security 2006, *Designing voting machines for verification*, which describes our experiences in building a hardware DRE prototype that eases the burden of verifying some critical security properties of voting machines. In particular, we focused on verifying that voting sessions are independent and free from prior voters' influence, and that ballots cannot be cast without the voter's consent. The techniques, especially those for preserving privacy and independent voting sessions, are broadly applicable across a range of voting technologies.
- We have begun to look at proving security properties of voting software, using software design techniques and program verification tools. Program verification methods can be used to verify security properties of relevance to elections. Also, we are examining how static analysis can be combined with good software practice and specific dynamic checks to enforce these properties. We hope to evaluate the capabilities and limits of current technologies and techniques for program verification and static analysis, as they apply to electronic voting, and identify opportunities for improvement and future research.
- We are working on the NEVA (Nonproprietary Electronic Voting Auditing) toolkit. This is designed to be easily extensible to various voting systems and to provide for straightforward extraction of a variety of reports that may be of use to election administrators and auditors. NEVA begins by extracting data from whatever machine readable files are available (vote image data, event logs and electronic pollbooks), converting this to a canonical form, and then providing this as input to analysis tools. The complete lack of standardization of the data output by the current generation of voting machines is a serious problem faced in the canonicalization of the data. It is clear that work on NEVA will both provide strong suggestions to voting system vendors about data that ought to be recorded but is not uniformly recorded today, as well as a useful tool for use by election administrators.
- We have developed a prototype program, with the working name "AttackDog", for managing and evaluating attack trees, which are basically AND/OR trees representing possible attacks on systems with metrics for computing the cost of each attack. AttackDog addresses several deficiencies that we found in other software for evaluating attack trees, including awkwardness in considering varying scenarios (such as the presence or absence of a particular countermeasure), difficulty in avoiding multiple counting of costs in some attack tree structures, and general inflexibility. We have produced some example attack trees for voting systems, and are now working with NIST to develop an attack tree for a cryptographic voting system. We hope to develop a practical attack tree methodology for security evaluation. Although AttackDog was developed with

voting systems in mind, and initial applications to voting, we believe that the system and methodology will be much more widely applicable to evaluating security risks in systems.

- We designed and implemented an all-electronic framework for independent audit of vote totals. This research is an effort towards developing a framework, which can be deployed in states that do not use any means of independent audit. Our framework determines the vote cast, through image comparison methods. We implement our technique in the device model of the XEN hypervisor, thereby eliminating the need to trust the Windows OS that runs the voting machine. We further show that our framework is robust and accurate by demonstrating that even if the voting software has been maliciously altered to flip the votes, the auditing framework will still count the votes accurately. This work will be submitted to the 2007 USENIX security conference.

### ***Relating Policy to Technology***

This section describes the ACCURATE research related to the nexus of policy and technology.

- We worked with election officials in two California counties, San Mateo and Yolo, to develop procedures to help these counties conduct their post-election audits. California requires each county to manually recount the ballots in 1% of randomly selected precincts. We developed a comprehensive set of procedures, beginning with pre-election preparation, to help counties deal with a number of practical issues in a sound manner. For example, the procedures include the use of ten-sided dice rolled before public observers, rather than a pseudo-random number generator, for random precinct selection. This work continues in order to evaluate the effectiveness of our proposed procedures and to iterate and produce a new version informed by use in actual elections. We plan to present this to the California Association of Clerks and Election Officials (CACEO), the International Association of Clerks, Recorders, Election Officials and Treasurers (IACREOT) as well as publish an article relating to what we've learned in an election or auditing-related forum.
- We have conducted research on the constraints intellectual property law places on the ability of regulators to engage in testing and oversight of voting systems. Currently, we are researching the components of an appropriate certification and testing process for voting systems. In addition, we have begun developing a theoretical model for deriving technical design requirements from legal and/or social policy and are developing voting system requirements through application of this model.
- We prepared a white paper that identifies and analyzes salient legal issues facing election officials in the contexts of voting machine procurement, testing and use, and responses to public records act requests. To an increasing extent, election officials must consider whether and how trade secret and copyright protection of

voting system components affects their ability to perform their own tests of voting systems. We also discuss how these protections for voting systems affect officials' ability to provide information in response to public records requests. Research for this paper involved a review of dozens of contracts between manufacturers and election jurisdictions, a review of a wide variety of state and federal laws, and interviews with election officials. We provided a draft version of this report to a public election observer, who used the paper's trade secret analysis to obtain critically important information about a vote tabulation database. We will develop a separate branch of this work, which is to analyze legal barriers to requiring source code disclosure for voting systems.

- We presented a draft of a paper exploring how agencies have identified technology changes as equivalent to “policy-making” and how that has shifted the process of adoption. The paper examines two case studies the U.S. e-passport adoption process and the migration to remotely available court records both of which were treated by the respective agencies like “policy-making” rather than technology procurement. It contrasts this with the federal and state approaches to the adoption of DREs.
- We submitted public comments to the EAC regarding the EAC's proposed Voting System Testing and Certification Procedures Manual. This Manual governs how the EAC will conduct business with manufacturers, test labs, and the public in the context of voting system certification. ACCURATE not only provided comments about specific provisions of the Manual, but also submitted a narrative document that related specific changes to broader arguments based on the EAC's role within the testing and certification process. Our comments had a substantial impact, as the final version of the Manual provides for more accurate and timely information about voting system certification, greater test lab independence and accountability, and greater public disclosures from the EAC. We will continue to take advantage of opportunities to comment on EAC documents and endeavor to find other ways to affect voting system oversight for the better.
- We prepared and submitted, on behalf of ACCURATE, comments to the EAC regarding the 2005 VVSG. These comments covered a wide range of technical, legal, and regulatory topics. This research involved a detailed review of both volumes of the VVSG and an analysis of how those guidelines could better conform rigorous procedures for developing secure, usable, and accessible systems. Our review of the VVSG also indicated that the certification process, which is based on compliance with the VVSG, lacks transparency; the Guidelines provide for little information about how a voting system performed under testing, other than the summary conclusion that the performance was adequate. As the comments argue, these deficiencies permit the certification of voting systems that are insufficiently secure, accessible, and usable; and they undermine voter confidence.

