



**DRE Analysis for May 2006 Primary
Cuyahoga County, Ohio**

August 2006



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About ESI

Election Science Institute is a non-partisan, non-profit election science organization, which seeks to improve the election process using rigorous science-based approaches done in collaboration with the nation's foremost election science experts.

Our strategy is to bring county election officials and citizens together with expert researchers, engineers and leading technologies to create model election systems that are auditable and transparent. By embedding scientifically-based best practices into local election systems, our democratic ideals are well-served.

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August 15, 2006

Commissioner Jimmy Dimora, President
Commissioner Peter Lawson Jones
Commissioner Timothy F. Hagan
Cuyahoga County Administration Building
1219 Ontario Street, 4th Floor
Cleveland, Ohio 44113

SUBJECT: ANALYSIS OF MAY 2006 PRIMARY ELECTION
CUYAHOGA COUNTY, OHIO

Dear Commissioners:

Enclosed is the analysis of the May 2006 Primary in Cuyahoga County prepared by Election Science Institute. On behalf of the researchers and many others who worked on this report, thank you for your willingness to let us behind the scenes to conduct a thorough review of how the new election system is performing in the early stages of use.

Your openness will certainly result in elections that are ultimately more accurate for the voters of Cuyahoga County. Indeed, the lessons learned through this analysis will be useful to election boards around Ohio and throughout the country. This project is an important step to restoring confidence in the outcome of our elections.

Key findings and recommendations are outlined in the Executive Summary; a detailed account of the research is found in each of the seven sections of the report, with each section corresponding to the research commissioned by Cuyahoga County. As you know, voting machines are only a component within the larger election system. Any assessment of an election system must include an evaluation of administrative procedures, pre-election programming and testing of the voting machines, voter and booth worker interaction, and counting and auditing procedures. We would like to underscore that our findings are based on research of the entire election system. Although the new touch screen election system is vastly different from its predecessor, it is still the case that an election can only be as successful and reliable as the human administration of all the components of the election system.

Also on behalf of the ESI team, I believe it is important to say directly to you that the current election system appears to provide some of its promised benefits at potentially great cost; namely, that the election system, in its entirety, exhibits shortcomings with extremely serious consequences, especially in the event of a close election. These shortcomings merit your urgent attention. Relying on this system in its present state should be viewed as a calculated risk in which the outcome may be an acceptable election but there is a heightened risk of unacceptable cost.

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While the challenges facing Cuyahoga County's election system are considerable—time, resources, and the will to do the difficult work that is needed—ESI remains confident that the most significant constraint for election system improvement is the will to achieve meaningful improvement in the election system. With the cooperation of the voting system vendor, public officials, the public and the media, the serious issues uncovered during this investigation can be addressed employing widely used management science methods and process improvement techniques

As I mentioned when I stood before you in late April, prior to the Primary Election, meaningful improvements can be achieved but are not likely to be complete before the November 2006 or November 2008 general elections.

ESI stands ready to assist you. We are committed to working with you and your community in whatever way necessary to provide the most accurate and transparent elections possible and helping voters understand that an improvement program is in place and its goals will be achieved.

Thank you once more for the opportunity to work with you, and thank you for your leadership.

Sincerely,
ELECTION SCIENCE INSTITUTE

Steven Hertzberg
Project Director

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Analysis of May 2006 Primary Election Cuyahoga County, Ohio

Executive Summary

Background

Following the 2004 General Election in Ohio, Cuyahoga County adopted a new voting system using the Diebold touch-screen voting system. The new system complies with both the new federal election technology standards established under the Help America Vote Act of 2002 (HAVA) and with recently enacted Ohio legislation that requires voting systems to produce a paper ballot that can be verified by the voter. Under Ohio law, this paper ballot (Voter Verified Paper Audit Trail (VVPAT) serves as the official ballot in the event of recount or contested election.

The May 2006 Primary, the first major election using the new system, presented an opportunity to assess the new system's benefits and weaknesses. The Cuyahoga County Board of Commissioners decided that an independent scientific analysis of the Primary election would give elections officials objective feedback on the accuracy, reliability and usability of the new voting system.

