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Computer Scientists and Political Scientists Seek to Create a Fiasco-Free Election Day

In the wake of 2000, researchers focus on the touchy technology of voting

By FLORENCE OLSEN

Katherine Harris isn't the only one red-faced about November's election turmoil in Florida. David Baltimore, president of the California Institute of Technology, says that Americans are embarrassed by technology failures, and that academic institutions must "help repair the voting process so that we won't see anything like this again."

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In December, Mr. Baltimore offered Caltech's brainpower to help fix the nation's voting-technology problems. Joining him in the offer was Charles M. Vest, president of the Massachusetts Institute of Technology. "A nation that can send a man to the moon and put a reliable A.T.M. machine on every corner has no excuse," he said. The presidents pledged that their researchers would produce a voting machine that would be reliable, affordable, and easy to use.

Since then, a team of political-science and engineering professors at the two institutions has been studying voting technology. Part of what they have found is not so much a well-defined engineering problem as the sum of many administrative shortcomings in precinct polling, absentee voting, and voter registration; many election officials agree. The scholars have also thought about how technology can provide solutions to a range of election-related problems.

Four months into the Caltech/M.I.T. project, the researchers have completed a preliminary analysis of voting-system technologies used in the past four presidential elections. It is arguably the most extensive study ever made of voting systems' reliability and of how well various technologies help or hinder voters in expressing their preferences.

The study examined hand-counted paper ballots, which are used in some rural counties, and mechanical lever machines,

which are used in many places but are no longer manufactured. The researchers were surprised to find that direct electronic recording, the most high-tech voting technology in use today, has produced just as many spoiled, unmarked, or uncounted ballots as the mechanical punch-card machines.

Election Day 2000 provided academics with a rare opportunity to play visible roles in a tense political drama and its aftermath. Computer-science professors, political scientists, and college presidents got involved as lawyers sought their opinions in affidavits, commissions asked for their testimony in hearings, and public officials appointed them to lead committees. But none garnered more attention than the presidents of M.I.T. and Caltech, who promised that their researchers would tackle the voting-technology problems brought to light by the disastrous performance of Florida's punch-card machines.

The team of Caltech and M.I.T. researchers is full of inventive and analytical minds, with a wide range of experience. Stephen Ansolabehere, a professor of political science at M.I.T., is the principal author of the voting-technologies report. He is also the M.I.T. project manager for the 11-member research team, which includes seven M.I.T. faculty members.

Thomas R. Palfrey, a professor of economics and political science, is Mr. Ansolabehere's counterpart at Caltech, where four faculty members work on the voting project. "If we were lawyers, it would be called pro bono work," he says.

The team also includes Nicholas Negroponte, a professor of media technology at M.I.T., and Jehoshua Bruck, a professor of computation, neural systems, and electrical engineering at Caltech.

"It's unusual for social scientists to work with engineers," says Mr. Ansolabehere, whose necktie and white shirt contrast sharply with the black T-shirt and black pants worn by Ted Selker, an associate professor of media and arts technology at M.I.T. When Mr. Selker was at the International Business Machines Corporation, he directed the research group that designed the "eraser-tip" joystick that is built into the keyboard of the I.B.M. ThinkPad. "I'm an inventor," he says, "and I always wanted to be a professor."

The initial hope was that the researchers would, if nothing else, produce a reliable voting machine. Election officials say the makers of voting systems have put too little money into research to improve existing voting technologies, much less develop new ones. The manufacturers currently produce only three types of machines -- punch card, optical scan, and direct electronic recording, or D.R.E. If the engineering brains at Caltech and M.I.T. could invent a better voting machine, says Paul W. Craft. Florida's chief of election svstems. "it would be

useful to Florida; it would be useful to the nation."

D.R.E. machines are programmable computers with touch-sensitive screens or keypads that a voter presses to cast a ballot. Election officials like them because they count votes quickly and eliminate the expense of printing ballots. But studies also show that people need more time to vote when they use D.R.E. compared with other methods.

In November 2000, only about 9 percent of the nation's counties, comprising little more than 10 percent of the electorate, used D.R.E. systems. But their use is expected to increase as more counties try to modernize their voting equipment in the aftermath of the electoral confusion. Ms. Harris, Florida's secretary of state, has proposed that the state spend $200-million to develop its own D.R.E. system for use in 2004.

Public opinion increasingly favors voting on computers and even on the Internet. Election officials feel pressure to invest millions of dollars in computerized and networked voting systems. A survey by the Pew Research Center for the People and the Press shows that more than 40 percent of Americans aged 18 to 29 would prefer voting over the Internet; it is an age group comfortable with computers and computer networks. But the Caltech/M.I.T. team, along with other computer scientists in academe, say their research raises concerns that those systems are still far from being user-friendly, and that they could, in fact, produce an entirely different and equally thorny election crisis.