- We are examining the role of poll worker training and written references or *documentation* about voting technology to further constrain residual vote variation across California counties. We hypothesize that differences in how poll workers are trained and in voting technology documentation will affect the usability of the machines for the voters and thus the residual vote rate. For groups of California counties using the same type of voting equipment at the polling place, we've begun to evaluate the characteristics of reference materials according to a list of document design heuristics, and plan to produce a comparative analysis of documentation materials across counties that use the same technology. Developing a similar set of heuristics for the content and format of the training on these machines, we hope to do a comparative analysis of training as well. Finally, we investigate, for each machine, whether variations in training and/or documentation helps to explain variation in residual votes, or voter error, across the counties. This analysis will provide valuable insight into how training and documentation vary with respect to voting technology and the impact that might have on voter utilization of these machines.
  
- We examined the potential role of source code disclosure and open source code requirements in promoting technical improvements and increasing transparency of voting systems. We described the gradual decrease of transparency surrounding voting technology that occurred over the course of United States' electoral history, the implications that source code disclosure has for transparency, the negative effects that enclosing transparency has had at different levels and the regulatory and legislative efforts to increase access to source code. We then looked at the benefits and risks of open and disclosed source code regimes for voting systems, efforts to provide open source voting systems, existing open source business models that might translate to the voting systems context, regulatory and market barriers to disclosed or open source code in voting systems and alternatives that might exist outside of public disclosure of source code. We concluded that disclosure of full system source code to qualified individuals would promote technical improvements in voting systems while limiting some of the potential risks associated with full public disclosure. As a follow-on to this policy analysis, we are in the early stages of writing a paper entitled, "Legal Barriers to the Disclosure of Voting System Source Code" that more fully sets out the various legal hurdles and issues involved with source code disclosure. An important branch of this research involves analyzing whether compelling unwilling vendors to disclose source code raises constitutional concerns. Beyond this, however, we will examine legal issues that arise if voting system vendors are willing to disclose source code, but other parties—such as election officials—might not be. In addition to more fully articulating the legal landscape surrounding disclosure of voting system source code, this research will also examine voluntary and mandated source code disclosure in other sectors to gain additional perspective and guidance. We intend to make work accessible to policymakers, election officials, vendors and advocates who seek to gain a richer understanding of the legal consequences of disclosed source code, while also advancing the state of legal scholarship in this area.

- We are continuing to study post-election audits along several dimensions. Auditing requires both technological capability and a legal framework that regulates how audits are conducted. We began our work with a review of state laws on election auditing; currently, there is no federal law or regulation requiring audits. Along with the Brennan Center for Democracy at NYU Law School, we led a blue-ribbon panel of election officials, computer scientists, political scientists, mathematicians and attorneys to critically analyze the existing theoretical studies of post-election audits. As a part of this work, we have been consulting with staff counsel to a member of the U.S. House of Representatives, who will introduce election reform legislation containing an audit provision. We are preparing a report that dissects the theories that underlie each audit model discusses the costs, benefits, and technical hurdles associated with each. We will publish this report on the ACCURATE website, the Brennan Center website, and the American Enterprise Institute-Brookings Institution Election Reform Project website. We will build on the detailed knowledge we have gained of auditing law and theory to prepare a law review article that relates auditing to other legal and regulatory approaches to ensuring election integrity.
  
- We wrote a letter on behalf of an individual to the Minnesota Secretary of State, urging the Secretary to release information that the individual had requested regarding voter registration database testing. The previous Secretary of State refused to release this information, asserting that it was “security information” that was exempt from disclosure under Minnesota public records act. Our letter provides background about computer system security for a general audience, analyzes applicable provisions of Minnesota law, and applies both of these frameworks to the specific requests that the individual had submitted. This is one of the first pieces of work that outlines the implications for “security through obscurity” theory for voting systems administration. We will make this letter part of a package of materials that we will distribute to incoming secretaries of state to familiarize them with a variety of election administration issues and to invite them to make them aware of the areas of expertise represented within ACCURATE.

### ***Usability and Accessibility***

This section describes the ACCURATE research related to usability and accessibility.

- Our work on prerendering ballot images has continued with the design and development of a more accessible system, with support for audio ballots as well as synchronized video and audio voting interfaces. We have consulted with accessibility experts and with the ACCURATE Advisory Board on this ongoing work. These consultations revealed the importance of synchronized video and audio (which is also recommended by the draft Human Factors and Privacy section of the 2007 VVSG). Consequently, we are studying how electronic voting systems can provide synchronized video and audio in a trustworthy way.

- We are studying how prerendered voting systems can provide an "electronic sample ballot". The existence of the user interface as a separate, public artifact offers many advantages in security, transparency, and accountability. Just as paper sample ballots enable voter training and allow the public to inspect the ballot layout for mistakes, a published user interface enables similar training and inspection for electronic voting and might improve the chances of avoiding ballot formatting controversies such as have occurred in past elections. Preparing the user interface outside the voting machine also simplifies the voting machine software, and thereby dramatically reduces the amount and difficulty of software verification needed to assure the correct functioning of voting machines.
- Based on the recommendations of NIST, we have been simultaneously investigating ballot completion time, error rates, and subjective satisfaction. We have procured various forms of voting equipment (lever machines and punch cards) and designed and conducted multiple experiments to get baseline usability measures for extant pre-electronic voting technologies. So far, we have evaluated these methods using both student populations and more representative samples. We have also translated our materials into both Spanish and Chinese and have been collecting data from these populations as well (data are still being collected from the Spanish sample while we have recently finished data collection with the Chinese sample and are analyzing the data). So far we have found a consistent pattern of higher subjective usability for paper ballots and some evidence that punch cards and lever machines lead to more errors than paper ballots. We have so far found little evidence that voting method has much impact on time taken to cast ballots. We are now extending this work to include DREs.
- We are exploring a series of exit polls and in-polling-place behavioral measures collected as part of the 2006 election. This election offered us two unique local opportunities: first, an election in which the candidate from the locally-dominant major party was forced to run as a write-in (where most voters used a DRE with a particularly tedious write-in system); second, a local jurisdiction where voters were free to choose between a DRE and a paper ballot and where we had access to the inside of the polling place. While we are still coding and analyzing the data, preliminary analyses suggest numerous highly interesting findings, such as voters' perception of usability has a substantial impact on their confidence in the accuracy of the outcome of the election.
- We are investigating the usability of voter-verified paper audit trails (VVPATs). We have generated spools of simulated VVPATs based on the VVSG specification using a thermal printer similar to those used in commercial VVPATs and asked people to audit election results using the procedures outlined in the VVSG. We have looked at both time and accuracy measures, and the preliminary results are not encouraging.
- We have since designed a new voting system called VoteBox. VoteBox serves several purposes. First, it is intended to be a research vehicle for computer

