A Preliminary Assessment of the Reliability of Existing Voting Equipment

The Caltech/MIT Voting Project
Version 1: February 1, 2001

R. Michael Alvarez, Associate Professor of Political Science, Caltech
Stephen Ansolabehere, Professor of Political Science, MIT
Erik Antonsson, Professor of Mechanical Engineering, Caltech
Jehoshua Bruck, Professor of Computation and Neural Systems and Electrical Engineering, Caltech
Stephen Graves, Abraham Siegel Professor of Management and Director of Leaders for Manufacturing, MIT
Nicholas Negroponte, Professor of Media Technology, MIT
Thomas Palfrey, Professor of Economics and Political Science, Caltech
Ron Rivest, E. S. Webster Professor of Computer Science and Engineering, MIT
Charles Stewart, Professor of Political Science, MIT

We are grateful to the Carnegie Corporation for its generous sponsorship of this project. As additional data becomes available, this report will be updated. For additional information contact the Caltech Media Relations Office (626) 395-3227 or the MIT News Office (617) 253-2700, or via email: *voting@hss.caltech.edu*.

Abstract

This is a preliminary report on the Caltech/MIT Voting Project's study of the effect of voting technologies on unmarked and spoiled ballots. The five voting technologies studied are paper ballots with hand-marked vote, lever machines, punch cards, optical scanning devices, and direct recording electronic devices (DREs), which are similar to automatic teller machines. The study focuses on so-called "under-votes" and "over-votes" which are combined into a group of uncounted ballots we call residual votes. These include ballots with votes for more than one candidate, no vote, or that are marked in a way that is uncountable.

Careful statistical analysis shows that there are systematic differences across these technologies, and that paper ballots, optical scanning devices and lever machines have significantly lower residual voting rates than punch card systems and DREs. Overall, the residual vote rate for the first three systems averages about 2 percent, and for the last two systems averages about 3 percent.

This study is the most extensive analysis ever of the effects of voting technology on under- and over-votes. The study covers the entire country for all presidential elections since 1988, and examines variations at the county level. When the study is complete, it will encompass presidential elections going back to 1980, and will examine a finer breakdown of the different technologies, and a breakdown of residual votes into its two components: over- and under-votes. This report will be updated later to include this additional analysis.

The analysis is complicated by the fact that voting systems vary from county to county and across time. When a voting system is switched, say from lever machines to DREs, the number of residual votes can go up for many reasons, including voter unfamiliarity with the new apparatus. In particular, electronic voting technology is in its infancy and has considerable room for improvement. It seems the most likely one to benefit significantly from new innovations and increased voter familiarity.

A Preliminary Assessment of the Reliability of Existing Voting Equipment

The Caltech/MIT Voting Project[1]

Version 1: February 1, 2001[2]

American elections are conducted using a hodge-podge of different voting technologies: paper ballots, lever machines, punch cards, optically scanned ballots, and electronic machines. And the technologies we use change frequently. Over the last two decades, counties have moved away from paper ballots and lever machines and toward optically scanned ballots and electronic machines. The changes have not occurred from a concerted initiative, but from local experimentation. Some local governments have even opted to go back to the older methods of paper and levers.

The lack of uniform voting technologies in the US is in many ways frustrating and confusing. But to engineers and social scientists, this is an opportunity. The wide range of different voting machinery employed in the US allows us to gauge the reliability of existing voting technologies. In this report, we examine the relative reliability of different machines by examining how changes in technologies within localities over time explain changes in the incidence of ballots that are spoiled, uncounted, or unmarked – or in the lingo of the day the incidence of "over" and "under votes." If existing technology does not affect the ability or willingness of voters to register preferences, then incidence of over and under votes will be unrelated to what sort of machine is used in a county.

We have collected data on election returns and machine types from approximately two-thirds of the 3,155 counties in the United States over four presidential elections, 1988, 1992, 1996, and 2000. The substantial variation in machine types, the large number of observations, and our focus on presidential elections allows us to hold constant many factors that might also affect election returns.

