Lost Votes in Florida's 2006 Election

An Investigation into Excessive Undervotes on the iVotronics in the Attorney General's Race

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by

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1. UNDERVOTE SPIKES ON THE IVOTRONICS

Six years after Florida's 2000 election debacle, a failure of the state's electoral system in the November 2006 general election once again made national headlines. In Sarasota County, more than 18,000 ballots did not record a vote in the Congressional District 13 race, where only 369 votes separated the candidates. While the media focused on the sensational Jennings-Buchanan race, little attention was paid to much higher undervote rates in the attorney general's race in neighboring counties, perhaps because the outcome of the race did not seem in doubt.

Undervote rates on the ES&S iVotronics—a direct recording electronic (DRE) voting machine—in the attorney general's race in three counties—Charlotte, Sumter, and Lee—were astronomical. In Charlotte and Sumter, one in four ballots cast on the iVotronics did not contain a vote for the second most important office in state government. In Lee County, one in five ballots on the iVotronics did not register a vote in the race. These rates were *seven to eight times* the statewide median undervote rate in this race, which stood at just over 3 percent. In contrast, undervote rates on paper absentee ballots in all three counties hovered around 3 percent, in line with Florida's other counties.

The astronomical rates might have escaped public attention altogether if one of the counties—Charlotte—had not been a part of CD-13. Once the high rates came to light, they were quickly dismissed as attributable to poor ballot design, even though the ballot was unremarkable and the magnitude of the undervote far exceeded the effects of the worst designs in history—the butterfly ballot, for instance.

Still, this was only part of the story. In January, the state published its usual overvote and undervote report on the election—mandated by the legislature since the problems of 2000 and 2002.[1] This report looks at undervotes and overvotes in the top two races on the ballot by voting system and by county in order to evaluate the performance of the state's certified voting systems and election procedures. The idea is to identify and address problems immediately in order to avoid another repeat of Florida's embarrassing 2000 mess.

The state report did not explicitly state that the iVotronics did not perform as well as other systems, but that fact was easily deduced from the data presented in the report and the accompanying tables. In both races examined in the report—the U.S. Senate and Governor's races—the summary rates on the iVotronics far exceeded those of any other equipment in use in Florida. In the Senate race, the undervote rate on the iVotronics was a whopping 123 percent higher on the iVotronics than on the Diebold optical scanners, the voting system used in 32 of Florida's 67 counties. The iVotronic undervote rate also did not compare well with the state's other DRE (direct recording electronics) voting system, the Sequoia Edge. The iVotronic rate was 22 percent higher than the rate for the Sequoia DRE. In the governor's race, the numbers were similar, with the iVotronics having a 65 percent higher undervote rate than the Diebold optical scanners and a 19 percent higher rate than the Sequoia machines.

[1] See Florida Department of Sate, *Analysis and Report of Overvotes and Undervotes for the 2006 Election*, January 31, 2007.

When we discovered this disparity, we began to investigate further. What we found was surprising. The summary rates given in the state's report obscured the real problem—extraordinarily high rates in a few counties. Overall, most of the iVotronic counties had rates similar to those using other types of equipment, but undervote spikes in one or two counties drove up the summary percentages. These undervote spikes were excessive by three measures: (1) they were vastly higher than those experienced in other counties; (2) they were vastly higher than those experienced in other top-of-the-ballot races in the same county; and (3) they were much higher than those on absentee ballots in the same race in the same county. [2]

Our investigation relating to that report provided the impetus for this more in-depth examination of the undervote problem on the iVotronics. It was clear to us from our previous research that the problems in CD-13 and the attorney general's race were not about ballot design—they were the most visible and extreme examples of a voting system that had failed in top-of-the-ballot races throughout the state. Undervote spikes occurred only on the iVotronics—no other voting system had these spectacular failures.

Undervotes are a measure of an election's success. By any standard, a 20 or 25 percent undervote in a top-of-the-ballot race indicates a massive failure of the electoral process and a colossal disenfranchisement of voters. In this paper, we do not seek to prove that large numbers of votes were lost on the iVotronics in Florida's 2006 general election—that is amply demonstrated by the data. Instead we would like to determine exactly what role the voting system played in losing votes.

2. HASN'T THE UNDERVOTE PROBLEM BEEN EXPLAINED?

Many people believe that the undervotes in the 2006 election have been explained as the result of poor ballot design. This is emphatically not true. Florida Fair Elections Center is the first entity to undertake a comprehensive examination of the undervotes in this election. No other individual or group—public or private—to our knowledge has examined the data for all these counties. Investigations and explanations to date have generally been confined to Sarasota's CD-13 race, although a few have alluded to the problems in the other counties. Any valid explanation of the undervotes, however, must explain the even greater undervote rates in the attorney general's race—not just Sarasota's CD-13.

Neither the recount nor the state audit of CD-13 produced much useful information about the cause of the undervotes. A recount on an iVotronic is necessarily futile so we did not expect to learn anything from it. The state's so-called audit was likewise unlikely to produce much reliable information as its construction was seriously flawed and the state had a strong interest in finding no problems that could not be assigned to voter choice or error. As expected, the conclusion was that the machines performed well,

[2] See Garber, *Lost Votes in Florida's 2006 General Election*, for a more in-depth discussion of undervotes statewide on the iVotronics.

even though this was clearly not so. There was no effort to find out what in fact did happen.[3]

By contrast, the report by the FSU scientists tasked by the state with examining the iVotronic software (SAIT report)[4] does provide much useful information, even though it does not reach any satisfactory conclusion due to scope limitations, incorrect assumptions, and information withheld by the state, the vendor, and the county.

Unfortunately, the perception by the public, and indeed many experts, is that the matter has been resolved by the SAIT report—that the scientists found no problems with the software. This is untrue, however. The FSU computer scientists found many vulnerabilities, some of which they declined to discuss because of the vendor's proscriptions against revealing proprietary information. They did conclude that these vulnerabilities did not cause the undervotes, but the limitations on the study's scope make this finding inconclusive as it only covers a small portion of the possibilities. For one thing, the scientists did not examine the hardware at all, nor the other software in the iVotronics.[5]

Finally, none of the reports listed above have investigated thoroughly the machine problems that occurred in these counties and their possible relationship to the undervotes.

3. SMOOTHING FILTERS AND SWEATSHOPS IN MANILA

In the months following the November 2006 election, most researchers were unaware of an important fact: that ES&S had warned its Florida customers in August 2006 of a slow response problem with its 12-inch iVotronics that was allegedly due to a smoothing filter "issue." The letter said that several customers had complained about the slow response problem. After receiving machines for evaluation in its headquarters in Omaha, it had been able to reproduce the problem. Because the problem occurred only after the introduction of the new 8.0.1.2 firmware, the company concluded that it was due to the addition of a smoothing filter in this new firmware.

The problem, the letter said, would mean that voters would need to hold down their selections longer than normal for them to be highlighted. It further said that this problem was confined to the 12-inch iVotronics, that it didn't happen on every machine, and that it didn't happen in every instance on any particular machine.

The company said that the problem would require a firmware change that would have to be certified. They said they planned to do so before the November election but

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[3] Florida Department of State, *Audit Report of Election systems and Software Inc.'s IVotronic Voting System in the 2006 General Election for Sarasota County, FL,* February 2007.
[4] Yasinsac et al., *Software Review and Security Analysis of the ES&S iVotronic 8.0.1.2Vvoting Machine Firmware,* February 23, 2007.
[5] For a discussion of the SAIT report's limitations and suggestions for further forensic investigation see Dill and Wallach, *Stones Unturned*, April 13, 2007.

recommended that their customers take some specific ameliorative actions for their upcoming September primary. These included educating their poll workers about the problem and placing a poster (that was included with the letter) in each polling booth to remind voters to hold down their selections until highlighted.

This letter was sent to the supervisor of elections of every Florida county using the 12-inch iVotronics as well as to David Drury, the head of the Bureau of Voting System Certification. Yet when attorneys requested the vendor's correspondence in connection with both the partisan and nonpartisan lawsuits, neither the supervisor of elections, the vendor, nor the state of Florida provided this important piece of evidence about machine failures. The FSU computer scientists were not given the letter during their investigations. The existence of the letter was not widely known until it was discovered on an election integrity website in March 2007. The letter reignited and reinvigorated calls for answers about the cause of the excessive undervotes and cast doubt on whether the state of Florida had made a good faith effort to investigate the problem. The vendor denied that the problem could have caused the undervote problem, but it was clearly relevant to the investigation of machine malfunctions.

Yet another bombshell came in the summer of 2007. Again, it did not come from the official investigators, but from the media. "The Trouble with Touch Screens," a documentary aired on *Dan Rather Reports*, revealed that the iVotronics used in Florida were produced in a sweatshop in Manila, under deplorable conditions, with little or no quality control or performance testing, by workers making less than $3 a day. The documentary revealed the fact that all the screens on all these machines were quietly replaced in late 2003 and early 2004 because they were defective. The machines made in tropical Manila and sent to hurricane-prone south Florida had not been designed to withstand heat and humidity! As a consequence, the screens began failing at an escalating rate. These failures usually began with a loss of calibration.

This shocking revelation changed our entire approach to this investigation. While it reinforced our belief that machine failures likely caused the extraordinary undervotes, it put these failures in an entirely different context. Far from being a convergence of numerous, unrelated failures, the problems experienced in the 2006 election are what would be expected from aging, substandard equipment. When electronic components are assembled under these kinds of conditions, who knows what problems might occur now or in the future? While the hallmark of good quality control is uniformity of performance over an extended period, the consequence of poor quality control is variable performance and a short lifecycle.

The revelations also redirected our efforts. We began to look more carefully at how the machines had been maintained since their acquisition and what components had been replaced. *We asked ourselves if the replacement of numerous components might have had adverse effects on machine performance through hardware/software conflicts, particularly given the coincidence of the undervote problem with the use of the new firmware.* We also examined more carefully the performance of the screens themselves.

4. APPROACH, PURPOSE, AND SOURCES

4.1 Approach and Purpose.

In this report, we will present the findings of our research into the high undervote rates in the attorney general's race in three counties—Charlotte, Lee, and Sumter.[6] We will compare what we find in those counties with the abundant information available on the Sarasota CD-13 race. Finally, we will look at the same data from Martin County, which has the same voting equipment and a similar ballot and yet did not have excessively high undervotes, to see if we can isolate the relevant differences.

We have chosen to investigate the attorney general's race because it offers a number of advantages for research:

(1) It has the worst undervote rates by far of any race in Florida's 2006 election;

(2) We can conclusively establish a normal undervote for the race, thus eliminating arguments about voter disgust and other extraneous issues; and

(3) We have several sources of information since a number of counties had excessively high undervotes in the race.

Overall, it allows us the best chance of figuring out why the iVotronics lost votes in this election.

Our most in-depth research has focused on Charlotte County. Located just south of Sarasota, it encompassed both the CD-13 race, in which it had low undervote rates, and the highest undervote rates in any race in the state in the attorney general's race. Thus, it seemed the natural choice. So the data and analysis provided in this report concentrates mostly on Charlotte and then presents the corresponding evidence from Lee and Sumter.

As we neared the end of our investigation, we realized belatedly that we really needed to compare what happened in these high undervote counties to the experience of a county using 12" iVotronics that did not experience undervote spikes in 2006. This would help us to determine the relevant differences that resulted in much lower undervote rates. With only two counties to choose from—Martin and Collier—we selected Martin because of its relatively small size and proximity to our offices.

[6] Two other counties—Miami-Dade and Broward—had excessive undervotes in the attorney general's race; however, we have decided not to include them in this paper for several reasons: (1) both counties have rates that are less than half those of the three counties being studied; (2) both counties have a history of election problems and high undervotes, (3) Miami-Dade had high undervotes on its absentees as well as its iVotronic ballots, suggesting that its problems may be somewhat different from those in the other counties; (4) both counties have 15" iVotronics rather than the 12" in use in the other counties so they are not completely comparable in terms of their voting systems, and finally, (5) the two counties are so enormous that even the most perfunctory review of their records would require an effort beyond that of our meager resources.

We want to note that this report does not cover the Sarasota CD-13 race in any depth. For a comprehensive analysis of that race, we direct readers to our report *Vanished Votes* available from our website www.floridafairelections.org.

4.2 Sources

For the purposes of this study, we requested, accumulated, and examined extensive election records from each of the subject counties. While Florida has a very broad public records law that mandates access to most election records, compliance is not always swift, complete, or cheap. For a more in-depth discussion of sources and methodology, see Appendix A to this report.

5. SUMMARY OF FINDINGS

Our research on undervote spikes on the iVotronics in the 2006 election made it clear to us from the beginning of this project that the machines were the likely culprit in this election fiasco. Still, it wasn't until near the end of our work that we understood with any clarity exactly how the machines could have contributed to these excessive spikes in undervotes. The problem was to determine not only how machine malfunction might drive undervotes, but how it would be directed to affect only one race on the ballot and how that race might be different in different counties.

We had a sharp learning curve for this project. We discovered that no one was an expert on these machines. The extreme secrecy demanded by the vendor, and enforced by the state, meant that no one really understood even the basics about how the machines worked and, consequently, how they failed. We found no one could or would answer such questions as: Do the machines run on batteries or AC power? Where is the smoothing filter located—in the firmware or the touch screen controller? Are the touch screen controllers really off-the-shelf components or are they specially designed to work in the iVotronics? How could the slow response problem be experienced intermittently and randomly if it were really the result of a smoothing filter problem? Why do the PEBs contain a microprocessor? Why do all these components need batteries?

We quickly determined that these aging iVotronics were assailed by a number of machine failures that seemed likely to affect undervotes—screen malfunctions and power supply-related problems were rampant. But why and how did they affect only one race? Then we learned that the power problems and the screen problems were really the same—that is, that power supply failures were experienced by voters and poll workers as screen problems. In fact, all problems were observed by their effect on the screens.

In the midst of our research, we were aided by a fortuitous circumstance—the airing of Dan Rather Reports, "The Trouble with Touch Screens." The revelations of this documentary changed everything. We learned for the first time that Florida's iVotronics were produced without even the most basic quality control standards under deplorable conditions in a Manila sweatshop by workers making less than $3 a day. It was a shock to find out that the screens on all the Florida' iVotronics were quietly replaced in late 2003 and early 2004 because they were never designed to withstand the heat and humidity of Manila or southwest Florida.