security, and we have recently submitted a paper to IEEE Security & Privacy describing a robust (i.e., byzantine fault-tolerant) network architecture for storing votes and other election-day events. Our key insight is that hard disks are huge and the number of machines is relatively small. As such, we can afford to broadcast everything, everywhere. Algorithms that are  $O(n^2)$  in the number of voting machines are perfectly reasonable. VoteBox also supports human factors research. It's presently being used for human subject experiments. This means that the VoteBox codebase must support features that are decidedly not secure (e.g., logging every event by every user without any anonymity features). VoteBox's software architecture is designed to allow for these "evil" features in a controlled fashion, where their presence or absence can be easily proven. We expect this will lead to another publication. VoteBox was primarily implemented by two undergraduates, working over summer.

## **Education**

This project has provided outstanding opportunities for students. This section provides an overview of courses that were developed and taught and students who have received training through the center's activities.

### **Courses**

ACCURATE researchers incorporated electronic voting topics into their courses. The following courses and course projects took place under our NSF funding.

- Rice University: *Election Systems, Technologies, and Administration* taught by Dan Wallach and Mike Byrne, along with Rice political science professor Bob Stein. This course attracted 20 students, with an even distribution across the sciences and humanities. Students were graded primarily on their course projects, which included the implementation of a voting system called VoteBox for human factors experimentation, and two field studies on election day, November 7. In the 22nd Congressional District of Texas (Tom DeLay's former seat), we conducted an exit poll to measure the effectiveness of the write-in campaign being run by Shelly Sekula-Gibbs (who, as a result of the timing of Rep. DeLay's resignation, was unable to have her name on the ballot except as a write-in). In Jefferson County (Beaumont), Texas, in collaboration with the County Clerk's office, we conducted an exit poll and additionally had observers inside the polls with stopwatches. Jefferson County voters were given the choice of voting either via optical scan forms or via touch-screen electronic machines, creating a natural experiment to study the effectiveness of these two technologies. We expect a number of joint conference and journal publications will result from the data that we collected and will be co-authored with many of the Rice undergraduates who took this course.
- University of Iowa: *Computer Security*, taught by Doug Jones who used numerous examples from electronic voting in projects and exercises.

- Stanford University: *The Design of Secure Systems*, taught by Dan Boneh and David Dill. This project oriented class required the students to design a secure voting system. There were 14 students, who all worked on different aspects of the same project. The course focused on security engineering issues that are potentially useful in voting systems. One of the topics was the use of trusted platform hardware, specifically TCG, to do secure key distribution and ensure that only approved software was running on the system. There was a focus on proper management of cryptographic keys to protect from uploading malicious versions of the system software, and for digital signing of election data. The students implemented cryptographically tamper-resistant audit logs by using forward digital signatures. When the data were cast vote records (electronic ballots), the signature scheme was modified so that the order in which the votes were cast could not be inferred from the data. A prototype voting system was implemented in Java. There were three major components: a rudimentary “election management system” for generating and signing ballot data, keeping track of the machines, precincts, and ballot styles, and tallying the data from the precincts; an “authorization terminal” for generating electronic tokens for voters that can be used exactly once (we used iButtons, from Sun Microsystems); and “voting terminals”, which are the machines upon which voters cast the votes. The class demonstrated the system at a software fair for programming projects at the end of the quarter. An election was held for “best project.” To make the point that a system that is relatively secure from external attacks is still vulnerable to internal attacks, we stole the election and announced that our project was the best (and we confessed to stealing the election as well – there was no prize).
- Stanford University: Undergraduate Computer Security class, co-taught by Dan Boneh. The students used voting as a motivating example in the first three weeks (~95 students). Students learned about the desired security properties of voting systems, and some of the problems with current approaches.
- Stanford University: *Digital Dilemmas*, taught by David Dill. The course explored the interplay between technology and policy issues. The students had a mix of backgrounds, including technical and non-technical. Electronic voting was one of three specific topics covered. For that segment of the course, there were lectures on the basics of voting technology and computer security, as well as guest lectures on legal and policy aspects of the issue. As a project, students witnessed poll closing procedures at the end of the November 7, 2006 election at several polling places in Santa Clara and San Mateo Counties, California, documented the procedures in detail, and submitted reports to Verified Voting Foundations Election Transparency Project.
- Johns Hopkins University: *Computer Security & Privacy*, taught by Avi Rubin. About 1/3 of the course syllabus concerned electronic voting and voting issues. Student projects involved building and analyzing rigged voting systems.

- Johns Hopkins University: *Advanced Topics in Computer Security*, taught by Avi Rubin. The entire course was devoted to the special topic of electronic voting. Students built an anomaly detection system that was trained on a sample voting system that was given to the students. Then, the voting system or the tally would be manipulated in some way, and the students' anomaly detection systems were supposed to raise an alarm. Most of the students used system call patterns and the Linux system call *ptrace* for their anomaly detection. Halfway through the semester, the students exchanged detection systems, and then they tried to design hacks to the voting system that would go undetected. Then, the groups had several weeks to improve their system based on feedback from the other groups, and to write their final reports. In addition to this project, the class read different research papers related to security, virtualization and e-voting every week.
- University of California at Berkeley: Students in the Samuelson Law, Technology & Public Policy Clinic worked on electronic voting related projects including the white paper, discussed above, that identifies and analyzes the legal issues that election officials face when purchasing, testing, and administering electronic voting systems. All sixteen of the law students in the Clinic became familiar with the issues surrounding electronic voting, the interplay between intellectual property protections and misuse of those protections and the ability to assess the security of technology.
- University of California at Berkeley: In the Spring semester of 2007, Deirdre K. Mulligan will lead a graduate-level reading group seminar entitled, "Coding for Policy and Regulating Design". This course is intended to acquaint Berkeley graduate students, including those involved with the ACCURATE and TRUST centers, with the literature surrounding when, what and how to embed policy in technical systems, and to engage them in developing theories and strategies that respond to these questions.