The central finding of this investigation is that manually counted paper ballots have the lowest average incidence of spoiled, uncounted, and unmarked ballots, followed closely

[1] The Caltech/MIT Voting Project is a joint venture of the two institutions. The Caltech/MIT Voting Project is a joint venture of the two institutions. Faculty involved are R. Michael Alvarez (Associate Professor of Political Science, Caltech), Stephen Ansolabehere (Professor of Political Science, MIT), Erik Antonsson (Professor of Mechanical Engineering, Caltech), Jehoshua Bruck (Professor of Computation and Neural Systems and Electrical Engineering, Caltech), Stephen Graves (Abraham Siegel Professor of Management and Director of Leaders for Manufacturing, MIT), Nicholas Negroponte (Professor of Media Technology, MIT), Thomas Palfrey (Professor of Economics and Political Science, Caltech), Ron Rivest (E. S. Webster Professor of Computer Science and Engineering, MIT), and Charles Stewart (Professor of Political Science, MIT). The principal author of this version of the report is Stephen Ansolabehere. We are grateful to the Carnegie Corporation for its generous sponsorship of this project.

[2] As additional data becomes available, this report will be updated.

by lever machines and optically scanned ballots. Punchcard methods and systems using direct recording electronic devices (DREs) had significantly higher average rates of spoiled, uncounted, and unmarked ballots than any of the other systems. The difference in reliabilities between the best and worst systems is approximately 1.5 percent of all ballots cast.

We do not attempt to isolate, in this report, the reasons for differential reliability rates, though we offer some observations on this matter in the conclusions. Our aim is measurement of the first order effects of machine types on the incidence of votes counted. This is, to our knowledge, the first attempt to assess reliabilities of voting technologies as they are used in the field nation wide.

Machine Types and their Usage

We contrast the performance of five main classes of technologies used in the US today. The technologies differ according to the way votes are cast and counted.

The oldest technology is the paper ballot. To cast a vote, a person makes a mark next to the name of the preferred candidates or referendum options and, then, puts the ballot in a box.[3] Paper ballots are counted manually. Paper ballots enjoyed a near universal status in the US in the 19th Century; they remain widely used today in rural areas.

At the end of the 19th Century, mechanical lever machines were introduced in New York state, and by 1930 every major metropolitan area had adopted lever machinery. The lever machine consists of a steel booth that the voter steps into. A card in the booth lists the names of the candidates, parties, or referenda options, and below each option is a switch. Voters flick the switch of their preferred options for each office or referendum. When they wish to make no further changes, they pull a large lever, which registers their votes on a counter located on the back of the machine. At the end of the voting day, the election precinct workers record the tallies from each of the machines. Lever machines automate both the casting of votes and the counting of votes through mechanical devices.

Punch card machines automated the counting process using the computer technology of the 1960s. Upon entering the polling place the voter is given a paper ballot in the form of a long piece of heavy stock paper. The paper has columns of small, perforated rectangles (or chads). There are two variants of the punch card – one, the DataVote, lists the names of the candidates on the card; the other (VotoMatic) does not. In the booth (for VotoMatics), the voter inserts the card into a slot and opens a booklet that lists the candidates for a given office. The voter uses a metal punch to punch out the rectangle beside the candidate of choice. The voter then turns the page, which lists the options for the next office and shifts the card to the next column of rectangles. When finished, the voter removes the card and puts it in the ballot box. At the end of the day, the election

[3] How we mark ballots has changed over time. In the middle of the 20th Century, many states required that the voter cross out the options not chosen. See for example, The Book of the States, 1948.

workers put the cards into a sorter that counts the number of perforations next to each candidate.

Optically scanned ballots, also known as "marksense" or "bubble" ballots, offer another method for automating the counting of paper ballots. The form of the optically scanned ballot is familiar to anyone who has taken a standardized test. The voter is given a paper ballot that lists the names of the candidates and the options for referenda, and next to each choice is small circle or an arrow with a gap between the fletching and the point. The voter darkens in the bubble next to the preferred option for each office or referendum, or draws a straight line connecting the two parts of the arrow. The ballot is placed in a box, and, at the end of the day, counted using an optical scanner. Some versions of this technology allow the voter to scan the ballot at the polling place to make sure that he or she voted as intended.

Direct recording electronic devices, DREs for short, are electronic versions of the lever machines. In appearance, they resemble ATM machines. Most use touch-sensitive screens. Upon entering the booth, the voter touches the name on the screen to register his or her preference and, typically, the voter may review the entire session (or ballot) to check the vote. Like lever machines it is not possible to vote twice for the same office. The computer tallies the votes and sends them to a central location.