We then accelerated our investigation of the screens themselves. We discovered that the original screen failures involved loss of calibration. We further found that calibration was most difficult at the margins of the screen—just where the ballots had placed the attorney general's race and the CD-13 race. The effects of loss of calibration would make the machine seem less responsive to the voters—that is, they would have a difficult time getting their selections to take. We also found that screens can have problems in specific areas of the screen and not others.

But it wasn't until we inspected records in Martin County, an iVotronics county without an undervote spike, that we were able to put it altogether. We realized that it was possible that the smoothing filter issue was actually a distraction—that if the problem experienced by voters was with the screens, if it affected only iVotronics with 12" screens, and if the screens had historically been a problem, then maybe the issue was the screens, not the smoothing filter.

In fact, only a screen problem could explain why the undervotes became excessive when the problem race was located at the margins where calibration problems are most severe. As we learned about the machines, we began to realize that power supply problems, failing power inverters, IRDA board upgrades, and frayed video cables and defective video boards were all ultimately screen problems. We also realized that both before and after the election all the counties replaced numerous screens and assemblies. In contrast, no one mentioned the smoothing filter after the election or attempted to address it.

What we found in Martin County was quite a surprise. They seemed to have experienced all the same problems with screen responsiveness as in Charlotte, Lee, and Sumter. Much to our surprise, we found that these problems also seemed to be associated with higher, although not excessive, undervote rates in the Chief Financial Officer's race. Unlike Charlotte, Lee, Sumter, and Sarasota, Martin's problem race was not in the margins; it was located in the center of the page. And it also seemed that CFO undervotes were paired with undervotes in the Commissioner of Agriculture's race just beneath it. An examination of the higher undervotes found that they also had the same strange overrepresentation of straight party voters as in the high undervote counties.

Two things were different in Martin—the position of the race and the response to the machine problems. In Charlotte, there is no record of any concerted actions with regard to response problems. Quite simply, Charlotte zone techs did nothing whatsoever about slow response machines. In Sumter, we likewise find no evidence of any action to combat this problem. In Lee, it was clear that technical staff and field techs believed that they understood what the problem was—a smoothing filter issue involving the firmware. In fact, one message indicates that they responded to an inquiry from a poll worker about what to do by saying that nothing could be done. In contrast, Martin did what would have been obvious had the smoothing filter issue never been raised—they calibrated the screens. When necessary, they recalibrated the machines. They indicated that these actions did, in fact, help, although they also noted that some machines were losing calibration. Martin County's event log shows a total of 75 terminal screen

calibration messages from election day. Sarasota, Lee, Charlotte, and Sumter only have a handful of such messages on election day (6, 5, 8 and 2 respectively).

About the time we inspected the records in Martin County, by an amazing coincidence we received a document in the mail from Lee County that seemed to confirm that miscalibration of screens may have played a major role in the undervotes. The document was the back of an incident report. The person who had originally copied the reports had inadvertently missed the message on the back of the page, and we had requested that the backs of the relevant reports be copied and sent to us. What the back of the incident report revealed was that the poll worker had determined that the problem with his slow response machine was calibration. He even had a hand-drawn diagram to show the misalignment of the box on the screen and the spot that reacted to the touch! It all began to fit together.

We believe Martin County would have experienced the same excessive undervote rates in the CFO race if that race had been in the margins and if it had failed to calibrate the screens.

Of course, it is more complicated than simply recalibrating machines. The screen failures were exacerbated by power problems, possible hardware/software conflicts, and a multitude of failing or defective machine components. Further, the design of the ballot probably did induce some voters to miss the races at the margins, but it is likely that this is responsible for only a very small portion of the undervotes. Overall, it seems likely that calibration problems due to failing screens may have been responsible for a substantial portion of the undervotes.

Still, the multitude of machine failures and ballot design do not explain all the problems experienced by voters or reflected in the records. We believe it is likely that these problems exacerbated a programming bug or virus, possibly in the PEBs. We are not competent, however, to evaluate this possibility, and thus leave it to others to explore.

6. UNDERVOTES IN THE ATTORNEY GENERAL'S RACE STATEWIDE

Unlike the Sarasota CD 13 race, we can indisputably determine the normal range of undervotes for the attorney general's race.[7] This contest not only appeared on the ballot in every county but also in relatively the same position. The state of Florida mandates both the order of races and the order of candidates.

Regardless of voting system, the order was: U.S. Senator, Congressional (some counties had more than one district), Governor/Lt. Governor, Attorney General, Chief Financial Officer, and Commissioner of Agriculture. In each race, the Republican candidate was listed first, the Democratic candidate was second, and other candidates followed.

[7] Calculations about statewide rates actually involve residual votes, which include undervotes, overvotes, and illegal write ins; however, as a practical matter, undervotes make up nearly all residual votes because electronic voting systems do not permit overvotes; thus, only absentee ballots are susceptible to this problem. In the attorney general's race, there was no opportunity for write-ins. Therefore, we have not attempted to break out these categories separately, which would be a very difficult and time-consuming task. Rather we have lumped them together. It is unlikely that there is any noticeable effect of combining these categories.

6.1 Undervote Rates by Voting System

The problems become apparent when one looks at undervotes for this race by voting system. The table below shows the number of votes cast, the number of undervotes, and the undervote rate by voting system. The median undervote rate across the state for the attorney general's race was 3.14 percent.

Both ES&S optical scan and Sequoia Edge touchscreen counties had undervote rates of about 3 percent. Diebold optical scan counties did better with a rate of 2.72 percent. In the iVotronic counties, however, the undervote rate was an astounding *8.65* percent, three times the Diebold op scan rate and more than two-and-three-quarters times the rate for ES&S op scans and Sequoia DREs. When we translate these figures into actual votes lost, the problem becomes more tangible—if the ES&S iVotronic voters had voted on the Diebold system, about 95,000 more votes would have been counted in this race.

Table 4.1: Undervote Rates in Attorney General's Race by Voting System

Vendor	System Type*	No. of Counties	Ballots Cast	Undervotes	Undervote Rate
Diebold	Optical scan	31	1,557,587	42,366	2.72
ES&S	Optical scan	21	730,272	22,171	3.04
Sequoia	Touchscreen	4	1,001,807	30,087	3.00
ES&S	Touchscreen	11	1,588,091	137,415	**8.65**
Total		67	4,877,757	232,039	

**Note:* Diebold and ES&S optical scan systems used DREs for visually disabled voters.
Source: "Analysis and Report of Overvotes and Undervotes in the 2006 General Election," January 31, 2007, Florida Department of State, Division of Elections.

As shown in the figure below, most counties experienced undervote rates between 3 and 5 percent. In fact, there was little variation across non-iVotronic counties. The three highest spikes on the chart are Charlotte, Lee, and Sumter, where undervote rates were roughly six to seven times the state median. The two lesser spikes are Broward and Miami-Dade, which use the 15" iVotronics.

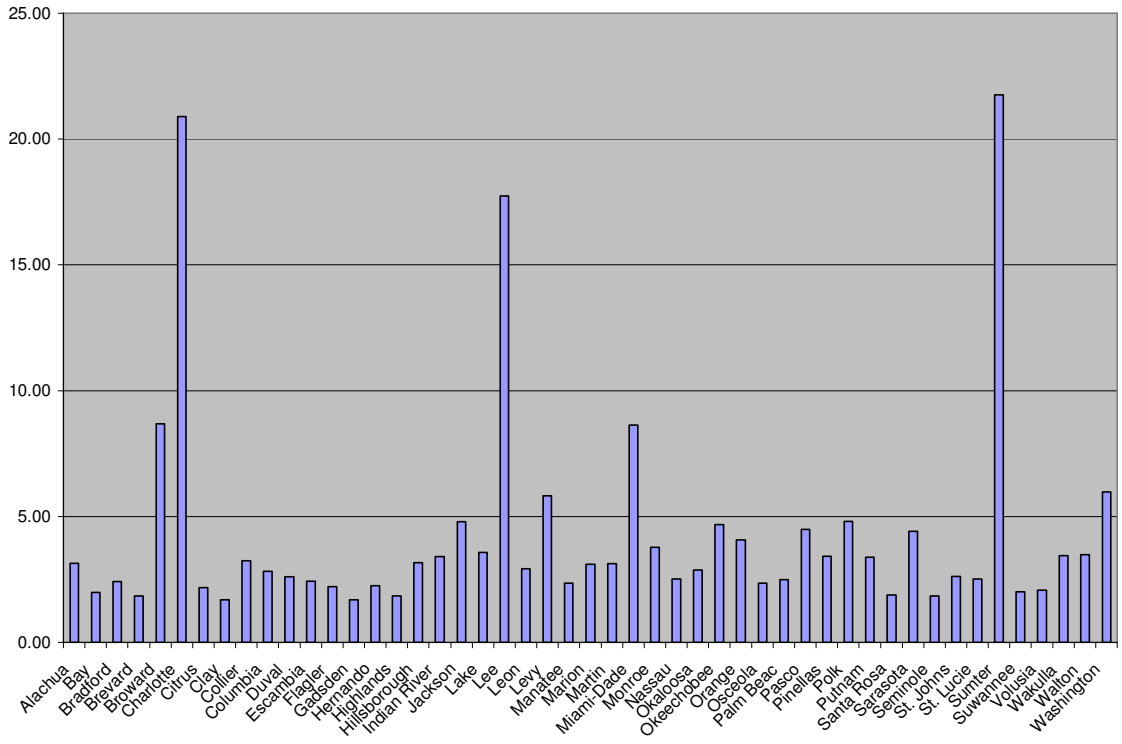

Figure 6.1: Attorney General's Race Undervote by County
*Counties with fewer than 7,000 total votes were omitted from the chart to improve readability.

6.2 The Real Shocker—Undervotes on the iVotronics Alone

As shocking as the summary undervote rates in the iVotronic counties are, they understate the real dimensions of the disparity. When the optically scanned absentee ballots are removed from the calculation, undervote rates for Charlotte and Sumter Counties shoot up to nearly 25 percent for both election day and early voting. Absentee ballot rates in the two counties are normal at 2.69 and 3.12 percent respectively. Lee County's undervote rate rises to 21 percent for election day and 20 percent for early voting. It too has a normal undervote rate of 2.38 percent on absentee ballots cast in this race. The table below shows the difference between undervote rates on absentee ballots and on the iVotronics. Note that the absentee undervote rates for every county except Miami-Dade are similar and are quite close to the state median.

Table 6.2-1: UV Rates, Attorney General's Race, iVotronic Counties, by Voting Mode*

County	UV %	Polling UV %	Early Voting UV %	Absentee UV %
Broward	8.68	11.02	7.88	1.99
Charlotte	20.88	24.90	24.41	2.69
Collier	3.24	3.74	2.68	2.68
Lake	3.57	3.92	3.27	2.24
Lee	17.74	21.01	19.16	2.38
Martin	3.14	3.68	2.53	2.60

County	UV %	Polling UV %	Early Voting UV %	Absentee UV %
Miami-Dade	8.62	9.64	7.01	5.91
Nassau	2.53	*	*	*
Pasco	4.50	4.97	4.31	2.0
Sarasota	4.36	4.77	4.45	2.91
Sumter	21.76	23.00	24.63	2.85

* Data by mode of voting were not available from Nassau County's website, but its undervote rate is low so a breakdown was not deemed necessary for the purposes of this paper.

7. UNDERVOTES IN TOP-OF-THE-BALLOT RACES FOR CHARLOTTE, LEE, AND SUMTER

Except for the attorney general's race, undervote rates in top-of-the-ballot races in Charlotte, Lee, and Sumter were unexceptional and similar to those across the state. Further, in all other races, voters on election day and during early voting had undervote rates very close to those of absentee voters for the same race.

In Charlotte County, *election day and early voters were nearly 10 times more likely to undervote in the attorney general's race than those who voted absentee.* Undervotes on absentees were only 2.69 percent while election day and early voters had rates in excess of 24 percent. As shown in the figure below, there was a problem in the attorney general's race that was not experienced in other races, and clearly, that problem was only on the iVotronics.

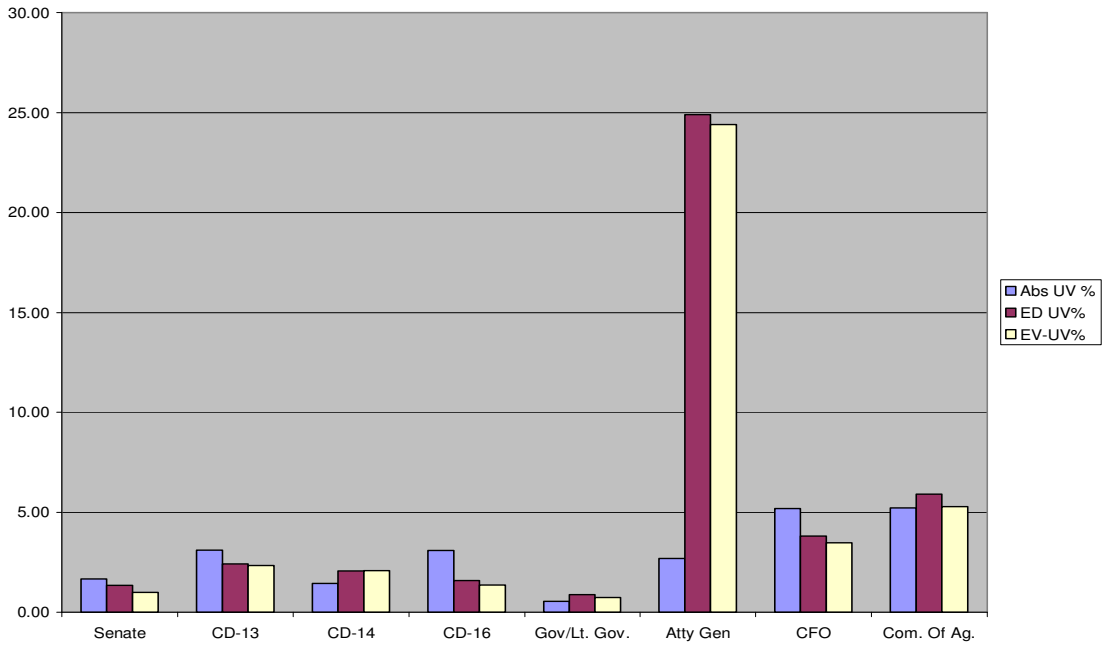

Figure 7.3-1: Charlotte County Undervotes, 2006 General Election, Top-of-the Ballot Races, by Voting Mode