### ***Students***

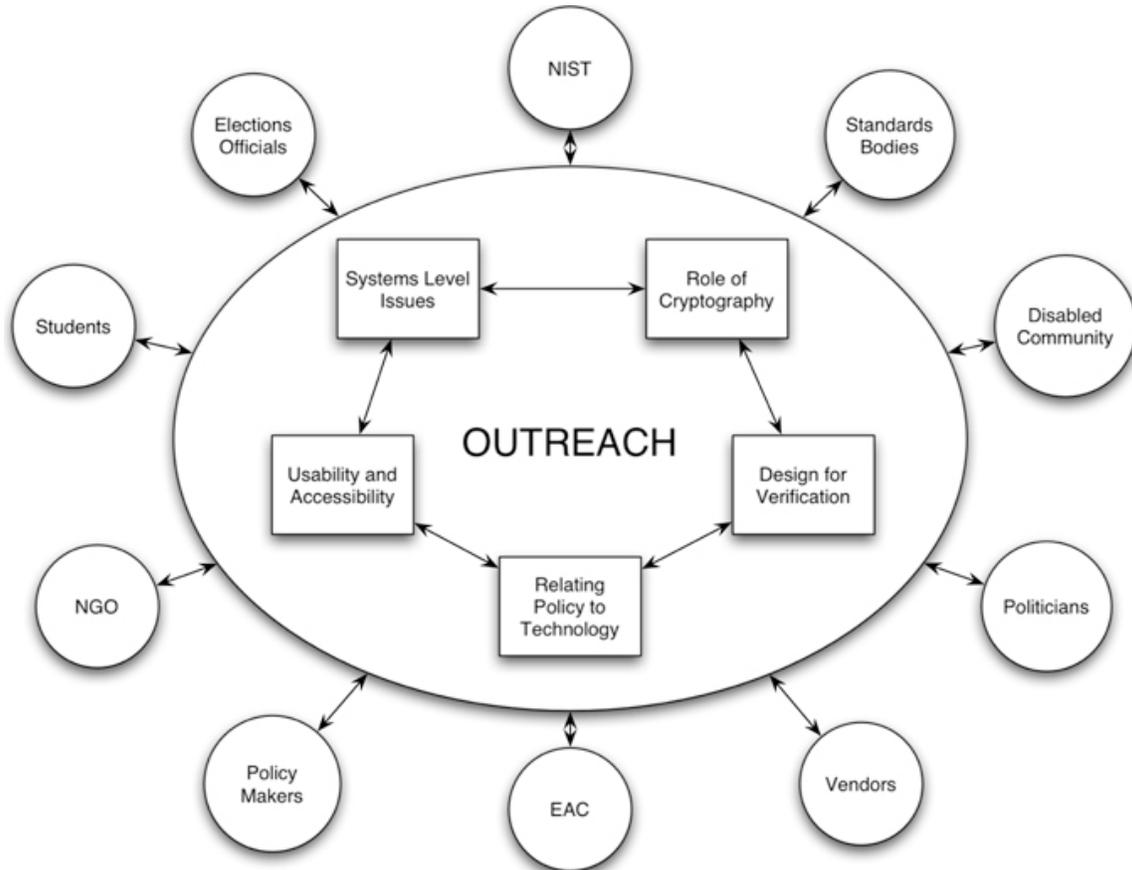
The following students have been funded under the ACCURATE center grant:

- Johns Hopkins University:
  - o Graduate students: Sujata Doshi, Ryan Gardner, Josh Mason
- University of Iowa:
  - o Graduate students: Robert Hansen
  - o Undergraduate students: Tom Bowersox, Patrick Holley, Tristan Thiede
- University of California at Berkeley:
  - o Graduate students: Arel Cordero, Naveen Sastry, Ka-Ping Yee, David Molnar, Chris Karlof, Joseph Lorenzo Hall
  - o Undergraduate students: Chris Crutchfield, David Turner, Drew Lewis
  - o Clinical Interns: Stephen Dang, Galen Hancock, Cecilia (Peggy) Walsh, Erica Brand, Jason Tokoro, Sarala Nagala

- Post Doc/Fellows: Aaron Burstein
- Stanford University:
  - Graduate students: Eric Smith
  - Undergraduate students: Tim King, Sean Ting
- Rice University:
  - Graduate students: Dan Sandler, Bryan Smith, Sarah Everett, Kristen Greene
  - Undergraduate students: Liz Guillen, Amy Lin, Stephen Goggin, Diego Caballero
- Other Institutions:
  - John Bethencourt, CMU
  - Tadayoshi Kohno, UCSD
- Ryan Moriarty, UCLA

## **Outreach**

When ACCURATE was first proposed, it was clear that the outreach component of the center was going to be central to our activities. This was displayed in our initial site visit presentation with the following graphic:



The picture illustrates that the primary research areas feed into our outreach program, which involves many different organizations such as the EAC, politicians, NIST, the disabled community, and the other parties who are features in the diagram. This section will describe ACCURATE's outreach activities in 2006. The activities fall into three broad categories:

1. working with election officials and participating in elections
2. post-election auditing and analysis
3. raising awareness of security and other issues via hearing testimony and working with the press

The remaining subsections provide details of these outreach activities of ACCURATE.