Each type of technology involves many variations based on specifications of manufacturers, ballot formats, and implementation. Our focus is on the five main types of machines, as we hope to learn which mode of voting looks most promising. In almost all states county election officials decide which machinery to use, so counties are, almost everywhere, the appropriate unit of analysis. Some counties do not have uniform voting technologies. In these, municipalities and sometimes individual precincts use different methods. These counties are called Mixed Systems. They occur most commonly Massachusetts, Michigan, Maine, New Hampshire, and Vermont, where town governments usually administer elections.

We examine the variation in usage across counties and over time. Our data on voting equipment come from the Election Data Services and from state and county election officials. We are in the process of reconstructing which towns used which machine types in mixed-system counties.

The data do not distinguish centrally counted and precinct counting of ballots. Some states provide information about which administrative units count the ballots for some machine types. Precinct and central counting of optically scanned ballots became quite controversial in the Florida 2000 election.

Table 1 displays the wide variation in machines used in the 2000 election. The last column reports the percent of the population covered by each type of technology in the 2000 election. One in five voters use the "old" technologies of paper and levers – 1.3 percent paper and 17.8 percent levers. One in three voters use punch cards – 31 percent of the VotoMatic variety and 3.5 percent of the DataVote variety. Over one in four use

optically scanned ballots. One in ten use electronic devices. The remaining 8 percent use mixed systems.

As impressive and dramatic have been the changes in technology over time. The third column reports the percent of the 2000 electorate that would have used each machine type had the counties kept the technologies they used in 1980. The data are pretty clear: out with the old and in with the new. Optically scanned ballots and DREs have grown from a combined 3.2 percent of the population covered to 38.2 percent of the population covered. There has been little change in the mixed and punch card systems. Paper ballots have fallen from 9.7 percent of all people in 1980 to just 1.3 percent in 2000. Lever machines, by far the dominant mode of voting in 1980, covered 43.9 percent of the electorate. Today, only 17.8 percent of people reside in counties using lever machines.

A somewhat different distribution of voting technology across counties holds, owing to the very different population sizes of counties. Punch cards and electronic devices tend to be used in more populous counties, and paper ballots tend to be used in counties with smaller populations.

Table 1

Usage of Voting Equipment in the 1980 and 2000 Elections

	Percent of Counties Using Technology		Percent of 2000 Population Covered by Technology	
	1980	2000	1980	2000
Paper Ballots	40.4	12.5	9.8	1.3
Lever Machines	36.4	14.7	43.9	17.8
Punch Card				
"VotoMatic"	17.0	17.5	30.0	30.9
"DataVote"	2.1	1.7	2.7	3.5
Optically scanned	0.8	40.2	9.8	27.5
Electronic (DRE)	0.2	8.9	2.3	10.7
Mixed	3.0	4.4	10.4	8.1

The shift in technology deserves some comment. The impetus comes in no small part from technological changes throughout the society. Punch card, optically scanned, and electronic methods all involve computer technology, and these modes now dominate voting. Election officials also benefit from automating the voting, especially the counting process, in order to reduce costs and speed up reporting. To the extent that there has been a concerted effort to improve voting equipment in the United States it has come from an initiative begun in the early 1970s to use computers in voting. An influential 1975 report sponsored by the General Accounting Office and subsequent reports by the Federal

Elections Commission laid the foundation for methods of certification and served as a focal point for the organization of election directors. These reports called for increased computerization of voting equipment and systems, among other recommendations.

Residual Votes: A Yardstick for Reliability

Our measure of reliability is the fraction of total ballots cast for which no presidential preference was counted. We call this the "residual vote."

A ballot may show no presidential vote for one of three reasons. Voters may choose more than one candidate – commonly called an over vote or spoiled ballot. They may mark their ballot in a way that is uncountable. Or, they may have no preference. The latter two possibilities produce under votes or blank ballots. The residual vote is not a pure measure of voter error or of machine failure, as it reflects to some extent no preference. Consequently we prefer the term residual vote instead of error rate or uncounted vote.