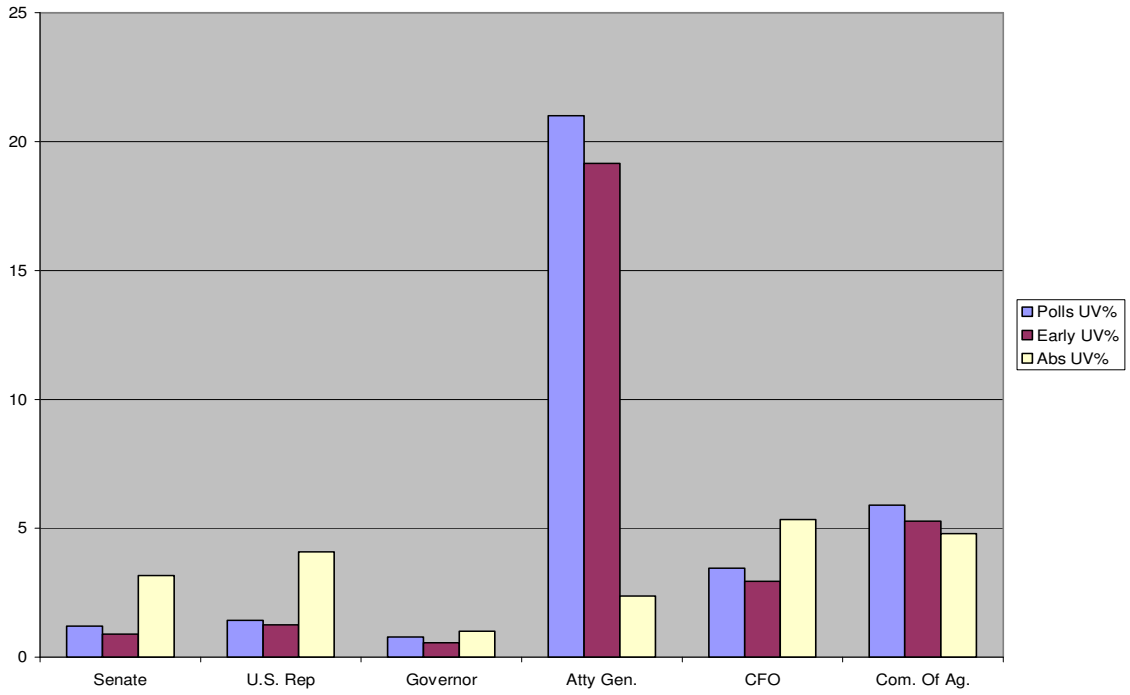

Figure 7.3-2. Lee County Undervotes, 2006 General Election, Top-of-the-Ballot Races by Mode of Voting

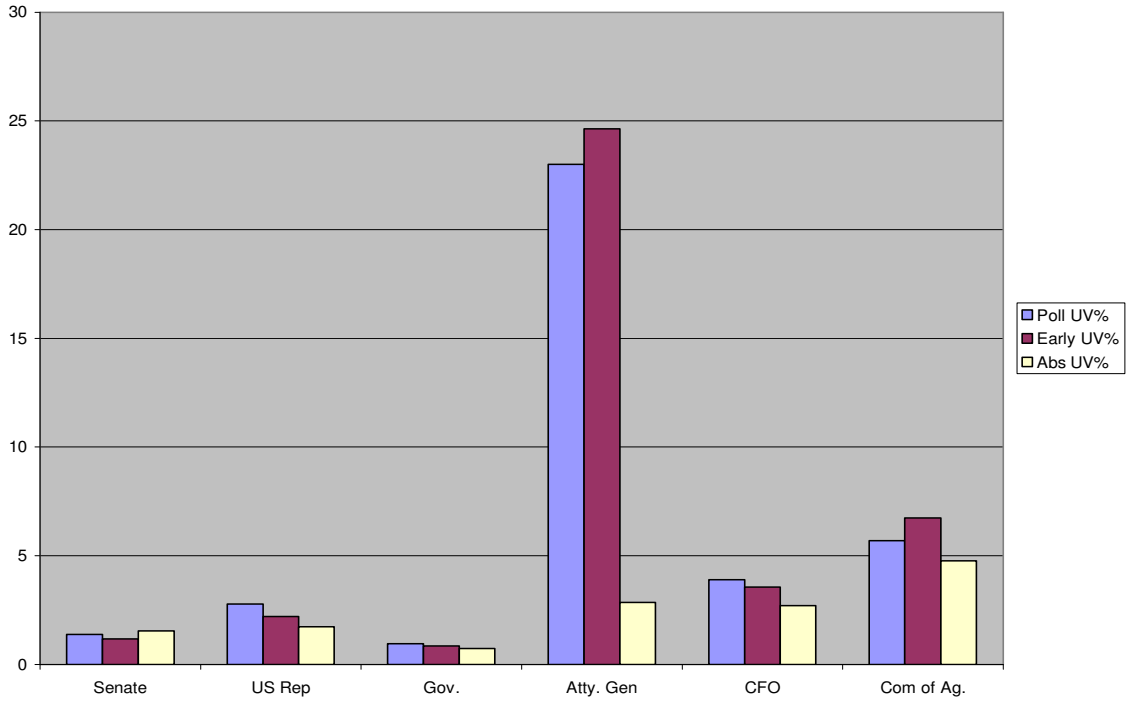

Figure 7.3-3. Sumter County Undervotes, 2006 Election, for Top-of-the-Ballot Races by Voting Mode

7.1 Undervote Rates by Precinct

We looked at undervote rates by precinct to determine if problems were widespread or confined to specific precincts.[8] If the problem were confined to a few precincts, it would be easier to isolate the problems and relate them to the undervotes.

For all three counties—Sumter, Charlotte, and Lee--problems were widespread, with high undervote rates in nearly every precinct.

Charlotte County. In Charlotte, the median undervote rate (24.67%) very nearly mirrored the summary undervote rate (24.90%), indicating that problems were not localized. Sixty-five of the 78 precincts had rates between 20 and 29 percent. Another five precincts had rates between 19 and 20 percent, and only one had a rate below 15 percent (14.29%).

Despite this relative uniformity, some precincts clearly had more problems than others and deserve closer scrutiny. Eight precincts had undervote rates above 30 percent. The highest undervote rate was experienced in precinct 73, which had an astounding 40.16 percent undervote rate.

This uniformity extended to early voting results as well. Until recently, we did not have information from the supervisor of elections to place machines at particular early voting sites. Nevertheless, we were able to group machines according to the PEB used to open the machine and, therefore, determine which machines were used together. Thus, we were able to find that there were three early voting groups (although there were five early voting sites). Undervote rates in these groups were: 26.07, 24.68, and 22.39. Again, even though there were significant variations by site, all undervote rates were very high, suggesting widespread or systemic problems.

Lee County. Lee's statistics are very similar to those of Charlotte and Sumter, even though it is a much larger county. It has a total of 171 precincts, compared to 80 in Charlotte and 37 in Sumter. Its turnout was more than 155,000, compared to 55,000 in Charlotte and 30,000 in Sumter. Its precinct undervote rates in the attorney general's race ranged from a low of 13.43 percent to a high of 39.99 percent. Only five precincts had rates higher than 30 percent, and three were below 15 percent.

In early voting, there was little variation in undervote rates by site. Its four early voting locations had rates of 18.23, 18.47, 19.52, and 20.19.

Sumter County. In Sumter there was even less variation in the undervotes by precinct. For election day, undervotes ranged from a low of 11.85 percent to a higher of 31.70 percent. The median rate was 21.56 percent. Only one precinct had a rate above 30 percent, and only two had a rate below 15 percent. The great majority of precincts had rates that fell between 20 and 25 percent.

[8] Two Charlotte precincts had fewer than 10 total votes cast. These were eliminated from consideration, thus giving us a total of 78 normal-sized precincts.

Early voting locations, however, did show a greater variation in rates. Three of the four locations—the Villages Office, Villages Library, and the Bushnell Main Office—had similar rates at 25.86, 24.11, and 24.12 respectively. The fourth location—Wildwood—had a substantially lower rate at 17.70 percent. Higher rates at the Villages could be attributable its high population of newcomers to the county and to Florida, although it would not explain why the undervotes would be confined to a single race. The difference between Bushnell and Wildwood, however, is not readily attributable to such factors. It is worth noting that Wildwood was the smallest of the three locations, with only five machines, including its ADA machine.

8.0 STRAIGHT PARTY UNDERVOTERS

In Sarasota, analysis of the ballot images for the CD-13 race by Mebane and Dill showed that voters who otherwise voted a straight Democratic ticket were more likely to have an undervote in the CD-13 race than those who voted a straight Republican ticket. Other partisan patterns were also noted in that race. We contacted Dr. Dill who graciously offered to analyze the ballot images from Charlotte, Lee, and Sumter using the same program.

In all three counties we found that those who voted a straight Democratic ticket had a better chance of having an undervote than those who voted a straight Republican ticket. In Charlotte, the difference was quite similar to that found in Sarasota. The trend was less pronounced in Lee County and very slight in Sumter County.

But undervotes in the subject race in all these counties have one thing in common—an unusually high number of people who otherwise voted a straight party ticket—with no other undervotes—had an undervote in the attorney general's race in Charlotte, Lee, and Sumter and in the CD-13 race in Sarasota. Yet straight party voters are the most motivated voters. Intuitively, they are the voters least likely to undervote in an important, top-of-the-ballot race.

To check the partisan composition of the undervotes in each of the counties, we removed from consideration all ballots that contained an undervote in the congressional and statewide races other than the attorney general's race or that contained a vote for a third-party candidate. Thus, we removed most of the ballots likely to have legitimate undervotes, assuming that voters who choose to undervote in one race are more likely to undervote in others. Also, voters who choose third-party candidates might be likely not to make a selection in a race that does not allow a third party choice or write-in. This is a very conservative approach that is likely to overstate the number of intentional undervotes.

In Charlotte County, we are left with 33,543 ballots that contain a vote for a Republican or a Democrat for all top-of-the-ballot races other than the attorney general's race. Most of these partisan voters were straight party voters—nearly 70 percent voted either a straight Democratic or a straight Republican ticket. In fact, the totals are very close—each accounting for about a third of the partisan voters, with Republican voters having a slight edge. In fact, straight party ballots comprise more than half of all ballots cast on the iVotronics in Charlotte County's 2006 general election.

What we find is that nearly one in four straight party Democratic voters had an undervote in the attorney general's race. Among Republican straight party voters, the numbers were significantly lower, but still very high, with about one in five undervoting only in the attorney general's race.

Table 8-1: Undervotes in Charlotte County's Attorney General's Race
Partisan Voters Only for Statewide Races*

Partisan Votes, Statewide Races	Total Ballots	AG Undervotes	AG Undervote Rate
0 Reps, 5 Dems	11446	2670	**23.33**
1 Rep, 4 Dems	2948	596	20.22
2 Reps, 3 Dems	1906	384	20.15
3 Reps, 2 Dems	2057	411	19.98
4 Reps, 1 Dem	3478	672	19.32
5 Reps, 0 Dem	11708	2220	**18.96**
	33,543	6,953	20.73

*Ballots with no undervotes in other statewide races nor any votes for 3-party candidates. The five races are Senate, U.S. House, Governor, Chief Financial Officer, and Commissioner of Agriculture.

The numbers for Lee County are somewhat lower, but have a similar relationship. One in five of those who otherwise voted a straight Democratic ticket (with no other undervotes) had an undervote in the attorney general's race. Straight party Republican voters had a slightly lower rate of a little more than one in six (17%).

In Sumter County, the same pattern holds. More than one in five (21%) of those who otherwise voted a straight party ticket had an undervote in this race. Among Republicans, the rate was slightly lower at just under one in five (19%).

This finding is enormously important as it seems that in all the counties with excessively high undervote rates people who voted a straight party ticket and who had no other undervotes in top races had very high undervote rates in the attorney general's race. We suspect that it is these voters who comprise the difference between high undervote counties and ones with low undervotes. Our inspection of Martin County records confirms this suspicion.

9. LOCATION AND DEMOGRAPHICS

Three of the four high undervote counties—Sarasota, Charlotte, and Lee—are located on Florida's southwest coast. Sumter is located northeast of Tampa.

While Charlotte, Lee, and Sarasota are densely populated counties with fairly stable populations, Sumter is changing from a lightly populated, rural county to a popular retirement spot. The Villages, a popular golf retirement community, has attracted large numbers of affluent retirees from northern states as well as from other Florida counties.

In 2004, Charlotte County was devastated by Hurricane Charley as Punta Gorda took a direct hit. Less affluent than its neighbors Lee and Sarasota, the county's struggle to

recover is still continuing. Sumter has been hit by a number of tornadoes in the last few years, some associated with hurricanes. All four counties have the legendary heat and humidity associated with Florida.

All three counties are Republican strongholds and went for Republican candidates across the board in 2006, with the exception of conservative Democratic Senator Bill Nelson. As he did across the state, Nelson was able to attract Republican votes in these counties and win by a large margin.

Although we have not completed a demographic analysis of those who voted by each mode, these counties are probably like the rest of Florida. Statewide, the strategy of the Republican Party has been to push absentee balloting while the Democratic Party has emphasized early voting. Election day voters tend to reflect the partisan mix of the county.

10. THE VOTING SYSTEM

Charlotte, Lee, Sumter, and Sarasota counties use identical voting systems—12" iVotronic direct recording electronic (DRE) voting machines made by ES&S for election day and early voting and the ES&S M650 high-speed optical scanner for absentee ballots. The DREs are colloquially referred to as touch screens because the voter interface consists of a reactive screen similar to those in Automatic Teller machines. Some of the touch screens are referred to as "ADA machines" because they are outfitted with an audio ballot and a zoom or large print ballot to serve visually impaired voters. (ADA is the acronym for the Americans with Disabilities Act.) Under the federal Help America Vote Act (HAVA) of 2002, each precinct and early voting site is required to have at least one machine for visually disabled voters.