### ***Working with Election Officials and Participating in Elections***

One of the strengths of ACCURATE is the close tie that we've developed with members of the elections community. Our board of advisors, for example, includes the co-chair of the New York State Board of Elections, the Secretary of State of California, the Assistant Secretary of State of New Hampshire, the Chief Deputy Clerk/Recorder for Yolo County, California, and the former chairman of the EAC. In addition to these resources with whom we speak frequently, center members have worked closely with other elections officials. Here are some of the specific activities that took place in 2006:

- David Wagner is a member of the Technical Guidelines Development Committee (TGDC), the committee responsible for overseeing the drafting of federal voting system standards. He also serves on the Security and Transparency Subcommittee of the TGDC. Furthermore, Dr Wagner is a member of the California Secretary of State's Voting Systems Technology Assessment Advisory Board and works with the California Secretary of State's staff on voting technology issues. He is a member of the Alameda County Election Advisory Committee. He served as a technical advisor to the Alameda County Registrar of Voter's Equipment Selection Committee in 2005. He also served as a technical advisor to the Northern California branch of the ACLU and to ACLU national on e-voting technology issues. Prof. Wagner is Technical and Security Advisor to the Overseas Vote Foundation.
- A number of ACCURATE members worked with local election officials in efforts to document and improve "random audit" procedures in Yolo and San Mateo Counties, California. In the random audit in California and several other states, paper cast vote records from a small percentage of randomly-chosen precincts are counted by hand and compared with machine counts from those precincts, to check for machine counting errors. We had at least three meetings with San Mateo County Registrar of Voters Warren Slocum and his staff to understand the current auditing processes, and the many problems the elections office faced with conducting those audits optimally. On the advice of ACCURATE members, a

- publicly observable random selection procedure involving colored 10-sided dice was used to select precincts to be audited. The paper records for optical scan ballots and printouts from San Mateo's new DREs were all counted in public. ACCURATE member David Dill observed all of these processes, as did many local citizens on behalf of political parties and the Verified Voting Foundation. Findings and recommendations derived from this project will be written and distributed for the benefit of other jurisdictions who are refining their manual audit procedures. Participants from ACCURATE in the San Mateo County project included: Aaron Burstein, Arel Cordero, David Dill, Joe Hall, and David Wagner.
- Dan Boneh and David Dill recently met with Warren Slocum again to learn about San Mateo County's procedures for voting by mail. They hope to create attack trees for vote-by-mail and to suggest measures to improve the trustworthiness of the system.
  - Douglas Jones submitted comments to the Colorado Senate Majority Leader and the Colorado Secretary of State on proposals before the state of Colorado to reduce use of polling places and increase reliance on postal voting, focusing on the consequences of this with regard to ballot security and the accuracy with which ballots are tabulated.
  - In a briefing for members of Congress and their staffs, coordinated by the National Committee for Voting Integrity, Joseph Lorenzo Hall and Doug Jones gave short presentations on the effectiveness of the current federal certification regime. Mr. Hall concentrated on illustrating a particular set of cases, involving voting systems manufactured by Diebold Election Systems, Inc., where the federal certification process had allowed non-compliant voting systems to slip through the cracks. See: Joseph Lorenzo Hall, "Background on Recent Diebold Election Systems, Inc. (DESI) Vulnerabilities". *NCVI Briefing for Members of Congress and Staff*, United States Congress (2006).
  - Aaron Burstein, Stephen Dang, Galen Hancock, and Jack Lerner wrote a white paper that identifies and analyzes the legal issues that election officials face when purchasing, testing, and administering electronic voting systems. They interviewed election officials and solicited their feedback on the paper to ensure that it addressed situations of concern to them and offered practical guidance. In addition, they provided a draft version of the paper to a public election observer, who used guidance from the paper to succeed in obtaining a vote tabulation database that was critical to a post-election audit.
  - Avi Rubin worked with Elizabeth Bobo in the Maryland House of Delegates to draft a bill requiring paper records of votes. Dr. Rubin testified met with Maryland Governor Ehrlich and his staff, as well as with the speaker of the Maryland House of Delegates to discuss the bill. After the bill was defeated in the Maryland Senate, Dr. Rubin worked with delegate Bobo again to produce a new bill with the goal of improving election machinery in Maryland.

- Avi Rubin worked as an election judge in Baltimore County in the September, 2006 Maryland Primary as well as in the November general election.
- Douglas Jones has worked with several agencies (the Arizona Senate Government and Accountability Committee, the Organization for Security and Cooperation in Europe Office for Democratic Institutions and Human Rights, and Voter Action, in the Conroy vs. Dennis case in Colorado. In each of these cases, he has been able to gain access to machinery or documents that would otherwise be unavailable. In the Arizona case, he was able to access and test absentee ballot tabulating equipment. In the Colorado case, he was given access to proprietary documentation covering, among other things, the same tabulating equipment, as well as competing equipment made by several other vendors. Working with the OSCE-ODIHR, he was able to interview election officials, voting system developers, system administrators and testing authorities.
- Douglas Jones was a member of the Long Term Observer Team for the 2005 presidential elections in Kazakhstan for the Office of Democratic Institutions and Human Rights of the Organization for Security and Cooperation in Europe. He was also a member of the Election Assessment Mission for the 2006 parliamentary elections in the Netherlands for the Office of Democratic Institutions and Human Rights of the Organization for Security and Cooperation in Europe.
- Douglas Jones and Dan Wallach undertook an examination of proprietary documents produced by the four major voting system vendors, Diebold, Election Systems and Software, Sequoia and Hart, for the purpose of assessing the security of these systems and the competence with which the State of Colorado had assessed these systems. The results of this work took the form of testimony and expert opinions deposited with the Denver Circuit Court in the case, Conway vs. Dennis and released, in redacted form, as public records.
- Joseph Lorenzo Hall conducted two training sessions at San Francisco law firms for election technology specialist attorneys for the nonpartisan Election Protection Coalition. The presentations were teleconferenced around the country to other law firms in order to illustrate possible problems that these volunteer attorneys might face on Election Day. Volunteer attorneys dealt with problems with election technology in the field and were able to answer voter questions, advocate for technical and procedural remedies and better document problems they saw.
- ACCURATE students assisted the Samuelson Law, Technology, and Public Policy Clinic in writing a letter to Minnesota's Secretary of State in response to requests for disclosure of voting system information that were denied due to fears that they might compromise security. The letter provides background information on technology as it relates to policy, including on the issue of how transparency

and disclosure would improve security through better accountability, rather than harming it.