Voting by secret ballot on computers and the Internet poses unique privacy and data-security problems. No solutions are in sight, but computer scientists find such challenges appealing, says Rebecca Mercuri, a visiting lecturer in computer science at Bryn Mawr College. "We like problems like that, that we can't figure out solutions to."

Ms. Mercuri attracted a lot of attention after the election because of the arguments in her dissertation in computer and information science at the University of Pennsylvania -- "Electronic Vote Tabulation: Checks and Balances" -- which she defended in October, two weeks before Election Day.

The manufacturers, she says, claim but cannot prove that their computerized systems protect both the secrecy and the integrity of votes. System logs can show whether a computer has been tampered with -- but those same logs also can be used to identify how individual citizens voted.

"It's very, very difficult to maintain system security, maintain system logs, and provide the voter with the secret ballot as

required," says Mr. Craft, the Florida election-systems chief. He agrees with most of what Ms. Mercuri writes, with one exception. "She seems to be saying you shouldn't use computers to conduct elections, and I don't agree with that."

Some academics maintain that state agencies responsible for elections rely too heavily on the manufacturers of electronic-voting systems for assurances that their equipment will count every vote accurately. One of those critics is Douglas W. Jones, an associate professor of computer science at the University of Iowa, who is chairman of the Iowa Board of Examiners for Voting Machines and Electronic Voting Systems. Mr. Jones, who testified on voting irregularities in January before the U.S. Civil Rights Commission in Tallahassee, Fla., calls for greater scrutiny of voting systems by the Federal Election Commission and state-election officials.

Voting machines approved for use in many states are "utterly unacceptable," he says, "and are only approved because the agencies that regulate voting machines in those states are fundamentally naive about the vulnerabilities of the technologies they have chosen." For example, he notes, many states have approved the use of D.R.E. systems without requiring an examination of the software embedded in the machines.

Ms. Mercuri favors having the Commerce Department's National Institute of Standards and Technology certify the accuracy and integrity of any computer-based voting system used in federal elections. States would permit counties to purchase only certified systems.

The analysis done by M.I.T. and Caltech avoids the issue of fraud and focuses instead on equipment failures and poorly designed systems. The researchers suspect user-unfriendly voting machines in general as the primary reason that voters spoil their ballots by voting for more than one presidential candidate, or that some ballots register no vote at all for president.

In analyzing the performance of voting machines in the past four presidential elections, the group found an uncomfortably high problem rate -- what they called the residual voting rate -- for punch-card voting machines.

Based on data from about two-thirds of all counties, the rate averaged 3 percent for ballots cast with punch-card systems.

But the researchers were equally disconcerted to see the same problem rate showing up for electronic machines. The average rate for the other voting technologies -- paper ballots, lever machines, and optically scanned ballots -- was 2 percent.

"Just as with punch cards," says M.I.T.'s Mr. Ansolabehere, "we see a potential for catastrophe with electronic machines."

In February, faculty members on the Caltech/M.I.T. team published their preliminary data. Ms. Mercuri says the statistics confirmed what she and other computer scientists "had believed in our gut": that old-fashioned lever machines and paper ballots are the most accurate and easily understood voting technologies in use today. "People are laughing and calling me a Luddite," she says, "and here Caltech and M.I.T. come out with the same thing!"

Both of the older technologies, she says, have safeguards that are lacking in punch-card machines and touch-screen D.R.E. voting systems: Should a hand recount of votes become necessary, paper ballots make it easy. Votes cast on lever machines can't be recounted, but the machines can be inspected by opening them up to see, for instance, whether a gear has slipped or been tampered with. If problems are discovered, the counting errors are usually limited to only one or a few machines, she says. But a programming error in the D.R.E. software that creates ballots or counts votes affects not just one but every machine in the county. If a recount is needed, there are no paper ballots to serve as backups.

"The machines have [failed] and do fail," says Ms. Mercuri, who serves as an election official in Mercer County, N.J. On Election Day 2000, for example, a few major-party candidates received no votes at all in some New Jersey jurisdictions that were using new D.R.E. equipment. When election officials there raised questions, she says, the manufacturer maintained that no votes had been lost -- the explanation, it said, was that "no votes were cast for those candidates."

Computer experts have known for some time about programming problems with computerized vote-counting systems, says Lance J. Hoffman, a professor of computer science at George Washington University. "I very much fear the disappearing electrons," he says.