All of the counties link their machines together at the polling place in what is termed a "daisy chain." The first machine is plugged into the wall outlet, the second is plugged into the first, the third into the second, and so on. In Charlotte and Sarasota, a maximum of five machines were linked in this way. In Sumter, up to ten machines were linked. After opening all the machines in sequence, the zero tape is printed from the last machine. [9]

All iVotronic counties with high undervote rates updated their 7.4.6.0 firmware—the software resident in the individual units—with the new 8.0.1.2 firmware just before the 2006 election cycle. This firmware is *not* federally qualified and, thus, is not used in the majority of states; Florida does not require that its voting systems undergo federal qualification as a prerequisite for state certification. We believe that the 8.0.1.2 firmware is only used in Florida. For each of these counties, the 2006 election cycle was the first use of the firmware.

All of Florida's iVotronic counties acquired their machines after the great election debacle of 2000. In 2000, Lee, Sumter, and Sarasota were using punch cards, well known

[9] Information on machine set up was obtained from zone techs, poll workers, and elections staff in Charlotte, Sarasota, and Sumter County.

for hanging and pregnant chads. Charlotte was already using optical scanners, the system recommended by the Governor's task force set up after the 2000 election. Charlotte was one of only two counties in Florida to go from optical scanners to DREs, known colloquially as touch screens, after the 2000 election. It is difficult to understand why the county would have made such a decision. Not only did this relatively poor county dump the system preferred by the task force, it acquired one with much higher costs for acquisition, operations, and maintenance.

Virtually everything about the components and operation of the iVotronics is considered by the vendor to be proprietary. Those few individuals who are able to open up and inspect the individual machines are prohibited from revealing anything about them. In fact, ES&S repeatedly warns in its contracts with the counties that doing so would void their warranties. Consequently, we are unable to say what components are actually in a particular unit. Because these units are old by computer standards, however, we know that many of the components, including all the screens, have been replaced.

In the fall of 2003, ES&S replaced all of the Bergquist screens in the iVotronics sold to its southwest Florida customers because they were defective.[10] The iVotronics in Charlotte and the other counties have screens made by three different manufacturers—Bergquist, Elo, and Microtouch. We do not know if other replacement parts are all the same or if they are also made by different manufacturers. In the last year and a half, Charlotte has replaced another dozen and a half screens. Lee and Sumter County also replaced numerous screens both before and after the 2006 election.

In spring of 2006, all four counties replaced their motherboard batteries. Charlotte, Sarasota, and Lee also replaced all their "stick" batteries just prior to the 2006 election cycle. Sumter County replaced their stick batteries a few months after the election. PEB (personal electronic ballot) cards were sent back to ES&S for replacement of their batteries during the summer of 2006. PEB and motherboard batteries are lithium batteries. The stick batteries consist of a sleeve containing six nickel batteries. In addition, the county bought 15 power supplies before the 2006 general election and another 70 afterwards. So they replaced about 14 percent of their power supplies within a year, and more than 11 percent after the November election.

Maintenance records show replacement of IRDA boards and cables (shown as "upgraded"), video boards and cables, power inverters and other components. Records do not indicate manufacturer or other information. All of the counties use Decision One—an ES&S contractor—to provide maintenance of its iVotronics and other components of its voting system.

11. WHAT HAPPENED?

Ultimately, before we can determine causes of the undervotes, we have to decide what happened. Based on the information we have been able to obtain, we are confident that the following problems occurred:

[10] Sarasota maintenance records indicate that all screens, regardless of manufacturer, were replaced.

1. Machines were nonresponsive or slow to respond.

Throughout Charlotte, Lee, and Sumter counties, the iVotronics exhibited long response times and required unusual or prolonged pressure in order to register a response, just as they did in Sarasota County. These symptoms are consistent with the "smoothing filter" problem acknowledged by the vendor to affect these machines and described in its August 15 letter to its Florida customers and the state division of elections. As described in the letter, these symptoms varied from machine to machine as well as from time to time on the same machine; however, across all counties, voters and poll workers consistently complained of this problem.

In Charlotte, we have descriptions of this problem from early voting and election day poll workers, as well as campaign workers, voters, and a candidate for office. One early voting poll worker said that she had discovered on her own that sometimes selections needed prolonged pressure to register. According to Dr. Doug Jones, an electronic voting systems expert and professor of computer science at University of Iowa, this is a classic symptom of smoothing filter problems.[11] Poll workers and voters alike were utterly unaware of the ES&S warning so their contemporaneous accounts are particularly reliable.

Dr. Jones, however, makes it clear that we do not have any real knowledge that these symptoms are caused by the smoothing filter, other than the August 15 letter, and even that seems only to guess at this cause. He further explains that if this were simply a smoothing filter problem, it would be experienced uniformly and consistently across all machines and all voters—not randomly.

In their paper on remaining gaps in the investigation of the Sarasota CD-13 race, David Dill and Dan Wallach make the same point:

> *. . . if the smoothing filter is implemented purely in software, identical on every iVotronic, there should be no variation in its behavior from one iVotronic machine to the next, or from time to time..*[12]

Yet, it appears that the slow response problem did emerge erratically—not consistently or uniformly. If the problem really is the smoothing filter and it is located in the firmware as stated in the letter, then the capricious behavior suggests a bug. As Dill and Wallach say:

> *. . .non-determinism is a sign of potential bugs, and. . . inconsistent behavior may cause unpredictable problems for the voters.*[13]

Of course, it remains to be proven that the smoothing filter caused the slow response and that it is located in the firmware. The FSU computer scientists cannot illuminate us on this point because they did not even have the smoothing filter letter prior to

[11] Personal communication
[12] Dill and Wallach (2007),,12.
[13] Ibid.

conducting their research. [14] They did not mention finding a smoothing filter in the firmware, however.

Our investigation suggests that the smoothing filter is usually located in the programmable touch screen controller, not the firmware. The FSU computer scientists cannot help us with this point because an examination of the hardware, and its accompanying software and drivers, was deemed to be outside the scope of their work.

Unfortunately, Charlotte, Lee, and Sumter counties did not take the ameliorative actions suggested by the vendor in its August letter. Poll workers were not educated about the problem, and posters were not placed in the voting booths. Not a single poll worker or voter told us that he or she was aware of the "smoothing filter" problem prior to or during the election.

2. Selections in the Attorney General's Race disappeared from the review screen. As in Sarasota's CD-13 race, Charlotte County voters complained that their selections in the attorney general's race did not show up on the review screen, even though many were positive they had voted in the race. This problem appears to have been widespread and to have begun in early voting and continued through election day. All reported instances involved the attorney general's race.

One voter who voted during early voting told us that he was certain he had voted in that race because he "despised" the Republican candidate and made sure to vote against him. This same voter said that he had written a letter to the supervisor of elections but never received a reply. Another voter said that when his vote didn't show up on the review screen he thought he must have made a mistake, but when he talked to his wife she said she had the same problem. A candidate for office said that she experienced the problem with the attorney general's vote missing from the review screen when she voted early on election day at precinct 43. She called the supervisor of elections' office and ultimately wrote a letter to the editor, which was published.[15] Voters told us that their friends had the same experience. A campaign worker who was giving rides to the polls said that two women he took to the polls also experienced the problem with their votes disappearing from the review screen. He instructed both of them in how to go back to the race from the review screen. Without his help, he said he was sure they would have cast their votes without correcting their ballots.

Unlike Sarasota, where poll workers and voters were warned on election day to make sure their vote was recorded properly, we found no evidence that Charlotte County voters received any information or warnings from their election officials or candidates.

In Lee County, we did not conduct any public forums or do interviews with voters so our knowledge is restricted to what we have on incident reports, telephone logs, and zone tech logs. Fortunately, Lee's records are quite extensive and detailed. We find in Lee at least one instance of a voter complaining that his vote in the attorney general's

[14] Personal communication, Alec Yasinsac to Susan Pynchon
[15] Letter is attached as Exhibit C.

race would not take on that page and that he had to vote in that race by going to the review page and accessing the race from there.

We don't have any incident reports about review screen problems from Sumter, but Sumter's records are somewhat sparse.

3. Voters complained that they could not find the race on their ballot.
The following is the text of one of the few incident reports from one of Charlotte's early voting sites:

> *During voting, voter said he couldn't find a certain race. Marilyn stood behind him and directed him to go "previous page" back to find the race. Voter proceeded to finish his ballot and vote. After he was done, he told Marilyn he was not able to find the race he was looking for. I found his voting certificate to show him his ballot (sample ballot). I showed him the race he was looking for from the sample ballot in the hallway. He then told me he couldn't find it on the voting machine. I witnessed all of this from my vantage point at the door. Voter was on the iVo closest to me.*[16]

We spoke to "Marilyn," the poll worker who tried to help the above voter. When we asked her if she remembered which race the complaint referred to, she said firmly that *all* the problems were with the attorney general's race. She went on to explain people began complaining right away that they couldn't find the attorney general's race. She couldn't estimate the number, but said that it was "a lot." So many were missing the race, she said, that she started telling each voter to be sure to locate the race on the sample ballot before they went into the booth. She further told us that she was not directed to take these actions, but did so on her own initiative. Regardless, voters continued to maintain that they could not find the race.

This problem was widespread, affecting perhaps hundreds of voters, yet there is only one incident report and that one seems to have been filled out only because of the persistence of the voter in maintaining that the race was not on his ballot.

Of all the complaints voiced by voters had during the election, this one seems to have been the most prevalent and the one that definitely caused undervotes. After all, the voters cannot vote in a race if they can't find it. Why did voters have trouble finding this race, when they didn't have problems with any others? Most of these voters were familiar with the equipment, and the ballot layout was similar to that used in all past elections on the iVotronics. And given the prevalence of the complaints, why wasn't there any investigation of the problem or directions given to poll workers to warn voters about the problem? Certainly, by election day, the problem was well known to the elections office. They chose to do nothing.

This is not the first election in which races have allegedly been missing from iVotronic ballots. In Broward County (which uses 15" iVotronics) in March 2005 only two items appeared on the ballot—a commissioner's race and the gambling initiative. During the

[16] We attempted to contact this voter, but found that his name (as given on the incident report) did not appear on the disk of all voters.

conduct of a parallel election project by Ellen Brodsky of the Broward County Election Reform Coalition, sixteen of the 125 voters who participated said that the commissioner's race did not appear on their ballots. With only two races on the ballot, it is hard to see how they could have missed one of them! Yet these voters signed affidavits stating that the race was indeed missing. [17]

Voters in Sarasota also complained that the CD-13 race was missing from their ballots. Yet other voters found the race with no trouble and voted. Other voters said that Christine Jennings' name was "grayed out." Another voter complaint during the primary stated that selection boxes on the zoom ballot were faint and not easily seen by visually disabled people.

So why did so many people say that they couldn't find the attorney general's race on the Charlotte ballot, even though they were actively looking for it? It is possible that problems with the display for some reason made the race difficult to read. But we should not overlook the obvious—maybe it wasn't there.

Personal Electronic Ballots (PEBs) and Ballot Definition. What would cause the race to be missing from some ballots and not others? The most obvious culprit would be the PEBs. About the size of a deck of cards, these devices hold the ballot definition files. For each voter, the poll worker must insert the PEB into a slot in the iVotronic so that the appropriate ballot can be loaded. Each PEB contains a small battery-powered processor.

The SAIT report includes an appendix that examines the possibility of spreading a virus with a PEB.[18] It concludes that it would be relatively simple for a single individual to spread a virus using just one PEB. These devices are small and fit easily into a pocket or purse. Many people have access to them—elections office employees, vendor employees, maintenance workers, part-time contractors, and many others.

The report maintains that the would-be attacker would have to break into the elections warehouse to obtain one, but we find that laughable. That assumes that security measures are stringently followed, and the records suggest otherwise. Furthermore, many dozens of people—and their spouses, children, and friends—have easy access to the PEBs.

In the process of setting up the election, an infected PEB would expose many other PEBs and terminals to infection. Just before this election, all four counties sent off their PEBs to ES&S to have batteries replaced. What better opportunity to spread a virus could be imagined?

3. ADA machines were not working properly and were not available for use by regular voters.

Poll workers on election day in Charlotte, Lee, Sumter, and Martin counties were instructed not to use the ADA-equipped machines for regular voters because of

[17] "More Bugs Show Up in Florida," http://www.votersunite.org
[18] Yasinsac et al, 2007, 57

unspecified problems with the machines. A Charlotte County poll worker said that elections office staff told the workers not to use the ADA machines for regular voters because of problems experienced with the machines presenting a regular ballot. He was under the impression that the problems occurred during early voting; however, our investigation shows that the problem most likely surfaced earlier than that.

The poll worker's report is backed up by telephone messages, incident reports, and the machines' event log. Poll workers in at least two precincts asked for special permission to use the ADA machines for regular voters because of long lines or because other machines had failed. Interestingly, even though they apparently received permission to do so, they still did not use the machines.

The Charlotte event log makes it clear that use of the machines was discouraged. During the primary, when use of the machines was not officially discouraged, nearly 1,600 votes were cast on the ADA machines, with more than 14,000 cast on the regular machines. In the general election, when about 46,000 people voted, only 169 votes were cast on the ADA machines.

Incident reports from the general election in Lee County show that the elections office there also told poll workers to limit use of the machines to disabled voters. Further, no such restrictions were placed on the machines during the primary in Lee. In Sarasota, the supervisor of elections told poll workers to discourage use of the zoom ballot and instead use a magnifying overlay on the screen.

What was wrong with these machines? The answer depends on who you ask. The supervisor of elections of Lee County told us that they decided to limit use of the machines because voting on them took "three times longer" than voting on a non-ADA machine. When asked for clarification, she insisted that it took much longer for all functions on the machine—loading the ballot, selecting language, and actual voting—even for voting a regular ballot. She said that they did not want to have long lines because of delays on the ADA machines. Incident reports in Lee, however, suggest that *not* using the machines caused lines and long delays. Further, when we looked at voting times on the machines, we found many instances of ballots cast in only a couple of minutes.

The Sarasota County supervisor of elections also cited the length of time to use the machines as the reason for discouraging use of the zoom ballot. The Sumter County supervisor of elections said that she had never heard of this problem. She said that she has always reserved the ADA machines for the use of those who need them.
We believe that the problem with the ADA machines was indeed discussed at the September Users' Meeting. Even though that meeting brought together elected officials at public expense to discuss public business involving expenditure of public funds, the minutes of that meeting is not available to us.

The deputy supervisor of elections of Martin County told us that the recommendation not to use the ADA machines came from ES&S. She said that they suggested not using it because the ADA ballots did not have all the features of the regular ballot—such as

color. Later, she said that the regular ballots on the ADA machines showed the ballot "coding" and that was confusing for voters. By coding, she meant the formatting characters that indicated that text should be centered, boldfaced, and so on.