In April 2006, the Cuyahoga County Commissioners engaged Election Science Institute (ESI) to study all aspects of the new system during the Primary Election. Voting devices are only a small part of an election system: any thorough assessment of a voting system must include an evaluation of the administrative procedures, pre-election programming and testing of the machines, voter and booth worker interaction, and counting and auditing procedures. Although the touch screen systems are vastly different from optical scan and punch card, it still holds true that an election will be only as successful and reliable as the human administration of all system components.

The project was an important step toward making Ohio a model for sound, transparent implementation of new election technology.

The Scientists

ESI assembled a highly qualified interdisciplinary team of researchers with national credentials and began research immediately.

The team of statisticians, systems engineers, computer scientists and political scientists was able to use the Cuyahoga County Primary Election of May 2006 as a real-time laboratory to examine both the performance of the new Diebold VVPAT-enabled system in an actual election and the administrative procedures involved in deploying the new system.

To conduct a comprehensive and multi-dimensional assessment of the new system, the ESI team carried out an array of discrete, independent projects, each focusing on a different component.

- An exit poll of voters on Election Day was conducted by researchers from the Center for the Study of Elections and Democracy (CSED) and Edison Mitofsky, Inc. The survey asked voters about their experience and their confidence in the new system.
- A survey of booth workers was conducted by experts from The Pollworker Institute, Promark Research, and CSED. The survey probed booth workers about their experience and their opinions about strengths and weaknesses of the new system.
- A review and analysis of Election Day incidents reported by booth workers and command center staff fielding booth worker calls was conducted by scientists from the California Institute of Technology and the University of Utah Public Policy Center.
- A manual count of the VVPAT paper ballots carried out by elections officials from around Ohio and the country, along with statisticians and engineers, endeavored to reconcile the number of actual paper ballots with the results report printed on the VVPAT tape. The manual count project provided an indication of how difficult a formal complete recount would be, if required.
- An analysis of voter wait times and voting machine allocation by systems engineers from Ohio State University and Sagata Ltd. assessed how many voting machines would be required, and what other measures would be needed, to bring delays at polling places down to acceptable levels.
- A comparison of the paper ballot results, the results recorded on the machine memory, official results, and other reports was conducted by social and political scientists, including a principal investigator for the Election Assistance Commission Vote Count and Recount Project.
- A detailed threat analysis conducted by a systems engineer (a senior member of the American Society for Quality), an operations engineer and election officials assessed both the likelihood of particular threats and a standard for the proper functioning of the system.

Summary of Key Findings

Key Finding: After three months of exhaustive research, empirical evidence supports the key definitive finding:
The machines' four sources of vote totals – VVPAT individual ballots, VVPAT summary, election archive, and memory cards – did not agree with one another.

The current election system appears to provide some of its promised benefits at potentially great cost; namely, that the election system, in its entirety, exhibits shortcomings with extremely serious consequences, especially in the event of a close election. These shortcomings merit urgent attention. Relying on this system in its present state should be viewed as a calculated risk in which the outcome may be an acceptable election, but there is a heightened risk of unacceptable cost.

The ESI team arrived at this conclusion only after completing the seven projects described above. This conclusion is supported not only by the findings themselves but also by the difficulty encountered in conducting the projects.

Key findings from each of the research projects are summarized below. Duplicate findings in most cases serve as confirmation of that finding. In some instances, however, the findings from two projects may appear inconsistent for one or more reasons.¹

Election Day Voter Exit Poll Survey

Key Finding: The vast majority of voters surveyed were pleased with their experience with the new system, liked touch screen voting and had confidence that their votes would be recorded correctly.

ESI conducted exit poll interviews with voters from a statistically significant number of polling places on Election Day. The project had two distinct goals: First, it measured the attitudes of voters towards the voting experience and especially their reactions to new voting technology and processes. This study assessed the voting experience from the voters' perspective by surveying them immediately after they left the polling place. Second, it provided an assessment of the conditions voters encountered at the polling place, including the length of the lines, the characteristics of the booth workers, and the organization of the polling place.