- ACCURATE submitted public comments about the EAC's Voluntary Voting System Guidelines (VVSG). These comments suggest ways to improve the VVSG's framework by adopting a continual updating process and providing a means to use data about voting system experience in actual elections to shape future revisions to the VVSG. To address one of the principal concerns surrounding electronic voting systems—security—the comments recommend adopting a more rigorous security testing framework, including threat assessment, code review, and penetration testing. These comments suggest taking a systems approach to voting technology, viewing not only security but also usability, accessibility, and mechanisms for using data about actual voting experiences as integral to voting system development.
- We undertook a small survey to understand current practices regarding disclosure of electronic ballot definition files. We contacted the 20 largest counties in California and the 20 largest counties in Ohio in advance of the November 2006 elections. Our survey revealed that none of these counties were prepared to disclose this information to the public, motivating our research into an architecture that makes ballot designs public.
- We identified a number of best practices and proposed improvements to current practice. We authored a paper on random selection and transparency in election audits, "The Role of Dice in Election Audits," recommending the use of commonly understood random sources, such as dice, or drawings, as critical to maintaining election integrity. We presented the paper at WOTE 2006, as a result of a successful collaboration between U.C. Berkeley and Stanford. We subsequently worked directly with election officials at several counties in California (Alameda County, Marin County, and Yolo County) to improve the effectiveness and integrity of their random audits.
- We observed and documented election audits at five California counties in the June 2006 primary election and the November 2006 general election. Our observations have informed our research into practical and efficient procedures for auditing elections. We also collaborated on developing specific recommendations for San Mateo County's audit and canvass procedure.
- ACCURATE submitted public comments on the EAC's Voting System Testing and Certification Manual. Taken as a whole, these comments urged the Commission to revise the Manual to provide greater disclosure by the EAC regarding voting system certification (and decertification), more rigorous procedures for hardware and software identification, and greater test lab independence. We submitted comments about specific provisions in the Manual as well as a narrative document that discusses our recommendations in greater detail.

### ***Post-Election Auditing and Analysis***

ACCURATE members participated in analysis of several elections. Post-election audit is an important aspect of the election process, and one of the goals of the center is to help develop technologies that assist in the post-election audit process. This section describes some of the ACCURATE activities related to post-election audit and analysis. An example of the importance of post-election audit is the situation that occurred in the 13<sup>th</sup> Congressional race in Florida in November, 2006 where 18,000 undervotes were discovered after the election. This unusually high number corresponded to 13% of the votes. It may never be possible to discover what actually occurred in that election, but several members of ACCURATE were involved in attempts to discover what went wrong and to rule out certain theories.

- David Wagner is participating, at the request of the State of Florida, in an analysis of the controversial Congressional election in Sarasota County, Florida, in the November 2006 general election. He is a member of a team of computer scientists, led by Florida State University and appointed by the State of Florida that has been charged with conducting an independent analysis of the voting machines used in Sarasota County. Their charter is to determine whether machine failure may have caused or contributed to the undervote in the CD-13 race. The team has been provided with the source code for the voting machines, and will prepare a public report on its findings. Dan Wallach is also working as an expert witness in this investigation, and he testified in court on this subject. In total, Dr. Wallach has served as an expert witness in six different lawsuits in the past year, including one where he collaborated with Douglas Jones on evaluating the quality of the ITA reports as they pertain to security testing.
- Dan Wallach participated in a lawsuit, in Webb County (Laredo), Texas, where he analyzed the election results for anomalies. This work showed how many innocent mistakes, on the part of election officials, can have a substantial effect on the outcome of an election and the importance of engineering election systems to be robust against common mistakes.
- David Dill has been working with Prof. Martha Mahoney of the U. of Miami School of Law and Walter Mebane of the Cornell University Political Science Department to analyze audit logs from Florida voting machines, which can be obtained under Florida's open records laws. This includes audit logs from Sarasota County, where the results of the November 2006 election for Florida Congressional District 13 are still in dispute. Several problems with election administration and machine function have been revealed by this study.
- David Wagner and two ACCURATE Ph.D. students participated in a security review of the Diebold voting system, at the request of the California Secretary of State. Their review of the security of the AccuBasic interpreter discovered numerous security flaws and recommended interim procedural fixes for counties that can be used to mitigate the flaws' severity until Diebold can properly fix the

software. Those recommendations were accepted and adopted by the California Secretary of State.

- Michael Byrne and Dan Walach worked with the county clerk in Jefferson County, TX. She was looking for detailed empirical information on usage of paper ballots vs. DREs, both objective measures (time taken to vote) and subjective measures (voter perception of satisfaction) and whether and how these measures are affected by demographic factors such as age and ethnicity. She intends to use this information to help inform future decisions about deployment and purchasing of voting equipment.
- Douglas Jones is preparing two papers based on assessments of voting machines. The first paper is on the contents of the event log, inspired by an alleged vote fraud case in Holland, for which no data was preserved, and by the massive undervote in House District 13 in Florida, again, where insufficient data was preserved to uncover what had happened. The challenge is to log a sufficient number of events to determine what had happened without violating ballot secrecy. The second paper focuses on the role of parallel testing in the context of remote voting. This was inspired by flaws in the testing of the Internet voting system used in the Dutch elections. We have devised an end-to-end testing methodology that can detect a variety of network based attacks, and curiously, the same testing methodology can also be applied to postal voting.
- Douglas Jones submitted comments to the New York State Board of Elections on draft voting system standards proposed by that board on January 23, 2006, February 24, 2006 and March 15, 2006. He also submitted comments to the Colorado Senate Majority Leader and the Colorado Secretary of State on proposals before the state of Colorado to reduce use of polling places and increase reliance on postal voting, focusing on the consequences of this with regard to ballot security and the accuracy with which ballots are tabulated.
- Douglas Jones was a member of the Long Term Observer Team for the 2005 presidential elections in Kazakhstan for the Office of Democratic Institutions and Human Rights of the Organization for Security and Cooperation in Europe. He was also a member of the Election Assessment Mission for the 2006 parliamentary elections in the Netherlands for the Office of Democratic Institutions and Human Rights of the Organization for Security and Cooperation in Europe.