The residual vote does provide an appropriate yardstick for the comparison of machine types, even though it is not purely a measure of machine error or voting mistakes. If voting equipment has no effect on the ability of voters to express their preferences, then the residual vote should be unrelated to machine types. To measure such effects, we estimate the average residual vote associated with each machine type, and we assess whether these averages differ significant across machine type. Averaging guards against idiosyncratic results, and measures what we expect to happen in a typical case.[4]

In our data, the residual vote in the average county equaled 2.6 percent. In other words, in the typical US county from 1988 to 2000 2.6 percent of ballots casts did not register a presidential preference, for whatever reason. Because county populations vary dramatically, this does not equal the fraction of people who cast an under or over vote for president in these years. This figure is somewhat smaller: 2.1 percent of people who cast ballots did not register a presidential preference. There is considerable variation around this average. Our aim in this report is to assess whether machine types explain a statistically noticeable amount of the variation around this national average residual vote.

We examine the residual vote instead of just the over vote because technology can enable or interfere with voting in many ways. Some technologies seem to be particularly prone to over voting, such as the punch card systems implemented in Florida in the 2000 election. Lever machines and DREs do not permit over voting voting. Some technologies may be prone to accidental under votes. Lever machines either lock out a second vote or register no vote when the person switches two levers for the same office. Also, paper ballot are sometimes hard to count owing to the many ways that people mark

[4] Some analyses focus on extreme cases – under and over votes in specific elections in particular counties. Indeed, much of the analysis of Florida falls into this category. Such case studies can be misleading, especially if they reflect outcomes peculiar to a locale, or a local machine failure. Another advantage of averaging is that it washes out the effects of typographical errors, which are inevitable in data, even official government reports.

their ballots. Finally, some technologies might intimidate or confuse voters. Many Americans are unaccustomed to using an ATM or similar electronic devices with key pads or touch screens, and as a result DREs might produce more under voting. Also, it may be the case that we react differently to paper than to machines. We are trained in school to answer all of the questions as best as possible, especially on standardized tests similar to the format used for optically scanned voting. Improper installation or wear and tear on machines may lead to high rates of under voting. In Hawaii in 1998, 7 of the 361 optical scanners failed to operate properly.

In depth study of particular states and of contested elections may provide insight into the components of the residual vote or more specific problems related to voting equipment. A number of papers published on the internet examine the effects of machine types on over votes and on under votes separately for the Florida 2000 election.[5]

One important caveat is in order in this analysis. There are errors that we cannot count. There is no way to measure whether voters accidentally cast ballots for the wrong candidate. And, we know of no statistically acceptable measures of fraud. Residual votes provide the best available measure of the extent to which technology enables or interferes with the ability of voters to express their preferences.

Many other factors may explain under and over voting beside machine types. Other prominent offices on the ballot, such as senator or governor, might attract people to the polls who have no intention to vote for president. A large turnout might make it difficult for election administrators to tend to voter education at the polls. Demographic characteristics of the county's electorate might explain the incidence of people prone to make mistakes. The wealth of the county might account for expenditures on election administration. New machinery might produce elevated levels of voter confusion, simply because people make mistakes more with unfamiliar tasks.

We examine county-level election returns for President and total ballots cast in the 1988, 1992, 1996, and 2000 elections. The data cover approximately 2200 counties, though not for all years. As with the voting equipment data, our data on elections returns come primarily from the Election Data Services, though some come from the relevant election commissions of particular states. The large number of observations produces high levels of precision in estimating average residual vote rates associated with each machine type. Studies of one election in one state may not have yield sufficiently large samples to determine whether there are significant differences across voting equipment.

We examine the presidential vote in order to hold constant the choices voters face. Within each state one might also examine residual votes in Senate and governor races, with the caveat that these offices have higher "no preference" and thus higher residual votes.

[5] The site http://www.bestbookmarks.com/election/#links provides a list of many studies with links; there are similar sites. The papers are not products of or endorsed by the CalTech/MIT Voting Project.

To hold constant the many factors that operate at the county level, we exploit the natural experiment that occurs when locales change machinery. We measure how much change in the residual vote occurs when a county changes from one technology to another. The average of such changes for each technology type provides a fairly accurate estimate of the effect of the technology on residual voting, because the many other factors operating at the county level (such as demographic characteristics) change relatively slowly over the brief time span of this study.

To guard against other confounding factors, we also control for contemporaneous Senate and gubernatorial races on the ballot, total turnout, and year of the election.

Results

A simple table captures the principle results of this investigation. Table 2 presents the average residual vote rate for each type of voting equipment. The first column of numbers is the average; the second column is the margin of error associated with this estimate; the third column is the median residual vote rate; and the final column is the number of observations (counties and years) on which the estimate is based. The average is the arithmetic mean residual vote across counties. The median is the residual vote such that half of all counties have lower values and half of all counties have higher values. A lower median than mean reflects skew in the distribution of the residual vote produced by a few cases with exceptionally high rates of under and over votes. These averages do not control for other factors, but they reveal a pattern that generally holds up to statistical scrutiny.