- Most voters (about 90% of those surveyed) liked the new system and had confidence their votes would be recorded correctly, although 10% did have problems.
- The vast majority of voters liked touch screen voting.
- More than 95% of older voters and nearly 90% of African-American voters found the new system easier to use than the previous punch card system, although some older voters and African-American voters expressed slightly more concern with the new voting equipment and indicated they had more difficulties with the new machines in general.

Post Election Survey of Booth Workers and Election Day Technicians

Key Finding: Improved training, both practical and procedural, is likely to minimize incidents experienced on Election Day.

To gain perspective on the election system from Election Day workers, ESI spoke with and surveyed Booth Workers and Election Day Technicians shortly after Election Day. Our focus was to understand: (i) how well the new Diebold DRE voting system met voters' needs on Election Day; (ii) if the new Diebold DREs and Optical Scan voting machines functioned as specified on Election Day; (iii) the quantity and types of problems in the field on Election Day; (iv) the ability of the election system to cope with Election Day problems; (v) the capacity to mitigate Election Day problems in a timely manner; (vi) and the adequacy of the training received by Election Day workers to address Election Day challenges.

¹ For example, the percentage of booth workers who reported experiencing problems opening or closing the machines does not correspond to the percentage of incident reports involving opening or closing the voting machine. One reason for this apparent discrepancy: the booth worker survey focused primarily on operation of the voting machines but the incidents reports covered all problems. Another reason: while the Presiding Judge of the precinct would report the incident only once every booth worker, if asked, might report the same incident.

- About one-third of booth workers said they had difficulty setting up the machines and 45% said they had difficulty “closing out” the machines at the end of the day. Specifically, 38% had some difficulty with the printers and/or paper spools.
- 41% of booth workers noticed differences between how they learned to use the machines in training and how the machines operated on election day. A large majority (74%) of that group thought the training and actual procedures were either “a lot different” or “somewhat different” from one another.
- 51% disagreed that the training provided them with enough information to do their job well; 57% disagreed that they had enough hands-on practice with the voting machines.
- 53% of election workers also expressed concern that training on election law and administrative procedures was inadequate.
- About half of the booth workers attempted to call the command center on election day; 35% of those callers were able to speak to someone on the first try.

Polling Place Incident Report Analysis

Key Finding: Incident reports were widespread but concentrated, with 9% of precincts reporting 10 or more incidents. The most commonly reported incidents were voter registration issues (30.1%), election administration issues (22.6%), problems related to voting machines (16.2%) and issues involving booth workers (9.1%).

Booth workers are required to report all polling place “incidents” that might have an impact on the results such as anomalies in the voter check-in process, problems with the voting machine, fleeing voters and other events. ESI reviewed and analyzed both the incident reports provided by booth workers and the log kept by Command Center staff fielding calls from booth workers.

- 88.7% of all precincts reported at least one incident. However, certain precincts had a very high number of incidents. 9% of precincts reported having ten or more incidents and five precincts reported 20 or more incidents.
- Almost one-third (30.1%) of all incidents involved voter registration issues, such as incorrect addresses, misspelled names, or inconsistent signatures.
- 22.6% of reported incidents related to election administration, such as not being able to reach the Board of Elections by telephone, issues with training, steps in the process being skipped (such as not having voters sign the poll book when polls were busy), and lack of supplies.
- 16.2% of incidents involved problems with all voting equipment (i.e. the voting machines, the printing devices or the ballot access cards and encoder devices).
- 9.1% percent of incidents involved the booth workers, usually a worker not showing up. When the relationship between booth worker incidents and other reported incidents was examined more closely, there was a correlation found between the two—for example, a higher rate of machine failure, encoder or access card problems, or printer, administrative, supply, voter, and seal incidents. Such a correspondence strongly suggests that not having a full complement of booth workers at a precinct can lead to other problems at that polling place.