Mac Horton, supervisor of elections for Charlotte County, told us that the reason his county discouraged use of the machines by regular voters was because so many voters mistakenly pulled up the audio ballot instead of the regular ballot. He doesn't say why this became a concern in November 2006 and not before, but his explanation does come closest to explaining what we see on the event log and on cast/cancel ballot logs in other counties. [19]

Cancelled Ballots

The event log gives us some clues about the problems with the ADA machines. During the primary, Charlotte had an extraordinary number of "supervisor ballot cancel" messages on their event log for such a small election—221 in the primary versus 116 in the general election. These messages usually indicate that a ballot that was in process had to be cancelled by a poll worker with a special supervisor PEB before the voter finished making his selections. There are several reasons why a ballot would be cancelled: the voter may not get the type of ballot he wants—e.g., the audio instead of the regular or the zoom instead of the audio—either by poll worker or voter mistake or by machine malfunction; the machine may exhibit a slow response or other problem that prompts the voter to ask to move to another machine; or the machine may indicate that a ballot is in process when it is not.

Of the 221 ballots cancelled in the primary, more than half (111) were on the ADA machines, even though only 10 percent of the votes cast on the iVotronics were cast on ADA machines. Because of the restrictions on the use of the ADA machines, only 169 votes were cast on these machines out of the nearly 46,000 votes cast on the iVotronics during early and election day voting. Only 20 of the 85 ADA machines used in the general election recorded any votes whatsoever, and most of these consisted of only a handful of votes. During the entire two weeks of early voting, only two votes were successfully recorded on the six ADA machines set up for early voters. Yet while there were only 169 ballots cast, there were 52 ballots cancelled. Assuming that these are all intended ballots, nearly a fourth of the ballots initiated on the ADA machines in the general election were not successfully cast. It is interesting to note that 23 of the 52 messages appear on machines with zero votes.

Both Lee and Sarasota Counties also had a disproportionate number of cancelled ballots on the ADA machines. On their cast/cancel ballot logs, the reason given for canceling most of the ballots on the ADA machines was that the wrong ballot was pulled up by mistake. Usually, we would assume that the voters or poll workers simply made a mistake, but we have some incident reports that indicate that the ADA machines were responsible for the error. In one case, an incident report in Sarasota indicates that the ballot changed twice from regular to an ADA ballot while the voter was in the midst of

[19] Since preparing this paper, we have obtained more information on the problems with the ADA iVotronics during this election. We will anticipate releasing a separate paper on this subject.

voting! A Charlotte poll worker told us that the reason the machines weren't being used is because there was a problem presenting a regular ballot.

In Lee and Charlotte, the restriction on using the ADA machines represented a change in policy for this election. Although our information on this issue is sparse, it indicates that this new policy may have been suggested by the vendor because of machine problems that may have been related to a glitch in the firmware. At least, we believe that possibility should be investigated.

Known Defect in Firmware

One defect in the firmware applicable to the ADA machines was explained by the FSU computer scientists who examined the source code. They noted that the event log shows no PEB number next to the "normal ballot cast" messages on these machines. All votes on the iVotronics should be associated with a PEB number on the event log for audit purposes. On the ADA machines, the normal votes cast message shows "0 VTR" where the PEB number should appear. This inability to report the PEB number is assessed by the SAIT team as a benign defect in the firmware that occurs when the Spanish language capability is deselected. Charlotte, Sumter, and Sarasota did not have Spanish language ballots; thus, each of the counties had these messages associated with the normal votes cast on their event logs. Lee County, which does have a Spanish language ballot, did not have such messages, but had instead the PEB number as it should. We also confirmed on a Sumter County event log from 2004 that the previous version of the firmware did not have this problem.

This 0 VTR message is usually associated with a code 18 message "INVALID VOT PEB," which indicates that the machine is not able to read the PEB that has been used to activate the machine. These sometimes occur when the poll worker removes the PEB too quickly.

In Martin County, we found an interesting twist to this problem. It too had "0 VTR" associated with all the normal vote cast messages on its ADA machines—except for one message on one machine. In the middle of a line of such messages, there was interspersed a PEB number along with a normal vote cast. We are at a loss to explain how this could happen. But it does illustrate nicely how computers may not always behave consistently.

The presence of this firmware glitch may not have an adverse effect on the operation of the ADA machine, but it does adversely affect the ability to audit the election. The glitch results in erroneous entries on the audit log, thus making it impossible to audit the election using the PEBs as intended. It should be possible to ascertain that the votes listed on the log for each PEB correspond to those actually on the PEB. It is hard to understand why this very obvious problem wasn't caught by the state during the certification process. Anyone who examined the event logs for these machines should have seen the problem.

Consequences for Voters

During the September 5, 2006 primary, Charlotte County used a total of 539 iVotronics to serve a total of 15,922 voters. Two months later, they cleared and tested 512 machines to serve 45,998 election day and early voters in the general election. Inexplicably, they decided to use 27 fewer machines in the general election, even though there were more than three times the number of voters as in the primary. At least 20 machines used in the primary but not the general election were ADA machines.

While we can only guess at why the county used fewer machines in the general election when they expected many more voters, we can say conclusively that the failure to deploy sufficient numbers of machines in the first place, coupled with stipulations against using the ADA machines for most voters, meant that there were lines, both during early voting and on election day. Some precincts asked the elections office for permission to use the ADA machines for normal voters because of long delays.

Intuitively, one would expect long lines to result in higher undervote rates. When many people are waiting in line behind them, some voters may feel pressured to cast their votes without asking questions or going back to correct their ballot. Indeed, some voters may feel that they do not have time to check the review screen or find a missing race. Of course, when voters have waited a long time to vote, they may have to go to work or have other appointments that cause them to skip the review process. Unfortunately, when machines are malfunctioning—exhibiting delayed response, missing races, or losing votes on the review screen—some voters will undoubtedly take longer to vote and thus increase delays for other voters. Other voters will not bother to look at the review screen to check their selections, and still others will give up when the machine is not cooperative.

Lower Undervote Rates on ADA Machines

In Charlotte and Sumter counties, there were too few votes on the ADA machines to draw any conclusions about whether there is any significant difference in undervote rates on the ADA machines versus the non-ADA machines. In Lee, however, despite restrictions and admonitions from the elections staff, more than 3,200 votes were cast on the ADA machines. Undervotes in the attorney general's race on the ADA machines were about 16 percent, while the summary undervote rate on the non-ADA machines was 5 points higher at 21 percent.

12. VOTER ERROR OR MACHINE MALFUNCTION?

12.1. Effects of Bad Ballot Design on Undervotes

According to Charles Stewart, one of the nation's leading experts on the effects of voting technology on residual vote rates, there are two usual sources of unintentional undervotes—machine malfunction and voter confusion. The latter category covers what is generally called ballot design, or more properly with touch screens, ballot presentation.

In his expert testimony regarding the undervotes in neighboring Sarasota's CD-13 race, Stewart concludes that the undervote in that race:

> *…greatly exceeds the undervote rates that were estimated to have occurred in other well-established cases of voter confusion. This suggests a substantial possibility that the exaggerated undervote rates in this case were not solely due to voter confusion, but also caused by factors related to machine malfunction.*[20]

Stewart goes on to say that studies of voter error due to poor ballot design have found the effects to be quite small—in the range of 1 to 2 percent and occasionally as high as 5 percent for an exceedingly bad ballot.

In the case of the so-called "butterfly ballot," researchers were able to examine the ballots physically and to determine that the error rate was less than 1 percent. Stewart also refers to the 2003 gubernatorial recall race in California in which a very long and confusing ballot resulted in an estimated error rate of approximately 0.35 percent.

Stewart concludes that the excess undervotes in Sarasota cannot have resulted solely from voter error due to poor ballot design. Machine malfunction, he believes, is the source of a considerable portion of these undervotes.[21]

If this is true in Sarasota, it is even more clearly so in Charlotte, Sumter, and Lee where the undervote rate was 5 to 10 points higher, varied more from the absentee undervote rate, and the placement of the race in question was different. The common link among the counties is obvious—they used the same type of voting machines and they both were using newly installed firmware.

12.2 An Examination of the Ballot

Charlotte's ballot was nearly identical to the one used in both Lee and Sumter. It featured a single column format, with the attorney general's race on the third page, just below the governor's race.

For comparison, Sarasota also had a one-column format, but its high undervote race—CD 13—was located on page 2 of the ballot, just *above* the governor's race. These facts have led some analysts to conclude that simply being on the same page with the high profile governor's race could have been the problem. As indicated in the previous section, however, that effect would likely be in the range of 1 or 2 percent. So even if we were to assume some voter error on this basis, it would account for only a small portion of Charlotte's undervotes.[22]

Clearly, the ballot shown below is fairly unremarkable and definitely not on a level with such poor designs as the "butterfly ballot." Further, the location of the race at the bottom of the page means that the voter would be likely to see it when going to the "Next Page" selection in the bottom corner. The governor's race does take up most of the page, but conventional layout design teaches that the eye would naturally be drawn to the portion of the page with the most white space, not the spot with the most dense type. Indeed, in

[20] Stewart (2006), 38.
[21] Ibid., 35-40.
[22] Ibid., 35-39.

our opinion, only prior knowledge of high undervotes in this race would lead anyone to believe that this design could engender such a problem.

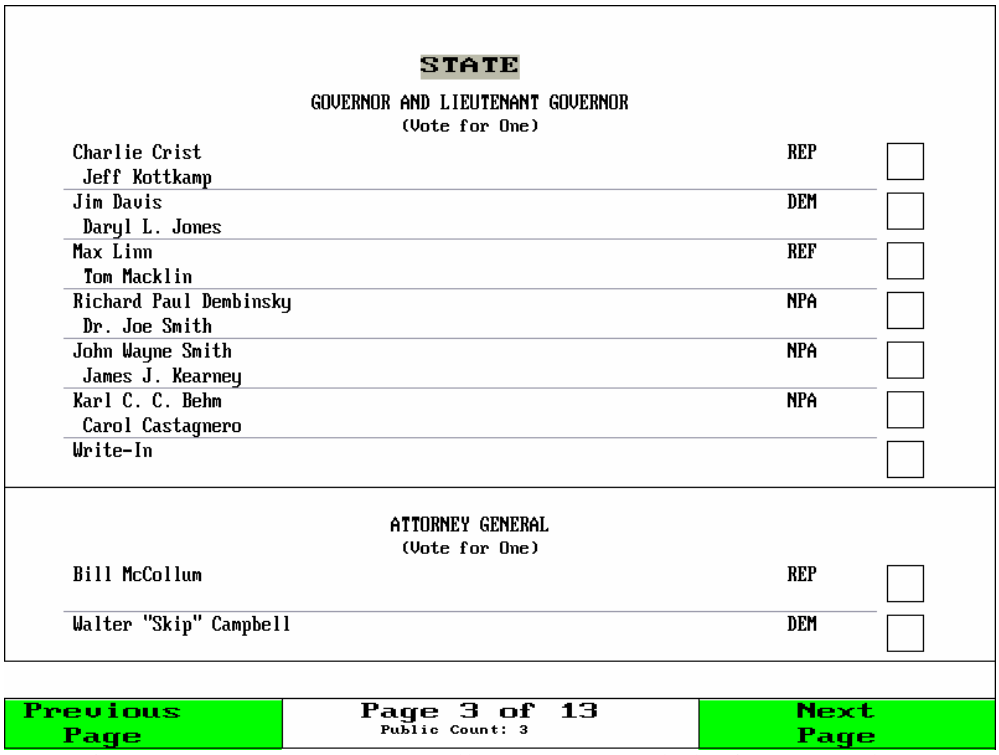

Figure 12-1: Sumter County Ballot, 2006 General Election, Page Three

Research on residual vote rates—the combination of overvotes, undervotes, and invalid write-ins—shows that DREs have higher undervote rates than optical scanners, but there is little on what aspect of the DREs causes the higher rates.[23] In general, research on DRE ballot design is spotty and inconclusive. To our knowledge, there are no agreed upon basics of ballot design for touch screen voting machines nor any evidence that particular types of design are more or less likely to increase voter error. For example, there is no research on single column versus two-column layouts, color vs. black and white, and so on. Further, and perhaps more important, there is no body of research on how the display itself or the functioning of the hardware would interact with particular designs. Thus, we are not aware of any specific guidelines that designers can use to minimize unintentional undervoting through better ballot design.

Another problem for determining the effects of ballot presentation is the small size of our sample. Only eight Florida counties use the 12" iVotronics; six of those used the same single column format as Charlotte. For those counties, there were only two viable choices for placement of this race[24]—on the page with governor's race or on the next

[23] Research does show that candidates who are listed first have an advantage over their opponents, but the state of Florida mandates that the governor's party is listed first, thereby ensuring that incumbents have an even greater advantage than otherwise.

[24] This assumes that placing each race on a page by itself is not a viable solution. While that has been suggested, there is no reason to believe that would work. While it would address some problems—such as page position, it might create a very long ballot and, thus, lead to greater down ballot undervoting.

page with the other cabinet races. Three counties chose the first option, and the other three chose the second option. None of these counties put the attorney general's race on a page by itself. Thus the opportunities for creative ballot design were limited.

12.3 Machine Malfunctions

As noted by Stewart, if the problem isn't exclusively caused by voter error, then it must be the consequence of equipment malfunctions. In all the high undervote counties, machine problems abounded. In Lee County, 56 of 171 precincts on election day had machine problems that resulted in machines being repaired, closed, or never opened. In Sarasota, more than half of its 155 precincts had significant machine problems. We know that Sumter and Charlotte had similar problems, but neither county has sufficient records to give us any reliable numbers.

In this section, we have organized the discussion of machine problems thus: (1) screen and display problems and (2) power-related problems.

12.3.1 Screen and Display Problems

With optically scanned paper ballots, the machine is not involved in the presentation of the ballot to the voter. In contrast, with DREs, ballot format and machine performance are inextricably linked, making it difficult to separate the effects of screen malfunctions from those of the format or design of the ballot.

Consider how the performance of the equipment can affect the presentation of the ballot. Screen brightness, resolution, external lighting, and the angle of the display are all factors in how the ballot is viewed. In addition, whether the machine is functioning correctly will determine if the ballot is presented as designed—there can be lines across the screen, upside down text, blank screens, dark screens, flickering screens, rainbow screens, and so on. Further, the PEBs, which contain the ballot definition files, determine how the ballot is formatted and shown on the screen. So how the screens, display, PEBs, and other components of the machines function is crucial to the presentation of the ballot to the voter and to the voting experience. Unfortunately, it is also variable; on DREs, each voter's view of the ballot is potentially different.