Two clusters of technologies appear in the means and medians. Paper ballots, lever machines, and optically scanned ballots have the lowest average and median residual vote rates. Indeed, lever machines appear to be the best, followed by paper, and then by optically scanned ballots. The average residual voting rates of these technologies are significantly lower than the average residual voting rates of punch card and electronic voting equipment. The differences among punch card methods and electronic voting equipment are not statistically significant. Punch cards and electronic machines register residual voting rates for president of approximately 3 percent of all ballots cast. Paper ballots, lever machines, and optically scanned ballots produce residual voting rates of approximately 2 percent of all ballots cast, a statistically significant difference of fully one percent. Or to put the matter different, the residual voting rate of punch card methods and electronic devices is 50 percent higher than the residual voting rate of manually counted paper ballots, lever machines, and optically scanned ballots. This pattern implies that simply changing voting equipment, without any additional improvements, could lower the incidence of under and over voting substantially.

Table 2

Average Residual Vote By Machine Type
In US Counties, 1988-2000 Presidential Elections

	Residual Vote			
Machine Type	Average	Margin of Error (a)	Median	N
Paper Ballot	2.0	+/- 0.14	1.9	1,020
Lever Machine	1.6	+/- 0.10	1.3	1,072
Punch Card				
"VotoMatic"	2.9	+/- 0.09	2.5	1,462
"DataVote"	3.2	+/- 0.33	2.3	296
Optically scanned	2.3	+/- 0.19	1.6	958
Electronic (DRE)	3.0	+/- 0.17	3.1	294
Mixed	2.1	+/- 0.23	1.7	322

(a) This is the 95 percent confidence interval for the estimated effect; the half-width of the confidence interval equals 1.96 s/vn, where s is the estimated standard deviation of the residual vote rate for each machine type.

Of course many other factors might explain the observed pattern, including features of the counties and specific elections. In order to hold these other factors constant we performed a multiple regression of changes in the residual voting rate at the county level on changes in the machine used at the county level, controlling for the year of the election, whether there was a switch in technology in a specific year in a given county, and the total vote in the county. This approach removes the effects of all factors that distinguish the counties, changes in turnout levels within counties, and some features of the election in the state.

In essence, our statistical approach is that of a "natural experiment." We observe how residual votes change within counties for changes in machine technologies. The figures in Table 1 suggest that there have been substantial and frequent changes in technology. Between 1988 and 2000, over half of all counties changed their voting technology. The effect of specific technologies on residual votes is expressed relative to a baseline technology, and the observed effects contrast the change in residual vote associated with a specific technology compared to a baseline technology. We chose lever machines to serve as this baseline for the contrasts. In other words, the statistical method used here allows us to measure the extent to which a specific technology is an improvement compared to lever machines.

Table 3 reports the observed difference between lever machines and other machine types, along with the "margin of error" (95 percent confidence interval) associated with the observed differences. The complete regression analyses are available upon request. Positive numbers mean that the technology in question has higher average residual vote than lever machines and negative numbers mean that the technology in question has lower average residual vote than lever machines. The wider the margin of error, the less certainty we have about the observed difference. A margin of error in excess of the actual effect means that the observed effect could have arisen by chance.

Table 3 presents results from two separate analyses. One analysis, presented in the first two columns, contains all valid cases. A second analysis, presented in the last two columns, trims the data of extreme cases. To guard against outliers and typographical errors, we omit the cases with lowest 5 percent of residual vote and highest 5 percent of residual vote. We omit counties with Mixed Systems.

Table 3

Which is Best?
Residual Vote Attributable to Machine Type Relative to Lever Machines
US Counties, 1988-2000 Presidential Elections

	All Counties		Excluding Extremes	
Machine Contrast	Estimated Difference In % RV	Margin of Error (a)	Estimated Difference In % RV	Margin of Error
Paper Ballot v. Levers	-0.70	+/- 0.53	-0.01	+/- 0.30
Punch Card "VotoMatic" v. Levers	1.13	+/- 0.52	0.83	+/- 0.29
"DataVote" v. Levers	1.95	+/- 0.80	1.35	+/- 0.44
Optically scanned ballots v. Levers	0.20	+/- 0.44	-0.01	+/- 0.28
Electronic (DRE) v. Levers	1.23	+/- 0.39	0.94	+/- 0.25

(a) This is the 95 percent confidence interval for the estimated effect; the half-width of the confidence interval equals 1.96 s/vn, where s is the estimated standard error of the estimated coefficient for each machine type.