- 8.4% of incidents were voting machine-only-related; more than half of the time because of machine failure. Almost 40% of the time the incident was a machine failure that resulted in the machine being shut down. One-quarter of the incidents were related to memory cards.
- A total of 4.2% of incidents were related to seals on the voting machines, printer canisters, and the bags in which materials were to be returned to the election offices; a small number overall, but problematic if chain of custody becomes an issue.
- Printing incidents were only 3.9% of the total reported, but they have the potential to be pernicious because the paper printout is the official ballot, according to Ohio law.
- Encoders and access cards accounted for 3.9% of incidents reported. Although complete card failures are less than one percent of all reported incidents, they could produce significant problems in polling places depending on their severity and how workers and election judges respond to cards that become stuck in machines, do not work, or come out of a machine².
- Ballot handling incidents were 4% of the total. Reported incidents included voters being sent away because the ballot could not be encoded, failure to have a voter complete the information on a provisional ballot, or voters being given the wrong access card or ballot.

Optimal Voting Machine Allocation Analysis

Key Finding: New strategies for voting machine allocation are needed to minimize voter wait time and distribute it equally across all locations.

Cuyahoga County is currently facing a decision whether to purchase additional voting machines, which is a significant expenditure. To help Cuyahoga County evaluate the need for these additional machines, ESI analyzed current machine allocation.

- Current machine allocation indicates that a potentially perilous strategy is in place. The simulation model shows that even a moderate increase in turnout will likely cause certain polling locations to be overwhelmed unnecessarily.
- Permitting voters to use any machine in a polling location or vote center greatly reduces waiting time.
- Ballots are different lengths based on local issues; that variability causes long waits and might contribute to the appearance of unequal treatment.

² ESI has become aware of encoder battery failure within other jurisdictions utilizing the same equipment. Election officials are advised to check the battery strength prior to each election.

Manual Count of Paper Ballots

Key Finding: VVPAT's were missing, missing information and the tally of the individual ballots did not always match the VVPAT summary printed at the end of Election Day

In order to validate the accuracy of Election Day vote tabulations by the Cuyahoga County BOE Diebold voting system, ESI conducted a manual count of the VVPAT paper ballots. Using a recount fixture that allowed for viewing the tapes without handling them, a team of election officials, booth workers and students tallied the votes for governor on each tape. The paper ballot tallies were initially compared to the results report printed on the VVPAT tapes. When the count did not match the count provided by the results report, the paper ballots were recounted.

- 85% of the VVPAT Ballots and VVPAT Summaries reconciled after the primary manual count, where approximately 15% required a secondary count
- 1.4% of the VVPAT cartridges exhibited missing ballots
- 16.9 % of VVPAT tapes showed a discrepancy of 1 - 5 votes between the tally of ballots and the results report; 2.1 % showed a discrepancy of over 25 votes
- During the manual recount team members discovered 40 VVPAT tapes (9.66%) that were either destroyed, blank, illegible, missing, taped together or otherwise compromised.
- Identifying information on the VVPAT tape such as precinct information and machine identification was inconsistent, as were the summary reports printed at the end of the day. 2.8% of the VVPATs were missing machine ID numbers; 5.4% did not identify the precinct, increasing the difficulty of a meaningful audit and raising questions about the integrity of the vote count.
- VVPATs showed evidence of booth workers using trial and error to print reports and start up or close down the machines; workers apparently attempted to overcome printer problems by shutting down machines, removing and replacing cards, and restarting machines.
- 72% of the labels identifying canisters containing the VVPAT tapes were missing information. 46% of the canister labels were blank.
- Booth workers frequently failed to sign the tapes. Such failures in chain of custody also increase the risk of a legal challenge.

Comparing the Count

Key Finding: Discrepancies were found across vote counts stored on different mediums across the election system

ESI conducted an exhaustive analysis of regular voted ballots from onboard machine memory compared to manual counts of paper ballots, official results, and other interim and election reports. The comparisons revealed a wide range of discrepancies. Some discrepancies may also reflect ESI's errors in processing.