12.3.1.1 Touch Screens, Humidity, and Nonlinearity

In 2003, Pivot International replaced all the Bergquist screens on the iVotronics it produced in its Manila factory. The recall was necessary because the screens, which were not designed to withstand high humidity, had become defective due to the poor environmental conditions in the Manila factory.

These defective screens had calibration problems that caused machines to be become nonresponsive or nonlinear—that is, go out of calibration. It is safe to assume that the legendary high humidity of south Florida would have made problems worse. In all, more than 20,000 screens were replaced.[25]

[25] Our records show that all screens were replaced in Sarasota and Sumter counties, including screens made by Microtouch. It is not clear what the counties were told about the recall.

While these screens were all replaced and changes were made to the design and process, it is still the case that Bergquist screens—and possibly all screens—are more likely to have calibration problems at the margins. Bergquist literature suggests a more exacting calibration procedure is required to ensure proper registration of touches near the edges of the screen. [26]

The attorney general's race in Charlotte, Sumter, and Lee and the CD-13 race in Sarasota were located near the margins of the screen. The attorney general's race was not only at the bottom of the page, but much closer to the bottom than most other races located similarly. Yet other races have been similarly located and not engendered these kinds of undervotes.

The question is whether other problems—such as low power or smoothing filter problems—could exacerbate these calibration problems at the margins. We know that power problems can affect the responsiveness of the screen. In fact, one of the first symptoms of a power problem is diminished responsiveness. Would that responsiveness be worse at the margins? Indeed, the SAIT report says that they found that the angle of the finger affected responsiveness. The angle would likely be more oblique at the margins, thus making it difficult to tell if finger angle or position was the cause.

Furthermore, all the counties in question were hit by hurricanes in 2004, a year after the screen replacements. Could the screens still be deteriorating because of exposure to heat and humidity? Perhaps other components are likewise susceptible to deterioration when stored and operated in a warm, humid climate.

12.3.1.2 Screen Problems During the Election

In Sarasota and Lee, we see the screen problems listed in the poll workers incident reports, zone tech reports, and conduct of election reports. In Charlotte and Sumter, these records are spotty at best. After months of requests, however, we were able to obtain many of Charlotte's maintenance records (although still not all). By comparing these records to the ones in Sarasota and Lee and taking into account the reports from voters and poll workers, we were able to determine that Charlotte seems to have experienced the same screen problems as these counties. We inspected maintenance records in Sumter and found evidence of the same problems and a few ones we had not seen before.

Like the other counties, Charlotte's maintenance schedule calls for Decision One to come on site to perform routine preventative maintenance once a year, usually in the late spring. Machines that have malfunctioned since the last annual maintenance are given a full QC (quality control) testing by Eric Smith or another Decision One employee. Based on this testing, the machines are either fixed or sent back to ES&S as RMAs (returned merchandise authorizations). In addition, if there are upgrades to software or hardware those may be installed at that time. For example, in the spring of 2006, the preventative

[26] *Bergquist Touch Screen Installation Instructions and User Guide*

maintenance sheets also included the installation of the motherboard batteries. Other maintenance times are scheduled as needed.

In 2005, the records show that Charlotte County began to experience problems with its Elo screens. In December 2005, the screens and assemblies of eight of these machines were replaced because of calibration problems. In May 2006, another Elo screen failed and was replaced in July. Yet another Elo screen came detached from the housing and had to be reattached in July as well. At the 2007 maintenance, at least six more screens were found to be bad. Unfortunately, we are still missing a few sheets from that maintenance. Since Mr. Horton has told us that the ones not supplied were ones that were being taken out of service rather than replaced, we assume some of them may also have bad screens. The maintenance sheets for 2007 are not the full QC sheets so they do not tell us the type of screen, but we believe they are likely to be Elo screens. It appears that Charlotte replaced at least sixteen (and perhaps more) of its Elo screens and assemblies during a period of a year and a half.

This problem with the Elo screens is reflected in the maintenance sheets from Sumter County. These show that Sumter replaced eighteen Elo screens between August 2006 and April 2007. Messages on the repair sheets indicate a number of responsiveness and calibration issues, including slow response, no response, calibration frozen, and unable to calibrate. The top half of the screen did not respond on two of the machines.

Other screen problems in the 2006 maintenance included slow response, no response, frozen screen, rolling screen, screen strobing, text upside down and backwards, and inverts on impact.

The upside, backwards text problem was addressed by fixing a video cable. Some slow response issues were addressed by cleaning the screen with Rid-Ox to eliminate oxidation. But most problems simply were listed as RMA (returned merchandise authorization) and sent back to ES&S.

Sarasota experienced a multitude of screen problems, of which slow response or extreme pressure to register selections and the missing vote on the review screen were by far the most common. Others included calibration problems as well as flickering, lined, frozen, blank, black, and dim screens. As mentioned above, some screen problems were clearly the result of other problems, such as low batteries or defective power supplies.

Lee County's incident and tech reports also show that many machines exhibited the slow response or excessive pressure problem. So far we have only found one complaint about a review screen problem, but that did, in fact, concern the attorney general's race. Lee experienced many of the same screen problems as Charlotte and Sarasota—horizontal lines; frozen, black, blank, and rainbow screens, and calibration problems.

Sumter County's Dark Screens

In addition to the slow response problems and screen replacements, Sumter County's maintenance records show a screen problem that we have not yet seen elsewhere—dark and very dark screens. These records show that prior to the 2006 elections many

machines were listed as having dark or very dark screens. These problems were likely the result of problems with the power inverter that bumps up the voltage to the backlight. These problems were addressed by "modifying the backlight power inverter for maximum output to the LCD display," according to the maintenance sheets. We are not sure how the power inverter was modified, but it seems that a setting was turned up to ensure that the backlight delivered maximum voltage to the display.

E-mails from Sumter elections to ES&S show that the county also returned 29 new iVotronics that had dark displays. It isn't clear whether these are the same sorts of problems as the old machines with dark displays or something different. We did discover, however that the machines have both "bright light" and "non-bright light" screens. The bright light screens are intended to be readable to bright light such as outdoors and would be suitable for such applications as displays on gas station pumps or on ATMs. Bright light screens use a reflective surface to light the screen. The downside of these screens is that they can appear washed out or dim in indoor settings.

Non-bright light screens are best indoors and use a backlight to provide the illumination for the screen. The downside of these screens is that they can be difficult or impossible to read in bright, outdoor lighting.

This problem was not seen in the other counties; however, Sumter's machine numbers suggest that it may have the oldest machines of the entire group. So perhaps these dark displays are a harbinger of failures to come. This subject will require additional research.[27]

12.3.2 Power-related Problems

With a touch screen machine, power supply affects nearly everything. When voltage dips because of a problem with the booth power supply or the batteries, it promptly affects the performance of the screen and display. It is the stick batteries that run the screen and display.

When the iVotronics begin running on battery power, they immediately go into a power-saving mode, much like a laptop computer. In this mode, they will not run the welcome or "splash" screen and revert from color to black and white. In between voters, the unit will also shut down to save power. Unlike a laptop, however, the iVotronic does not have a warning light or any other signal to tell poll workers that the machines are running on batteries. In fact, the absence of the welcome screen is often the first clue poll workers have that a machine is not getting power from the wall outlet.

The iVotronics's LCD displays require a substantial amount of voltage to operate properly. Unlike the touch screen controllers, which can run on less voltage than the batteries normally generate, the LCD displays have a high voltage inverter to bump up the voltage going to the fluorescent tube called the backlight, which is the source of

[27] Since writing this section, we have learned that the originally delivered iVotronics had two types of backlights, one of which was much brighter than the other. According to a Lake County election official, this was not disclosed by the vendor. Lake County discovered it had dimmer screens and thus asked to have all their machines replaced with ones with the brighter backlight.

illumination for the display. A good question would be: What are the consequences of low power for the brightness or resolution of the display?

12.3.2.1 Low Battery Messages and High Undervotes

The most unexpected discovery we made during our investigation of Charlotte's election concerned the connection between low battery messages and high undervote rates. A poll worker told us that his precinct had several machines that were exhibiting problems with responsiveness and missing votes from the review screen. Finally, one of the machines quit altogether. At that time, it was discovered that the machine's battery was completely dead. It was removed from the daisy chain and plugged in separately. (Up to five iVotronics are connected in series at the precinct.) The machines that remained daisy chained together continued to malfunction, but the machine that was separated from the others began to work properly.

This observation confirmed what we discovered in our examination of the event log—that low battery events correlated with exceptionally high undervote rates. Further, it also confirmed our observation that machines in the same precinct with a low battery machine also had very high undervote rates. In addition, it provided evidence that power supply problems could have exacerbated a variety of screen and display issues and triggered a problem that led to the review screen problem.

Evidence from the Event Log

An important resource for auditing elections on iVotronics is the event log. For each machine, this report indicates all actions or events on that machine. This includes the beginning terminal clear and test in which the machines are readied for use in the election through the closing of the machine at the end of election day or early voting. The opening and closing of the terminal, printing of zero and results tapes, error messages, and confirmation of votes being cast are all given a code and listed in this log. Therefore, we examined the messages on the event log to determine if they provided any clues to the machine problems. The following table shows the entries in Charlotte County's event log.

Table 7.2.1.2-1: Summary of Entries in Charlotte County Event Log

Code	Message	No of entries
1	Terminal clear and test	512
2	Terminal screen calibrate	14
4	Enter service menu	15
5	Service password fail	2
8	Date/time change	6
9	Terminal open	510
10	Terminal close	510
12	Audit upload	2
13	Print zero tape	126
14	Print precinct results	8
17	Votes recollect	1

Code	Message	No of entries
18	Invalid vote PEB	93
19	Invalid super PEB	37
20	Normal ballot cast	45,993
21	Super ballot cast	55
22	Super ballot cancel	116
27	Override	898
28	Override fail	6
36	Low battery lockout	35
37	Nonmaster PEB collection	3

The event log reveals a number of serious problems, such as the use of the override function to open and close machines during early voting, a machine that was not closed until November 14, and two machines with the wrong date. In addition, we see that there are no "Print precinct results" from election night. The eight recorded on the log are all from November 14, when the recount in CD-13 was done. While these are all very serious issues, it is not clear how these events would be related to high undervotes in the attorney general's race.

Low Battery Lockout. There is no warning when an iVotronic begins running on battery power. Batteries are supposed to last from two to six hours, but in practice, they are more likely to last closer to two than six hours. A low battery lockout message is not experienced until the iVotronic stick batteries are nearly dead.

The Charlotte County event log shows 35 low battery messages. Only two of the 35 low battery messages occurred during early voting. Our information about early voting is not sufficient at this point for us to evaluate the effect of these machines on early voting undervote rates. So the following analysis only concerns election day.

The remaining 33 messages occurred on election day on ten machines. Of these, one machine had no votes recorded, and the other had a low battery message only 40 minutes before closing. So we are left with eight machines that experienced low battery messages relatively early in the day—all prior to 2:00 p.m. on election day. One precinct had two machines with early morning low battery messages. Thus seven precincts were affected (about 9 percent of the total precincts).

All but one of the low battery machines had undervote rates higher than the median; that one machine had a rate at median. Looking at undervote rates on individual machines, however, can be misleading since most machines have fewer than eighty votes. Further, the number of votes on each machine varies considerably. Put simply, small variations in the number of undervotes produce large swings in undervote rates. To produce a more reliable measure, we calculated the undervote of all the machines together. That came to an astounding **31.25 percent**.

We also looked at the undervote rate of the precincts containing these machines. As mentioned earlier, we knew that the iVotronics were linked in what is termed a "daisy-

chain," with a maximum of five machines connected in this way. This revealed that the precincts that had low battery machines all had very high undervote rates. We also looked to see how their rates compared to the other precincts. In the following table the "Ranking" column indicates how the precinct's undervote compared to other precincts in Charlotte County. We considered 78 of Charlotte's 80 precincts in the ranking; two precincts were too small with only three voters in one and five in the other.

The results are clear. Precinct 73, with two low battery machines, had by far the highest undervote rate in the county, more than 40 percent. The second worst rate in the county was in precinct 36, another low battery precinct. Precinct 67 had the sixth worst undervote rate in the county. Thus three of the seven low battery precincts ranked in the top 10 percent for undervotes, and all ranked well within the top 40 percent in terms of undervotes.

Why Low Battery Messages Are Important

Low battery problems have plagued ES&S iVotronics for quite some time. In fact, a low battery message activated a bug in the machines in Miami-Dade County that caused it to scramble the entries in the event log, thus rendering it unusable for auditing the machines, which is the purpose of the log.[28] Dr. Doug Jones, a renowned computer expert from the University of Iowa who discovered the problem in Miami, told us that *low battery problems could interact with other machine problems to create unpredictable, bizarre results.*

Another problem exhibited by these machines in the past is the failure to record a low battery message when the machine batteries were in fact run down. The vendor says that this problem has been resolved. Unfortunately, the vendor has been known to claim that problems have been fixed when they have not. We cannot help but wonder if other machines in Charlotte had battery problems that did not show up on the event log. Further, low battery messages occur only when the battery is nearly dead. Machines may operate with low power for quite some time without being detected.

In fact, we notice in counties that have zone or field tech reports that when machines had response problems or screen anomalies the tech's first response was to reset the battery and check for other power problems. Often the problem was resolved by these actions or by replacement of the battery or power supply. In most of these precincts, no low battery message was ever displayed.

Defective Batteries or Power Supplies?

Even if the machines were running on batteries because of power problems, why did the batteries run down so quickly? Shortly before the election, Charlotte County replaced all of its "stick" batteries at a cost of $138.10 per machine, for a total of $84,931.50. Were these batteries checked either prior to or subsequent to installation to ensure that they were fully charged for the election? We don't know. The Charlotte County supervisor of elections has informed us that the batteries were installed during the clearing and testing for the election (presumably the primary) and that there is no paperwork for

[28] "More Bugs Show Up in Florida."

these maintenance activities. Regardless, the new batteries should not have failed during the election; however, in instances in Ohio and North Carolina last year, up to one third of the ES&S batteries supplied for optical scanners were reported to be defective.[29]

The stick batteries used in the iVotronics consist of six rechargeable batteries, held together in a plastic sleeve. As most of us know, over time these batteries lose their ability to hold a charge. Their capacity to hold a charge is also affected by how they are recharged, stored, and handled. Further, if any of the six batteries is defective, the machine will not receive sufficient voltage to operate on battery power.