***Raising Awareness of Security, Testifying at Hearings, and Speaking in the Media***

The ACCURATE center has had tremendous visibility in the media. Our co-PIs have been quoted on the front page of the New York Times, the Washington Post, the USA Today, on CNN, CSPAN, HBO, NPR, Time Magazine, Newsweek and in virtually every major media outlet. We have been the guests on the Diane Rehm Show, The Kojo Nnamdi Show, the Marc Steiner Show, and dozens of other radio programs around the country and the world. We have also served as major figures in several documentary

films about electronic voting and security. ACCURATE co-PIs have given talks, including several keynote addresses, about electronic voting to the ACLU, the League of Woman Voters, and at many other organizations' events. The work of the ACCURATE co-PIs has raised the public awareness to the point where in the last two years, 27 states have passed law requiring paper records of votes. Many other states are considering similar legislation, as is the federal government. Here are some details of specific activities of ACCURATE participants.

- David Wagner testified before the U.S. House of Representatives at a joint hearing of the Committee on Science and Committee on House Administration on electronic voting.
- David Dill, Dan Wallach, Peter Neumann and Avi Rubin testified on voting security issues before the California Senate Elections Committee.
- Douglas Jones testified on voting system standards before the Connecticut Voting Technology Standards Board in Hartford.
- Jack Lerner, Joseph Lorenzo Hall, Matt Zimmerman (Electronic Frontier Foundation) and Lillie Coney (Electronic Privacy Information Center) organized a half-day tutorial at the 2006 Computers, Freedom & Privacy Conference in Washington, DC intended to educate and update congressional staffers and other interested parties about the current state of our elections system. Avi Rubin (ACCURATE Director) gave a keynote presentation outlining the structural defects and technical vulnerabilities that threaten free and fair elections. Two Clinical Interns, Stephen Dang and Galen Hancock, presented their work on how intellectual property claims have been used to frustrate oversight, auditing and security testing of voting systems. The rest of the program covered HAVA implementation, federal and state legislative efforts, litigation overview, technological development and the nexus of voting rights issues and election technology.
- Deirdre K. Mulligan, Peter Neumann and Joseph Lorenzo Hall were asked by then-State Senator Debra Bowen to provide testimony on the potential role of open source software in California's election system. Bowen has since been elected as California Secretary of State and is interested in thinking of ways to compel or motivate the disclosure of voting system source code.
- Several ACCURATE members published an op-ed piece in the Sacramento Bee on the Sunday before Election Day 2006. The piece was positioned in the major paper of the California State Capitol in order to explain our perspective on what voters would encounter that Tuesday. The thesis of the piece was that much of what voters would interact with would be new to them, and that we need to increase the level of scrutiny and rigor of voting system oversight.

- Avi Rubin testified in the Maryland House of Delegates at a hearing of the House Ways and Means committee on a bill to provide voter verified paper ballots in Annapolis. Dr. Rubin also testified at a Board of Public Works hearing chaired by the governor of Maryland about the voting machines used in Maryland.
- Avi Rubin co-authored an op-ed piece with former EAC vice Chair Ray Martinez about the importance of improving voting systems for the 2008 elections and learning from the problems in the 2006 election. The op-ed was originally published in the Baltimore Sun and picked up by many other newspapers.
- Avi Rubin published a mass market book, *Brave New Ballot* (Random House, 2006) about the security of electronic voting systems.
- Douglas Jones, working with Barbara Simons and Andrea Mascher has undertaken an extensive search of the patent literature in order to pin down the origin of the voting technologies currently in use and in order to investigate parallels between the debates surrounding the introduction of mechanical vote counting a century ago and the debates surrounding the introduction of computerized vote counting today's work was undertaken in support of several chapters of a book manuscript currently in preparation.
- Peter Neumann keynoted ACM CCS 2006 and gave an invited Classic Papers talk at the IEEE ACSAC 2006, both of which stressed the importance of considering trustworthiness (particularly of elections) as an overarching holistic system problem.
- Peter Neumann is serving on the ongoing National Research Council study group on Enhancing the Cyber Security Research Agenda, which is in the final stages of completing its report. This report reconsiders the earlier reports, *Computers at Risk* and *Trust in Cyberspace*, and attempts to go beyond them.

## Summary and Future Plans

ACCURATE is grateful to the National Science Foundation for their funding and support of our activities. As this annual report shows, the center has been very active in research, education, and outreach, and the far-reaching impact is apparent to everyone in the elections community. It is our plan to continue our activities on all fronts and to help make our democracy more secure, reliable, usable, auditable and transparent, while advancing the state of the art in computer security, cryptography, systems usability and accessibility, and technology policy.

More information about ACCURATE can be found on our center web site at <http://accurate-voting.org>.

# Appendix A

## Principal Investigators

- **Aviel D. Rubin** (Director) Department of Computer Science , Johns Hopkins University, rubin@cs.jhu.edu: <http://www.cs.jhu.edu/~rubin/>
- **Dan S. Wallach** (Associate Director) Department of Computer Science, Rice University, dwallach@cs.rice.edu: <http://www.cs.rice.edu/~dwallach/>
- **Dan Boneh** Department of Computer Science , Stanford University, dabo@cs.stanford.edu: <http://crypto.stanford.edu/~dabo/>
- **Michael D. Byrne** Department of Psychology, Rice University, byrne@rice.edu: <http://chil.rice.edu/byrne/>
- **David L. Dill** , Department of Computer Science, Stanford University, dill@cs.stanford.edu: <http://verify.stanford.edu/dill/>
- **Douglas W. Jones** Department of Computer Science , University of Iowa, jones@cs.uiowa.edu, <http://www.cs.uiowa.edu/~jones/>
- **Peter G. Neumann** Computer Science Laboratory , SRI International, neumann@csl.sri.com: <http://www.csl.sri.com/users/neumann/neumann.html>
- **Deirdre Mulligan** School of Law , University of California, Berkeley, dmulligan@law.berkeley.edu: <http://law.berkeley.edu/faculty/profiles/facultyProfile.php?facID=1018>
- **David A. Wagner** Department of Computer Science, University of California, Berkeley , daw@cs.berkeley.edu: <http://www.cs.berkeley.edu/~daw/>
- **Brent Waters** Computer Science Laboratory , SRI International, bwaters@csl.sri.com: <http://www.csl.sri.com/users/bwaters/>