- A lack of inventory controls and gaps in the chain of custody of mission critical assets, such as DRE memory cards, DRE units, and VVPAT cartridges, resulted in a significant amount of missing data. Because of the missing data, ESI is unable to give a definitive opinion of the accuracy of the Diebold TSX system.
- Due to limits in the data, software computational abnormality contributing to the count inaccuracies cannot be ruled out. Computational abnormality could be the result of a failure to adequately test the voting equipment before the election or to manage the various databases appropriately.
- In multi-precinct polling places, voters could vote on machines located in other precincts. Accordingly, ballots from a number of precincts appeared on the same VVPAT tape. VVPAT ballots, however, lack a header identifying the precinct. Without this information, it is not possible to conduct a precinct-level tally of the VVPAT ballots.
- While discrepancies between the VVPAT summaries and VVPAT ballots themselves were relatively small, discrepancies between paper record and the electronic record were considerably larger and more pervasive. For the most part the discrepancies can be characterized as the DRE memory cards and Election Archives registering more votes than were produced by the VVPAT summaries or by hand counts of the VVPAT ballots.
- These conclusions are based on the data ESI was able to obtain from the May 2 election; however, data could not be retrieved for 13 VVPAT summaries, 87 VVPAT cartridges, 53 election archives and 3 DRE memory cards, which were used to tabulate the official vote count.

Election System Functional Threat Analysis

Key Finding: The current election system, if left unchanged, contains significant threats to inventory control of mission critical election assets, error-free vote tabulation, and tabulation transparency. One likely result is diminished public confidence in a close election.

In consultation with a number of experienced election officials, ESI developed a functional threat analysis intended to help guide Cuyahoga in planning for November and beyond. Significant threats include:

- To the extent that the legal ballot is the VVPAT record, operating thousands of voting machines on Election Day offers many opportunities for DRE printer errors to have profound effects on the manual count. Consider that each machine has a printer and potentially multiple rolls of paper. Paper records of votes (the official records) may be lost without voters' awareness because of paper jams, paper not being loaded properly, ink issues, and other problems.
- Lack of a standardized proven manual count process is likely to result in recount error and inefficiency. With no proven VVPAT manual count process or counting aids in place, the BOE may produce inaccurate or unexplainable results that might be witnessed directly by the media, election law attorneys and activist groups and are likely to impact opinion about the fairness and accuracy of an election.
- Too few working DREs in a specific vote center result in long lines and people not staying to vote. High turnouts, long ballots and (to a lesser extent) machine breakdowns make the chance of at least one vote center with very long lines a virtual certainty. With a sensible allocation, it still can be impossible to predict which center will have the incidents.

- Inconsistent DRE programming can cause glitches in electronic count. Any issue that leads to unreliable consolidation of data is serious because thousands of votes could be lost or shifted by accident in the electronic count.
- Inconsistent DRE closedown procedures affect the manual count. Variability in how machines are closed down at the polling place on Election Day could lead to unreliable paper records, which would prevent a reliable manual count.
- The lack of memory card security can cause incidents. Considering that the memory cards used are fairly standard and the encryption efforts are questionable, straightforward issues with card security (lost, stolen, or substituted) are conceivable.
- Effective database management is crucial. Without direct observation of the data consolidation and electronic counting process and/or interviews with relevant personnel, ESI can only speculate about causes and issues in data management. Moreover, checks and balances of the data consolidation process can be designed to improve detectability.

Summary of Key Recommendations

Prepare a multi-year election improvement plan, with specific performance goals for each statewide election.