But perhaps the most relevant question is this: Why were these machines running on batteries anyway? In many cases, the machines may have been on battery power because poll workers did not plug them in properly or failed to plug them in at all. In other cases, the low battery messages indicate some power supply issue that has necessitated the switch over to battery power. The real problem may be faulty power supplies.

The power supplies are AC converters, similar to the ones used by laptop computers. Most of us who use laptop computers will never replace our power supplies, even though our computers receive much more use than do voting machines, which are typically used for only a few days once or twice a year. In the case of the iVotronics, however, the power supplies are located within the iVotronic booth, which also serves as the carrying case. In the booth, they are encased in plastic foam as a means of protecting the equipment during transport. As anyone with a laptop computer knows, however, these power supplies become very hot. Unfortunately, the foam casing serves as insulation to prevent the dissipation of the heat. The Sarasota zone tech told us that he believed that the failure of these power supplies might be due to excessive heat caused by this poorly thought-out design.

Before the election, Charlotte County ordered 15 power supplies; a few months after the election, it ordered 70 more of the supplies. That means that the county replaced nearly 14 percent of its power supplies in less than a year. A zone tech worker in Sarasota County who helped prepare the iVotronics there for election day told us that when they tested the power supplies before the election they found that many were defective. Even so, zone tech and incident reports in Sarasota County from election day show that power supplies still failed on election day.

Lee County's conduct of election report for the 2006 general election offers additional clues. It states that they had at least a dozen machines with "white" screens due to dead batteries, even though they also replaced all their stick batteries just prior to the election. Their conclusion is that the problem lies in some way with the booth power supply. We counted at least 15 such machines.

Their problem log from election day shows the extent of the problems. One field technician was charged with changing batteries as he made his rounds.

[29] Citation. (Document)

Sarasota had similar problems. Although all batteries and many power supplies were replaced just before the election, Sarasota zone techs were busy all day long, replacing batteries and power supplies.

Touchscreen Controllers and Low Battery Messages

We have also recently discovered additional reasons for concern with the low battery problems. According to the SAIT report, the touchscreen controller, the programmable microcontroller that determines the X and Y coordinates for each touch selection and sends them to the main processor, also sends the battery voltage messages. If the device were experiencing a number of problems simultaneously—smoothing filter problems along with fluctuating voltage readings, the main processor could have been bombarded with interrupts that interfered in some way with the communication with the processor. This lends credence to the possibility that two simultaneous problems affecting the function of this device could have interacted to produce unpredictable results—such as the failure to transmit selections in the attorney general's race to the processor.

According to a representative of a leading manufacturer of touch screens,[30] the touchscreen controller is not normally used to transmit battery voltage messages or to turn the backlight on and off as indicated in the SAIT report. This suggests that the touchscreen controller is not a commercial-off-the-shelf (COTS) product as indicated in the state certification, but designed specifically to work with the iVotronic. If this is true, the device should have been tested and certified with the iVotronic. Only COTS devices do not require certification.

Following up on this lead, Warren Parrish, a Sarasota County elections activist, contacted makers of the touchscreen controllers. A spokesman from Hampshire Company revealed that the company had previously negotiated with ES&S to make touchscreen controllers for the iVotronics. He said that ultimately ES&S informed them that it planned to make its own controllers in order to save money. The Hampshire spokesman expressed doubt that ES&S had the expertise to make such a sensitive, sophisticated device. With what we now know about the production of ES&S touch screens, this decision seems even more problematic.

A spokesman from Elo, a manufacturer of touch screens used in some iVotronics, indicated that using a non-Elo touchscreen controller with their touch screens could result in problems with responsiveness because of conflicts in the software. He explained that their controllers contain their own software to govern response times and that using a smoothing filter in the firmware, as indicated by ES&S in its August 15 letter, could result in a conflict that would produce a longer response time.

13. MARTIN COUNTY

Martin County, which uses the same voting equipment as the high undervote counties, fared much better in the 2006 election. Undervote rates in four of its six top-of-the-ballot races were at or below the state median. The two races at the bottom of the statewide

[30] Hampshire Company

portion of the ballot had somewhat higher undervote rates than the state average, but the difference was only a few percentage points—nothing like the enormous differences in Charlotte, Lee, Sarasota, and Sumter.

Table 9.1: Undervote Rates for Martin County's Top-of-the-Ballot Races, by Voting Mode

Race	Polling		Early Voting		Absentees	
	Ballots Cast	UV%	Ballots Cast	UV%	Ballots Cast	UV%
U.S. Senate	28,298	1.37	15,946	1.00	9,042	1.55
U.S. Representative	28,032	1.13	15,848	1.00	8,981	2.03
Governor	28,298	0.85	15,946	0.63	9,042	0.85
Attorney General	28,298	3.68	15,946	2.53	9,042	2.52
Chief Financial Ofc.	28,298	7.30	15,946	8.53	9,042	3.09
Com. Of Agriculture	28,298	7.62	15,946	8.66	9,042	4.35

So we looked at the basic data from Martin County to see if we could figure out why it avoided the same massive undervote rates as its counterparts. We inspected incident and zone tech reports as well as precinct level results, the event log, ballot images, and the system logs to see if we could find clues to the difference in outcome.

What we found was surprising. Contrary to our expectations, we found that Martin County experienced significant machine problems on election day, most of which were related to slow or delayed response. We also found that in at least some circumstances these problems appeared to be related to somewhat higher undervote rates in the two races in which the county experienced higher than average undervote rates. We also found interesting partisan patterns to the undervotes.

Perhaps, most significant, however, was our finding that Martin County dealt with its screen problems very differently from the other counties. We believe this holds an important clue to why Martin County's undervotes did not skyrocket like those in Charlotte, Lee, Sarasota, and Sumter.

13.1 Background

Martin County lies just below St. Lucie County on the southeastern coast of Florida. It is smaller than Lee, Charlotte, and Sarasota, but larger than Sumter. Like the other counties in this report, Martin uses the 12" iVotronics for its primary voting equipment. It too purchased its machines after the 2000 election. Like the other counties, the screens on its iVotronics were also replaced in the massive recall of defective Bergquist screens, beginning in late 2003.

Unlike Charlotte, Lee, and Sarasota, Martin did not replace stick batteries before the election. Martin also uses a different contractor—Next Technologies—to provide maintenance for its iVotronics and other voting equipment.

13.2 The Ballot

Like the other counties, Martin used a single column format; however, it placed both the congressional race and the gubernatorial race on pages by themselves. The cabinet

races—attorney general, chief financial officer, and commissioner of agriculture—were listed on a separate page—like Sarasota's placement of these races. Martin County also used a single column format for its ballot, but Martin did not experience high undervote rates in its congressional race or in the attorney general's race.

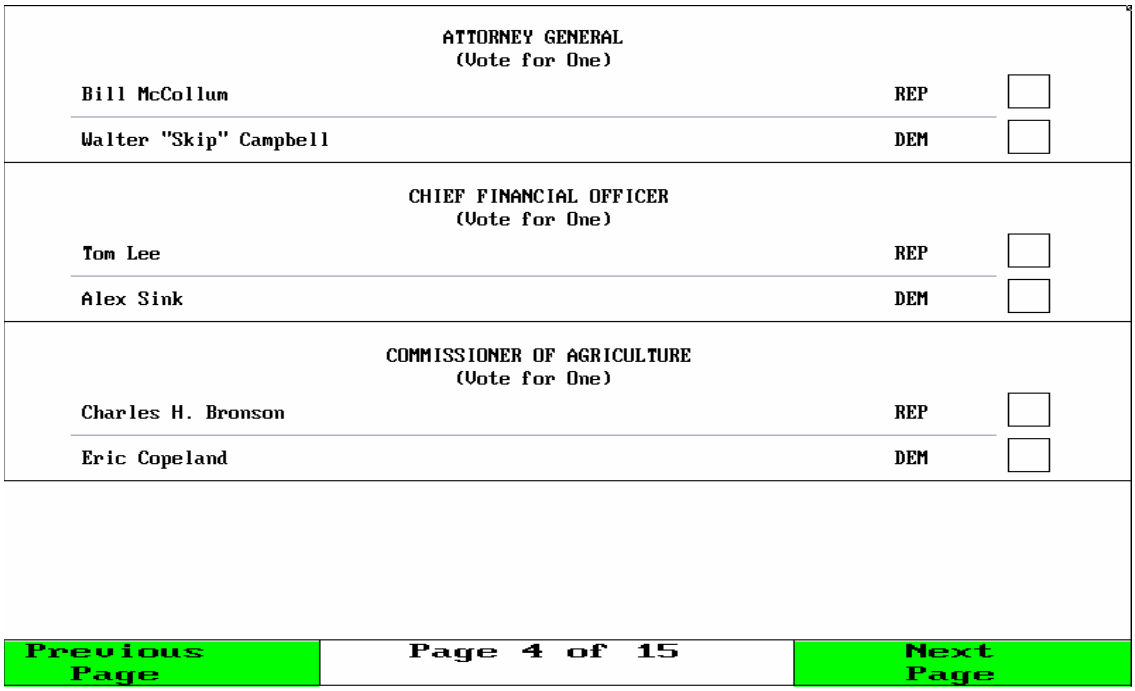

Figure13- 1. Martin County Ballot, Page 4*

*Note: Most Martin County ballots had these races on page 4. Some ballots had these races on page 3 because ballot style #4 did not feature a congressional race.

13.3 Machine Problems and Actions Taken

Both precinct incident reports filled out by precinct clerks and zone tech reports filled out by staff assigned to address machine problems during the election show that many of Martin's precincts had problems with slow or delayed response machines.

About a third of Martin's precincts (19 of 53) reported significant problems with their machines. At least sixteen precincts explicitly reported screen response problems, including precincts 7, 9, 14, 16, 18, 20, 21, 28, 30, 32, 33, 36, 38, 42, 44, and 47. The event log shows that three other precincts—5, 29, and 48 had screen problems that resulted in re-calibration of at least one machine, but were not reported on zone tech reports.

While Martin experienced the same problems as the other counties what it did in response was very different. It calibrated the screens—sometimes repeatedly, to get them to work properly. Zone tech notes indicate that this measure was often effective in

alleviating the problem—at least for awhile. Martin's event log shows a total of 78 terminal screen calibrate messages, 75 of which are from election day. In contrast, Lee County, which is about three times larger than Martin, has only five such messages—none of which are from election day. In Charlotte County, there were only eight such messages on election day. Sumter had two such messages. Sarasota, which is slightly smaller than Lee County, had six calibrate messages from election day.

Each of these counties experienced the slow or delayed response problem that the vendor had described as a smoothing filter issue with the firmware. Each had been alerted to expect the problem, yet Martin is the only county that responded to slow response problems by calibrating the machines—often repeatedly. Why? Is it perhaps because the other counties did not believe that calibration would help because they had been assured the problem was not a screen issue?

13.4 ADA Machines—Not Available for Regular Voters

As in Charlotte, Lee, and Sumter, Martin County poll workers were told that the ADA machines were not to be used for regular voters. This was a departure from previous policy, which allowed the machines to be used generally for all voters.

The question is why? In Martin County, we pick up additional clues for why the machines were off limits. Here we are told explicitly that you cannot pull up a regular ballot on the machine. Poll workers who question the problem are told that the audio ballot cannot be "bypassed." In response to our question about the problem with the ADA, we were told by deputy SOE Debbie Dent that the coding was visible on the regular ballot and that was confusing to voters. When asked to explain, she noted that commands for centering text of other such formatting commands were visible.

As in Charlotte County, this meant considerable pressure on other machines in some of the smaller precincts. For example, in precinct 28, there were only three machines. One was an ADA that was not available for use by regular voters. One of the other two experienced serious problems all day long. That left only one functioning machine for regular voters.

13.5 Precincts 16, 25, and 28—Real Problems

Incident reports, tech logs, and the event log all reveal that the most problematic precincts were 16, 25, and 28, which had multiple machine failures that persisted throughout the day. All three precincts also had higher-than-average undervote rates in the CFO and COA races.

In precinct 16, four of its five machines experienced problems during the day—including the ADA machine. In this precinct, they clearly ignored the directive not to use the ADA machine. They could hardly have done otherwise under the circumstances. Two machines had slow response or calibration problems, one failed to advance through ballot pages, and another malfunctioned and had to be reset. Only one machine managed to make it through the day without malfunctioning.

Precinct 25 had an ADA machine and five regular iVotronics. Its ADA only recorded one vote. Of the remaining five machines, four had response problems that required recalibration. Three of the four required multiple recalibrations during the day. *In this precinct the zone tech report explicitly states that the problem was that the calibration was off.*

Precinct 28 only had three machines—an ADA machine and two others. One of the machines malfunctioned throughout the day—voters complained that it required three or four tries to get selections to take. Poll workers had problems with a provisional ballot on the machine and said that items 5 and 6 in the instructions did not show up on the screen. Because of these problems, the remaining machine recorded an incredible 137 votes—many more votes than most precinct iVotronics.

13.6 Undervotes in the CFO Race

The undervote rate for the CFO's race for the state of Florida was 5.19 percent. In Martin County, the rate was 6.96 percent. On election day that rate was 7.30 percent. However, it varied considerably from precinct to precinct.

In the above mentioned precincts with considerable screen problems, the undervote rates in this race were 9.00 percent for precinct 16, 13.28 percent for precinct 25, and 14.50 percent for precinct 28. These are well above the median rate for the county as well as the state rate.

Unlike the other counties, this race is not in the margins of the ballot. It is precisely in the middle of page 4 of the ballot (or page 3 on a few hundred ballots).

An examination of the ballot images reveals some interesting patterns in the undervotes in this race. First, nearly all the undervotes in the CFO race are paired with an undervote in the following commissioner of agriculture race. So we are to believe that voters chose to vote for attorney general at the top of the page, skipped the next two races, and then voted the remainder of the fifteen page ballot.

The partisan makeup of the undervoters is extremely interesting. A large portion of the undervoters are straight party voters—either Democrats or Republicans—who voted for all other races but CFO and COA. Since Martin is largely a Republican County, most of the undervoters are Republicans.