Table 3 bears out the same pattern as Table 2. After introducing considerable statistical controls, two clusters of technologies appear in Table 3. Paper, optically scanned ballots, and lever machines appear to perform noticeably better than punch card methods and Electronic devices. Paper might even be an improvement over lever machines.

First consider the contrast between Paper and Levers. The analysis encompassing all counties produces an estimated effect of paper ballots relative to lever machines of -0.7. Compared to lever machines, paper ballots produce an improvement in the residual vote of 7-tenths of a percent of total ballots cast. This effect is larger than the margin of error of .53, so the effect is unlikely to have arisen by chance. Omitting extreme cases, the evident advantage of paper ballots vanishes. The effect becomes statistically insignificant and the magnitude is tiny.

In both analyses, the difference between optically scanned ballots and lever machines is quite small and statistically insignificant. Levers and paper and scanned ballots appear to offer similar rates of reliability, at least as it is measured using the residual vote.

Punch card methods produced much higher rates of residual voting.

Compared to lever machines, the VotoMatic variety of punch cards produced fully one-percentage point higher residual vote rate. In our examination of all cases, the effect is slightly above one-percentage point; excluding the extreme cases, the effect is slightly below one-percentage point.

Compared to Lever Machines, the DataVote variety of punch cards produced a nearly two-percentage point higher residual vote rate. Excluding the extreme cases, the effect is 1.35 percent of total ballots cast. The DataVote method seems to have the lowest reliability of all methods contrasted. This is surprising because much of the controversy in Florida focused on the VotoMatics, and proponents of DataVote have argued that that method is superior.

Electronic machines performed as badly as the punch cards. Compared to lever machines, the Direct Recording Electronic devices produced a 1.23 percentage point higher residual vote rate. In other words, a county that switches from Levers to DREs can expect a significant rise in residual votes of approximately one and one-quarter percent of total ballots cast. From our perspective this was the most surprising result, because neither sort of machine permits over voting. This effect is entirely due to a significant rise in under voting attributable to electronic devices.

Conclusions

Paper ballots, lever machines, and optically scanned ballots produce lower residual vote rates on the order of one to two percent of all ballots cast over punch card and electronic methods over the last four presidential elections.

Lever machines serve as a useful baseline: they were the most commonly used machines in the 1980s, the starting point of our analysis. The incidence of over and under votes with Lever machines is approximately two percent of all ballots cast. The incidence of such residual votes with punch card methods and electronic devices is forty to seventy percent higher than the incidence of residual votes with the other technologies.

We have not analyzed why these differences in residual votes arise. We believe that they reflect how people relate to the technologies, more than actual machine failures. State and federal voting machine certification tolerate very low machine failure rates: no more than 1 in 250,000 ballots for federal certification and no more than 1 in 1,000,000 ballots in some states. Certification serves as an important screen: machines that produce failure rates higher than these tolerance levels are not certified or used. We believe that human factors drive much of the "error" in voting, because the observed differences in residual voting rates that are attributable to machine types are on the order of 1 to 2 out of 100 ballots cast. Given the stringent testing standards for machinery in use, these differences are unlikely to arise from mechanical failures.

We have also not examined many details about the implementation of the machinery, such as manufacturer or precinct versus central counting of ballots or specific ballot layouts. We are in the process of collecting data to address this issue and other issues related to implementation and election administration.

A final caveat to our findings is that they reflect technologies currently in use. Innovations may lead to improvements in reliability rates. In particular, electronic voting technology is in its infancy during the period we are studying, and has the greatest room for improvement. It seems the most likely technology to benefit significantly from new innovations and increased voter familiarity.

In the wake of the 2000 election, many state and local governments are reconsidering their choices of and standards for voting equipment. Many manufacturers are seeking to develop or improve machinery. This report identifies a performance standard in practice – an average residual vote not in excess of 2 percent of total ballots cast. We also wish to call attention to the excellent performance of the optically scanned ballots, the best performing of the newer methods, and especially to the older methods of voting – lever machines and paper ballots.