- **Following a more thorough analysis of the election and research provided by ESI, refine and develop the functional threat analysis to determine priorities for the 2006 General Election and beyond.** The functional threat analysis can assist the Cuyahoga election officials in determining the priorities for the General Election and afterwards.
- **Extensive new booth worker training, expert procedural oversight and a procedural overhaul are recommended to address the risks to transparency posed by the new equipment and changing election requirements.** Booth worker training should focus on proper recording of information and handling of seals and locks, the treatment of equipment memory cards and the handling of printers providing a voting paper trail. Other issues relate to the voter registration file and appropriate ballot styles for voters. These and other challenges pose threats to a reliable voting process, as described in depth in the full report. It would be beneficial to examine the processes, procedures, and training related to the many issues examined and threats identified.
- The vast majority of precincts had few incidents reported, but certain precincts had a very high number of incidents reported. **It is recommended that precincts with many incident reports be subjected to a thorough audit.**

Revise booth worker training to address documented errors in opening and closing of the DRE voting devices and printout of the VVPAT ballots.

- Most booth workers liked the new system, but about one-third had difficulties operating the new equipment. Difficulties were most frequently reported with opening and closing procedures. Booth worker concerns about the quality and amount of training surfaced in response to several survey questions. **Booth worker proficiency required for smooth operation of the new system requires substantially improved training.**
- The training process used in the May primary election should be thoroughly reviewed to reduce the threat of malfunctions in future elections. **Include hands-on testing involving VVPAT printer machines and failure resolution in training. Use test rating results for allocation of workers such that at least one highly rated worker is at every location.**
- Inconsistencies in training and instructional ambiguities resulted in substantial differences between precincts in what identification voters were asked to show. **To ensure uniform implementation of new ID requirements, the instructions to booth workers must be clear and consistent in booth worker materials and training.**

Modify election processes to address documented problems in the chain of custody of mission critical election assets: memory cards, VVPAT Cartridges, and DRE voting devices. Develop, test and implement appropriate inventory control procedures.

- In order to be able to reconstruct the events of , the procedures for opening and closing machines and processing voters must be consistent. The data gathered by ESI in the course of the manual recount suggested a lack of consistency, which hindered auditability. This inconsistency is especially prominent in how booth workers complied or failed to comply with established policies. **ESI recommends that the BOE take strong measures to improve consistent application of policies and procedures associated with the creating and handling of memory cards and VVPATs.**

Work with voting system vendor to establish procedures that will ensure audibility of the election process, specifically to allow for a reliable comparison of the paper ballot and electronic count.

- **The BOE should work with the voting system vendor immediately to develop a machine-level auditing capability** that will make it simple and transparent to compare electronic and paper ballot data, and to thus identify the specific anomalies associated with specific machines.
- The attempt to count VVPAT ballot revealed multiple problems with the DRE printers. The VVPAT printer, whether resulting from human or machine error, will likely continue to present a significant liability in the elections process. And because the printer is necessary to create the official ballot, such a risk is deeply problematic. Some of these issues can be mitigated with improved booth worker training and greater familiarity with the machine on the part of the booth worker **ESI strongly recommends that the Board of Elections develop contingency strategies to ensure that printer issues don not prevent a manual count of paper ballots.**

Develop accounting procedures and report formats that will allow for a thorough post-election audit.

- The myriad difficulties ESI encountered and the extensive effort required to reconcile the paper ballot count and the electronic record make it difficult to forecast a reasonable limit on the levels of time and effort required for a comprehensive, thorough post-election audit. **The BOE needs to determine what information must be collected on Election Night and in the post-Election period and work backwards to develop the procedures necessary to ensure that information will be consistent and available.**

Develop and practice a meaningful manual recount process.

- The “recount fixture” should be developed and further refined for extensive use in a count of the VVPAT ballots. **To ensure the audit process works prior to the November General Election, ESI recommends that the BOE conduct a practice audit.**

In order to mitigate the probability of long wait times across many vote centers, the current approach for allocating voting machines on should be replaced with the SAG Method utilized by ESI in this report.

- More machines, alone, will not reduce waiting time to vote. In some instances, there are significant differences in ballot length between precincts, and it will take those voters longer to comprehend the ballot and cast their votes. **By conducting voting tests in a wide variety of districts before the election, machines could be allocated more precisely.**
- Ideally, it would be desirable to have machines on stand-by for speedy allocation to polling locations where long lines develop.