Machine #113581 from precinct 28 (a heavily Republican precinct), which malfunctioned all day long, is a good example. There were 124 ballots cast on this machine, despite its considerable problems. There were five undervotes in the Senate race, 1 in the congressional race, 3 in the governor's race, 7 in the AG's race, and 21 each in the CFO and COA races. Of those 21 undervotes in the CFO's race, only two were not paired with an undervote in the COA's race. Fifteen of the 21 undervotes were on ballots where there were only Republican selections.

The following chart shows the undervotes in this race on this machine:

No. Pattern (Senate, House, Gov, AG, CFO, COA)

10 R R R R U U
3 U R R R U U
1 R R R U U R
1 R R R U U U
1 R I R U U R
1 D R R R U U
2 D R D U U U
2 D R D D U U

The other machine in precinct 28 shows a similar pattern. That machine has an astounding 137 ballots recorded. There are sixteen undervotes in the CFO race. The pattern is as follows:

No. Pattern (Senate, House, Gov, AG, CFO, COA)

8 R R R R U U
1 R R R R U R
1 I R R R U U
1 U R R R U U
1 U R U U U U
1 D R R R U U
1 D R D R U U
1 D D D U U D
1 D D D D U U

Precinct 16, which is a Democratic precinct, is also extremely interesting. It had five machines—an ADA and four regular machines. Unlike the other precincts, they appear to have used their ADA since it has 32 ballots on it. Of those there are only two undervotes, but both follow the pattern shown above—R R R R U U. On four of the five machines Democrat Alex Sink beat Republican Tom Lee decisively. On the fifth machine, Lee won by a comfortable margin. The machine on which Lee won is the only one in the precinct that did not experience problems and the only one without a higher than average undervote rate. On all the machines the great majority of the undervotes are from straight party voters—17 of 28 undervotes come from straight party voters who undervoted in both the CFO and COA races.

Precinct 25, also a Democratic precinct, had very similar patterns. Interestingly, four of the five regular machines in that precinct had exactly the same number of undervotes in the CFO race—14. Undervotes in this precinct also were heavily weighted toward straight party voters.

13.7 Lessons from Martin County

The conclusions here seem obvious—Martin County recalibrated all screens that exhibited a slow response. Some were calibrated more than once. Sometimes, it didn't help, and the machine had to be taken out of service, but often it did, and these machines were used without incident from that time on.

Still, Martin County did have somewhat higher than average undervote rates in the CFO race, and in at least some cases, those higher rates seemed to be related to the screen problems. Further, those undervotes were disproportionately composed of straight party undervoters. Because Martin is so heavily Republican, most of the straight party undervoters were Republican also, but it was difficult to tell if the numbers were proportional to their representation in the overall population of voters.

14. SCREENS, BALLOTS, AND BUGS

14.1 Defective Screens Again?

In this search for the causes of the massive undervotes on the iVotronics in Florida's 2006 election, we have had to remind ourselves of the old adage "If it walks like a duck and quacks like a duck, it might be a duck." The same holds true here. Given that the problems experienced by voters all had to do with the screens, numerous screens were replaced both before and after the election, and the machines have a history of screens problems, then perhaps the problem lies in the screens, not the smoothing filter.

After most of our research had been concluded, we received a packet in the mail from Lee County that contained the back pages of incident reports that had inadvertently been missed when they were originally photocopied. One of them provided the final clue that pointed toward screen calibration as one of the culprits. The poll worker claimed that a friend of his came in to vote who was a computer expert. So he asked him to vote on their slow response machine and tell him what was wrong with it. The voter said right away that the problem was with the calibration. He drew a diagram to show how the box and the active spot on the screen were not lining up. Here we have the ultimate testimony—a person who was both a voter and a computer "geek" and who tested the machine at the time and recorded his conclusions.

It fit perfectly with what we had just learned from Martin County. It seemed that Martin County's problems did not escalate into astronomical undervote rates because their problem race was in the middle of the page and because they repeatedly recalibrated the machines.

Why didn't the other counties recalibrate their slow response screens? Because they believed that the problem was in the firmware—the vendor told them so. In fact, in Lee County, when one poll worker asked if anything could be done about the slow response of one of his machines, he was told that nothing could be done. Others were explicitly told that it was a firmware issue. Given that their problem races were at the margins of the ballot, recalibration might not have helped, but again, it might have.

We also learned during this investigation that Lee County was the ES&S client, mentioned in the smoothing filter letter, as sending iVotronics to be evaluated because of slow response problems. But Lee County also sent machines for evaluation that were listed as having dead spots on the screen. A few days later, ES&S sent out the now infamous "smoothing filter" letter. But, according to computer experts, the symptoms in the letter didn't add up to a smoothing filter problem.

We looked at maintenance records in 2007, when the machines were repaired that were used in the 2006 election. We saw no mention of smoothing filters, but we did see many screen replacements. The "smoothing filter" letter said that ES&S planned to make changes to the firmware and have it re-certified before the November election, but that never happened. In fact, there has been no mention of smoothing filters since the election.

14.2 What about the Ballot Format?

No doubt, the placement of races near the margins of the ballot and on the page with the high-profile governor's race caused some people to miss the attorney general's race; however, we believe this number to be relatively small. Absent screen calibration problems, this format could have been expected to contribute only a percentage or two to the undervote rate.

14.3 Low or Fluctuating Power Conditions

We have noted that Charlotte, Lee and Sarasota all replaced their stick batteries, as well as many of their power supplies, just before the election. Yet a substantial number of iVotronics in all three counties were running on batteries on election day. In precincts in which this was not discovered by technicians, machines stopped functioning altogether. Many more machines probably ran on batteries intermittently, without detection. In Charlotte, low battery messages showed a positive correlation with extremely high undervote rates.

In Sarasota and Lee, technicians concluded that the power problem related to the booth power supply in some way. It is possible, therefore that the power supply to some machines fluctuated considerably, causing a variety of problems, including screen response issues.

14.4 Maintenance and Aging Machines

Another difference between Martin County and the high undervote counties is their maintenance contractor. Martin County uses Next Technologies. Lee, Charlotte, Sarasota, and Sumter all use Decision One. This one company maintains thousands of machines stretched across hundreds of miles. Indeed, the maintenance sheets make it clear that a single individual seems to have the major responsibility for maintaining and repairing all the iVotronics in southwest Florida. With escalating problems and costs, it must have been difficult to maintain high standards.

14.5 A Bug in the PEBs?

Screen calibration and other machine problems will not, however, account for the exclusivity of the problem—that is, why was only one race on the Charlotte ballot affected (and in the other counties as well)? As pointed out by Dill and Wallach, erratic behavior suggests some sort of bug. That is the only explanation that we know of that can account for the variability of the problems. The most obvious suspect would be the PEBs as they hold the ballot definitions and the ballot seems to have been the source of the problem. Many, many people have access to the PEBs, and they are easily popped into a pocket or purse. The SAIT report explains the ease with which a virus could be

spread through the infection of just one PEB. And the report says that it could be done by a single individual.

The bug could have been introduced accidentally into the PEBs and inadvertently spread through the collection of these PEBs to replace their batteries or during other maintenance activities. If someone did attempt to influence the election through a virus spread by the PEBs, there is the possibility that it was incompetently done. Thus, it is possible that the effects of the virus were not as intended.

Further, machine problems such as screen calibration problems, smoothing filter software conflicts, defective booth power supplies, and screen illumination issues could have interacted with and exacerbated the effects of the bug such that a multiplicity of unintended consequences ensued.

Yet no one has examined the PEBs—not the FSU scientists, the state and county officials, nor the legion of computer experts that have written on the CD-13 race. In Sarasota, the PEBs used for the recount were not ones that were programmed for the election, so any problems related to those PEBs would not have been discovered.

We highly recommend an inspection of the PEBs used by the high undervote counties during the election to determine if they are implicated in this massive disenfranchisement of Florida voters.

14.6 Hardware/Software Conflicts

The problems coincided with the use of the new firmware. With all the various components replaced on these aging machines, the potential for conflicts between the hardware, along with its software and drivers, and the new firmware seems high. Yet no one to date has done the sort of dynamic analysis of the firmware that would check for these kinds of conflicts.

14.7 Long Lines

Machine problems led to long waits during early voting and on election day. When voters wait for extended periods to vote, they are less likely to take the time to resolve a problem finding a race or even to notice that a race is missing or to check the review screen. So machine problems can cause undervotes indirectly as well as directly.

15. RECOMMENDATIONS

In 2008, all Florida counties will be required to use optically scanned paper ballots for all voters, except the visually disabled. By 2012, these voters also must be accommodated by verifiable paper ballots. We are indebted to newly elected Governor Charlie Crist for this bold step to bring fair, accurate, and verifiable elections to Florida. But, while it is a necessary condition, it is not sufficient. It is not enough to have paper ballots—we must use them to audit our elections and to restore voter confidence. Finally, we need nonpartisan and competent election administration at the state and county level that places the interests of voters above those of the vendors. When that happens, the other problems will take of themselves.

APPENDIX A: SOURCES AND ASSUMPTIONS

Electronic voting machines are sometimes referred to as "black boxes," for the reason that what actually goes on within them is hidden from view. The vendors exacerbate this inherent problem by insisting that any meaningful examination of the machines constitutes a violation of their proprietary rights. Thus, all that we know about the performance of these machines is based on two sources: the interface with human beings (voters and poll workers) and the data and reports that the machine spits out at the conclusion of the election.

The most important and reliable information about the problems with an election comes from those who directly participated in the election—poll workers, technicians, candidates, campaign workers, and voters. After all, how do we know when there is a problem with an election? Even when results seem to be consistent with expectations, if large numbers of participants report problems, then the election is flawed and should be investigated. It is important to emphasize this fact because many of the reports and studies concerning the Sarasota CD-13 election seek to find explanations without giving due credence to the contemporaneous accounts of the voters themselves. This is a serious shortcoming. No explanation of the undervote problem can be satisfactory if it does not comport with the experiences of those who were there.

Consequently, for the purposes of this investigation we assume that contemporaneous accounts by voters and poll workers are the most reliable sources of information. After-the-fact accounts are also very valuable, although not necessarily as reliable because a person's memory can be affected by the stories of others. Therefore, for each of the subject counties we requested incident reports, election day telephone logs, zone tech reports, cast/cancel ballot logs, and correspondence from voters about problems.

In Charlotte County, we were able to go beyond these sources and solicit information directly from voters, candidates, campaign workers, and others. In response to an article about our efforts in the local paper, a number of Charlotte voters contacted us to tell us about their experiences. In addition, we called several people who had witnessed incident reports provided by the supervisor of elections. We are fortunate to have accounts from poll workers, campaign workers, a candidate, and ordinary voters who reported problems to the elections office during the election, thus giving us a contemporaneous account of what happened. On July 11, we held a forum in Charlotte County to allow more voters to come forward with their stories. Unfortunately, attendance was poor (due to conflicting public events), but we did hear new stories and presented the results of our research.

This more in-depth approach was essential in Charlotte because of the dearth of election records kept by the elections office and reluctant, incomplete, and slow compliance by the supervisor of elections. Acquiring the necessary public records and information from the Charlotte County elections office was a difficult and protracted process. We discovered that, unlike Sarasota and Lee Counties, which have an abundance of records, the Charlotte elections office does not routinely maintain many normal elections records, such as election day telephone logs, cast/cancel ballot logs, iVotronic custody sheets,

and zone tech logs. Only a handful of incident reports were available from Charlotte, even though we were informed by poll workers and voters that they had called and written about their complaints. A Charlotte poll worker told us that incident reports about machine problems were discouraged.

Lee County had by far the best records, although they were more expensive to acquire than those in the other counties. Compliance with our requests was not swift but it was fairly complete. Records in Sumter County were not as extensive, but the supervisor of elections and her staff were prompt, forthright, and courteous in meeting all our requests.

The lack of uniformity in records—both in the type and the diligence with which they are kept—makes comparisons across counties more difficult. Further, the failure of some elections offices to comply with requests completely and promptly makes the process of acquiring records time-consuming and costly.

In addition to the records listed above, we asked each of the counties for a wide variety of records related to voting system performance. These included a variety of electronic files such as event logs, ballot image logs, undervote image logs, various computer system logs, and summary and precinct-level results. We also requested maintenance records, correspondence with the vendor, invoices, and a variety of other records. We also communicated personally, via e-mail, telephone, or in person, with supervisors of elections for the various counties. We also asked for all of these same records from the September 2006 primary.

We were also fortunate to have available to us the copious evidence and analysis available on the CD-13 race in Sarasota because of our executive director's involvement in the investigation of that race. Further, we have an extensive collection of records from the 2004 election across Florida that includes records from Sarasota and Sumter. For a full list of the sources on which this report is based, please see the list of references.

As indicated in the acknowledgments at the beginning of this report, Dr. David Dill, founder of Verified Voting and professor of computer science at Stanford University, graciously offered to analyze the Charlotte ballot images for us, using the same program he used for his analysis of the Sarasota ballot images. Dr. Dill also provided machine totals for all machines used for the general and primary elections. We also sought the advice of numerous other experts in electronic voting technology and related fields. Election results and other data were obtained from the state division of elections and county websites, as well as through public records requests to these entities.

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- EL155.lst—iVotronic ballot image log, November election
- EL155U.lst—iVotronic undervote image log, CD-13 race
- EL155U.lst—iVotronic undervote image log, attorney general's race
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- Incident reports
- iVotronic repair and maintenance records, 2006 and 2007
- Precinct reconciliation forms
- Telephone logs
- Voter registration disk

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- EL155—iVotronic ballot image log
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- EL155—iVotronic ballot image log
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Susan R. Pynchon, executive director, Florida Fair Elections Center
Mac Horton, supervisor of elections, Charlotte County, Florida
Sharon Harrington, supervisor of elections, Lee County, Florida
Karen Krauss, supervisor of elections, Sumter County, Florida
Debbie Dent, deputy supervisor of elections, Martin County, Florida
Gary Beauchamp & Tim Durham, deputy supervisors of elections, Collier County
Dan Dehn, deputy supervisor of elections, Lake County
Melba Hamilton & Brian Corley, deputy supervisor and supervisor of elections, Pasco County
Warren Parrish, activist, Sarasota County
David Dill, professor of computer science, Stanford University
Doug Jones, professor of computer science, University of Iowa
Numerous poll workers, zone techs, and citizens of Charlotte and Sarasota Counties

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