# Appendix B

## External Advisory Board

- **Kim Alexander** — Ms. Alexander is president and founder of the California Voter Foundation (CVF), a nonprofit, nonpartisan organization dedicated to advancing the responsible use of technology in the democratic process.
- **Secretary Debra Bowen** — Debra Bowen was elected to be California's 30th Secretary of State on November 7, 2006, making her only the sixth woman elected to a statewide constitutional office since California was admitted to the Union in 1850. Born in Rockford, Illinois, Bowen graduated from Michigan State University in 1976 and earned her law degree from the University of Virginia in 1979. In 1984, she started her own California law firm specializing in small business start-ups, tax law, land use, and environmental issues. Her long history of community activism began in the 1980's when she became involved with her local Neighborhood Watch program. Bowen was elected to represent the 53rd Assembly District in 1992 and served three two-year terms before being elected to represent the 28th Senate District in 1998. Bowen served two four-year terms in the Senate before she was elected as California's Secretary of State.
- **Lillie Coney** — Ms. Coney is Associate Director with the Electronic Privacy Information Center (EPIC). Her issue areas include nanotechnology, surveillance, children's privacy, civil rights and privacy, coalition development, spectrum, census, and electronic voting.
- **David Jefferson** — Dr. Jefferson has been conducting research at the intersection of computers, the Internet, and public elections for over a decade. He is Chair of the California Secretary of State's Voting systems Technical Assessment and Advisory Board, which provides technical advice on the security, privacy, and reliability of voting systems.
- **Doug Kellner** — Mr. Kellner is Co-Chair of the New York State Board of Elections. He has served as one of the ten commissioners of the New York City Board of Elections since 1993. Before he became commissioner, Mr. Kellner

was the election lawyer for the Democratic Party in Manhattan and played major roles in election-related decisions and procedural-drafting in New York City.

- **Sharon Laskowski** — Dr. Sharon Laskowski is a computer scientist in the Information Technology Laboratory of the National Institute of Standards and Technology and manager of the Visualization and Usability Group, which is developing evaluation methods, metrics, and standards for human-computer interaction. She was the lead author of the report “Improving the Usability and Accessibility of Voting Systems and Products” as mandated in the Help America Vote Act (HAVA) of 2002, Public Law 107-252. Dr. Laskowski provides technical and research assistance to the Technical Guidelines Development Committee (TGDC). She leads the effort to develop the usability, accessibility and privacy requirements for the Voluntary Voting System Guidelines.
- **Scott Luebking** — Mr. Luebking is a usability and accessibility expert that has worked closely with California jurisdictions to educate their staff about the importance of usability and accessibility assessment for voting system evaluation and procurement.
- **Freddie Oakley** — Since 1999, Ms. Oakley has served as the Chief Deputy Clerk/Recorder for Yolo County, California. In addition to managing elections, she has implemented a plan to ensure privacy and security of Recorder-maintained documents, worked to incorporate the latest technology into both the Elections and Recorder processes and created a successful Junior Voter Program.
- **Ron Rivest** is a professor of computer science at MIT. He is co- inventor of the famous RSA algorithm, creator of MD5 and one of the world’s most renowned cryptographers. Professor Rivest is a recipient of the ACM Turing Award, the highest prize in computer science. Dr. Rivest is a member of the EAC’s TGDC.
- **Noel Runyan** has over thirty-six years experience with microprocessors, digital logic, analog circuits, speech output, systems architecture, human interface design, and development of access technology for persons with disabilities. He has extensive experience with the development and application of speech and

braille interface technologies and integration of computer systems with speech, braille, and/or large print output. He founded Speech Works in 1983, which was renamed Personal Data Systems in 1985, to develop communications devices for persons with visual impairments. In addition, Mr. Runyan has designed and developed hardware and software for the Audapter speech synthesizer and the Talking Tablet System as well as authored the EasyScan, BuckScan and PicTac scanning programs.

- **Dr. DeForest B. Soaries, Jr.** is the Senior Pastor of the First Baptist Church of Lincoln Gardens in Somerset, New Jersey. Highlights of Dr. Soaries' work include recruiting 265 families to become foster parents to 325 abandoned babies; helping 140 children find adoptive parents; constructing 124 new homes for low and moderate income residents to own; creating the first faith based Cisco Technology Academy in the country; operating the Central New Jersey STRIVE program for job readiness; serving hundreds of youth in an after school center and homework club; forming a youth entrepreneurship program; and redeveloping commercial real estate. Dr. Soaries is also the former Chairman of the United States Election Assistance Commission and was appointed by President George W. Bush on December 15, 2003 after being confirmed by the United States Senate. In February 2003, Dr. Soaries was appointed to be a public director of the Federal Home Loan Bank of New York. He was a member of the affordable housing committee of the bank. From January 12, 1999 to January 15, 2002, Dr. Soaries served as New Jersey's Secretary of State. Dr. Soaries earned a Bachelor of Arts Degree from Fordham University; a Master of Divinity Degree from Princeton Theological Seminary; and a Doctor of Ministry Degree from United Theological Seminary. He has also received six honorary Doctorate degrees from institutions of higher learning.
  
- **Anthony Stevens** — Mr. Stevens is Assistant Secretary of State for New Hampshire, a position he has held since 1994. In this role, he has served as the New Hampshire Coordinator for the Help America Vote Act and Project Manager for the Statewide Voter Registration System. He is also a member of the EAC's Standards Board. Prior to his current position, he was Vice President for Corporate Lending at Citibank and a member of the New Hampshire state legislature for two terms.