Biographies of the Study Team Members

Project Director

Steven Hertzberg, ESI's founder, is an Aerospace Engineer who spent his early career working as a civilian within the US Department of Defense. However, Steven successfully transitioned into a serial entrepreneur, participating in successful ventures in the automotive accessories, industrial food equipment, information technology, television and direct marketing industries. Mr. Hertzberg formed ESI shortly after the 2000 Presidential election in an effort to develop his concept of the Public Service Intermediary (PSI).

Project Team

Theodore T. Allen is an associate professor of industrial and systems engineering at the Ohio State University in Columbus. He received his PhD in industrial and operations engineering at the University of Michigan in Ann Arbor. He is a senior member of the American Society for Quality and an associate editor of the Journal of Manufacturing Systems. He has over 30 refereed publications related to design of experiments and six sigma systems improvement including a Springer textbook. Also, he is a partner in Sagata Ltd, whose work on elections is supported by the Election Science Institute.

R. Michael Alvarez, professor, Caltech, is one of the principal investigators for the Caltech/MIT Voting Technology Project, and is regarded as an international expert on elections, voter behavior, election administration, voting technology and political methodology. He has published three books and scores of peer-reviewed articles on these subjects, and is currently working on a new book on the electronic voting controversy (with Thad E. Hall).

Mikhail Bernshteyn is a founding partner of Sagata Ltd, which is a software and consulting company. He is also the director of its Canadian branch in Montreal. He received his PhD in industrial and systems engineering at the Ohio State University. He has published several articles in top tier journals in applied statistics and continues multidisciplinary research applying operations research and statistics.

Howard B. Christensen, PhD (statistics), accepted appointment as Asst. Prof. at Brigham Young University in 1967 and did a sabbatical at the Statistical Research Division, Bureau of the Census, 1974-1975. He has taught sampling courses at BYU from 1967 to present and developed and modified the sampling design for the Utah Colleges Exit Poll, a statewide exit poll in Utah. This sample survey has been conducted every even year since 1982. He also developed an off-year exit poll for Salt Lake City Mayor's race, 2003 and for a Utah Primary in 2006. He has consulted on numerous other sample survey projects. His research interests have been survey sampling, nonparametrics, and statistical education and he has written two introductory statistics books published by Houghton Mifflin, and Saunders/Harcourt Brace Jovanovich.

Thad E. Hall, assistant professor, University of Utah, is the principal investigator for the Election Assistance Commission's Vote Count and Recount Project. He has written several reports, articles, and a book on election administration and voting technology.

William Hertzberg of Intellectual Property Development (IPD) Consultancy designed and developed the Manual Count fixture that was utilized to handle the VVPAT. IPD Consultancy is a small product commercialization consultancy which specializes in facilitating the "Product Program" from ideation through market acceptance. IPD researches, plans, and implements both the technical development and market development process for consumer and industrial products. Services include such work scopes as technology/market assessments, product planning documentation, product presentation documentation, and sourcing prospective licensees or joint-venture partnerships and affiliation. IPD offers consulting services to operating companies as well as individual inventors.

Jonathan N. Katz, professor, Caltech, is a principal investigator for the Caltech/MIT Voting Technology Project, and is a recognized expert in the areas of electoral behavior and political methodology. He has published widely on these topics in the academic literature, and is a much-sought expert for questions about redistricting, election administration, and electoral law.

D. Roderick Kiewiet, professor, Caltech, has written four books on elections, congress and public policy, and authored numerous articles on voting behavior, congressional elections, legislative politics, Russian politics, ethnic politics in California, state and local government, public school finance, and American political history.

Joe Lenski is co-founder and Executive Vice President of Edison Media Research. With Edison Media Research, Joe oversees hundreds of media research projects each year in the United States, Canada, Europe and the Middle East. Under his supervision Edison Media Research currently conducts all exit polls and election projections in the United States for the six major news organizations - ABC, CBS, CNN, Fox, NBC and the Associated Press. Joe's experience with political exit polling began with the CBS Election & Survey Unit for the 1988 U.S. Presidential election and includes being involved in every major exit poll conducted in the United States in the last 18 years as well as organizing an extensive exit poll of 125 parliamentary districts in the Azerbaijan election in 2005. Joe is also a member of the Executive Council of the New York Chapter of the American Association of Public Opinion Research.