Indeed, the Caltech/M.I.T. study confirms several government and academic studies, one of which warned that relying on computerized vote-tabulating systems that are lacking in adequate safeguards would be comparable to "waiting for Chernobyl."

The original mandate for the project was to come up with a reliable machine, one that would count every vote accurately and reduce the risk of machine malfunction or fraud. In the first phase of the project, says Mr. Ansolabehere, the Caltech and M.I.T. researchers have chosen to take on "a whole bunch of little nagging problems that could be solved with little technological innovations," like making county voter-

technological innovations," like making county voter registration files accessible online in precinct polling places, and giving election administrators a simple spreadsheet tool for developing budgets to pay for voting-equipment upgrades.

"We're really at the stage of developing ideas for public consumption," he says. One of biggest contributions of the Caltech/M.I.T. project to the public debate, he believes, will be its collection and analysis of data on the cost to counties of running elections.

"Nobody knows the administrative costs associated with the different kinds of voting machinery," he says. "Punch cards are supposed to be cheap. They're not." And D.R.E. machines cost $3,500 to $4,000 each, a price that must be brought down, he says.

Election officials tend to buy expensive voting systems and hang onto them for 60 years, creating a large, outdated inventory. Only recently did Election Systems and Software Inc., of Omaha, one of the largest companies in the business, announce that it would begin leasing its equipment. That's a promising development, Mr. Ansolabehere says. "The business end of things is changing very quickly."

The research phase of the Caltech/M.I.T. project, financed by the universities and by a $250,000 grant from the Carnegie Corporation of New York, will end in June.

The universities will then distribute their research reports, as well as any useful software they develop, through organizations including the National Association of State Election Directors.

What is to happen in the next phase of the project, when the engineers will get their turn, is still uncertain. "When we went into this, we were hopeful that electronic machines would be a good platform," says Caltech's Mr. Palfrey. But the group has found programming flaws in D.R.E. systems, along with characteristics that they don't like. For instance, people often read a computer screen by moving their finger across the text. But if they do that on a touch screen, the first name they touch may get recorded as a vote and be hard to change, says Mr. Ansolabehere. As a result, he says, "the voter gets frustrated, cancels the session, and walks out."

The group's study, he adds, shows that voters did well using anything tactile, like paper ballots or lever machines. "People didn't do very well with anything that had to do with computers."

The Caltech and M.I.T. engineers may try to create a prototype for a new voting machine, or even several prototypes. Developing the prototypes could take up to two years.

Probably none of the new systems would be an updated version of the simple lever machine, although the engineers have toyed with that idea. In the Media Lab at M.I.T., Mr. Ansolabehere says "they have a [900-pound] lever machine that they're trying to make electronic -- without electrocuting anybody."

The engineers might also try to improve upon optical scanners for hand-marked ballots, which he says are one of the best-performing voting technologies in the study. "One of the ideas we're playing with is an electronic machine with a paper interface," he adds.

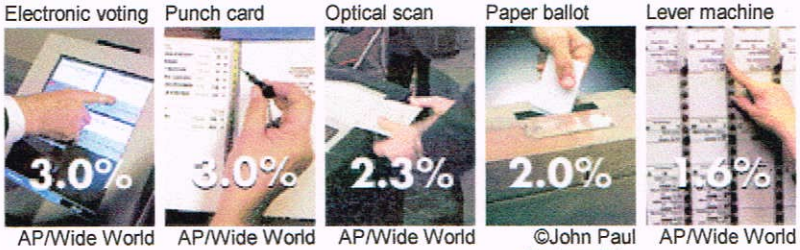
Given the interest of many election officials in D.R.E. voting equipment, the Caltech/M.I.T. group is keen to determine how those machines could be made easy for voters to use, cheap for manufacturers to build, and reliable for election officials to work with -- meaning that they record, count, and report votes accurately.

The group will seek to answer a basic question about electronic machines: Do they have inherent flaws that make them forever unreliable as voting systems? Or does the current, immature technology have the potential to improve over time? After all, Mr. Ansolabehere notes, D.R.E. electronic voting machines have some good features: Ballots can be programmed in many languages, and blind people, using earphones, can vote on electronic systems.

Mr. Selker, the invention-minded professor at M.I.T., wants to build a flawless voting machine. "The exciting thing for me," he says, "would be to make a system that makes it very difficult for the naysayers to say that a cheaper, more reliable system isn't possible."

How Fallible Are Voting Methods?

Researchers at the California and Massachusetts Institutes of Technology analyzed the votes cast for president in two-thirds of the nation's counties in the past four presidential elections to see which types of voting machines produced the highest average percentage of spoiled, uncounted, or unmarked ballots. Here's what they found:



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Source: Caltech/M.I.T. Voting Project

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