Corrie Lynn, ESI's Project Coordinator, has been involved in the independent public relations, marketing and training industry for over 11 years. She has produced a wide range of media, automotive, sales training and consumer programs across the US.

Warren Mitofsky, Mitofsky International's president, started and directed Voter Research & Surveys from 1990 to 1993, which was the election consortium of the four major television networks, ABC, CBS, CNN and NBC. It is now known as Voter News Service (VNS). From 1967 to 1990, Mitofsky was executive director of the CBS News election and survey unit, and was an executive producer of its election night broadcasts. He conducted the first exit polls for CBS in 1967, and developed the projection and analysis system used successfully by CBS and Voter News Service. He started the CBS News/New York Times Poll in 1975 and directed it for CBS for its first 15 years.

Quin Monson is Assistant Professor of Political Science and Assistant Director of the Center for the Study of Elections and Democracy at Brigham Young University. His PhD is from Ohio State University. His research and teaching are in public opinion; campaigns, elections, and voting behavior; survey research methods; and religion and politics. He co-directs the Utah Colleges Exit Poll with Kelly Patterson. He is the co-editor of *Dancing Without Partners: How Candidates, Parties, and Interest Groups Interact in the Presidential Campaign* (Rowman and Littlefield, 2007), *Electing Congress: New Rules for an Old Game* (Prentice Hall, 2007), and *The Last Hurrah? Soft Money and Issue Advocacy in the 2002 Congressional Elections* (Brookings Institution Press, 2004). His research has also appeared in *Political Research Quarterly*, *Political Analysis*, *Presidential Studies Quarterly*, and the *Journal for the Scientific Study of Religion*.

Kelly Patterson is associate professor of political Science at Brigham Young University. He is director of the Center for the Study of Elections and Democracy. He teaches and does research on campaigns and elections.

Douglas A Samuelson D Sc has over 30 years of experience in statistics, operations research, regulation and enforcement, litigation support, and decision and policy analysis. He has been a Federal policy analyst, a successful high-tech inventor, entrepreneur and executive, and a university faculty member. Currently he is President of InfoLogix, Inc., a research and consulting firm in Annandale, Virginia. He has a D.Sc. in operations research from The George Washington University.

Gary Smith has been the Chairman Board of Elections/Director in Forsyth County, Georgia since 2002. Gary has been instrumental in implementing the Diebold DRE voting system across Georgia, and now has 3 years of experience with the system. Gary is also a member of the Georgia Elections Task Force and the HAVA State Planning Committee, and resides on the Georgia Election Officials Association Legislative Committee and is an Executive Board member of the Voter Registrars Association of Georgia. Mr. Smith led the manual count operations.

Tracy Warren, of The Pollworker Institute, has more than 15 years of experience in public policy, with a focus on good government, campaigns and elections and constitutional issues. She was Director for the Constitution Project's Election Reform Initiative, housed at Georgetown University, and currently serves as Executive Director for The Pollworker Institute, a nonpartisan, non-profit organization dedicated to improving booth worker recruitment, training and retention. Since 2002, Warren has worked as a consultant on election reform and implementation of the Help America Vote Act for the U.S. Election Assistance Commission, the International Foundation for Election Systems, the Pew Charitable Trusts and the District of Columbia, among others. Her articles on election issues have appeared in *Campaigns and Elections*, *Elections Today* and *The National Voter*.

Dan Williams is an instructor of Statistics at Brigham Young University and operates DEW-It Research, a statistical consulting and questionnaire design firm, where he consult with various survey research companies, data collection companies, educational entities, and other organizations to design research projects, write survey instruments, design samples, and organize and analyze collected data.

