**Submission to the New York State Board of Elections on the
Proposed Standard for the Minimum Number of Voting Machines**

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Introduction

In April 2007, the New York State Board of Elections formally proposed a standard for the minimum number of voting machines required in each polling place as is required by New York State Election Law §7-203 (2)[1]:

> 7-203 (2) Notwithstanding any provision of law to the contrary, the state board of elections shall establish, in accordance with subdivision four of section 3-100 of this chapter, for each election, the minimum number of voting machines required in each polling place and the maximum number of voters that can vote on one voting machine. Such minimum number of voting machines shall be based on the voting machine in use, taking into account machine functionality and capability and the need for efficient and orderly elections and, in the case of a general or special election, the number of registered voters, excluding voters in inactive status, in the election district or, in the case of a primary election, the number of enrolled voters, excluding voters in inactive status, therein.

Unfortunately, the standard the Board proposed of one DRE for every 550 registered voters is demonstrably far too high and will condemn voters in New York State to long lines and waiting times at the polls, and the resulting voter disenfranchisement that comes with it.

Since the discussion on this standard began in 2006, New Yorkers for Verified Voting has authored three separate reports which have been formally submitted to the Board for consideration. This final paper will discuss some new material and review the findings from our previous reports. The reports themselves are included in the Appendix, and should be considered part of this submission.

The findings from our earlier reports are clear. Computer simulations of voter arrival times, surveys of other states DRE to voter ratio, and data collected during the 2006 General Election from an upstate New York county all demonstrate that *no more than 200 registered voters can be served by a single DRE.*

There is abundant evidence that the Board's current proposal of 550 voters per DRE is a recipe for disaster. If the current proposal is imprudently adopted and the State Board of Elections is called to account for the resulting debacle, they will not be able to say "we had no way to know this would happen."

Four Components of this Submission

This paper is divided into four sections plus Appendices which contain reports previously submitted to the New York State Board of Elections on to this topic:

- [Refutation of the formula used to determine the Board's proposed 550 voters per DRE ratio.](#)

- [Analysis of the actual ratio of voters per DRE using queuing theory.](#)

- [The Columbia County study of voter arrival times in the 2006 General Election.](#)

- [Voter to DRE ratios used by other states](#).

- [Conclusions](#)

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[1] http://www.elections.state.ny.us/NYSBOE/hava/Voting_Machines/6210.19Regs05302007.pdf

1) Refutation of the Formula Used to Determine the Board's Proposed 550 Voters per DRE

How did the New York State Board of Elections determine that 550 voters per DRE should be the proposed standard? It applied a simple formula to data results from a study it commissioned from American Institute of Research (AIR).[2] Unfortunately, the Board is employing a flawed formula using flawed data from a flawed study.

Problems with the AIR study

The AIR study, which was never completed but left in "Draft" status,[3] drew much criticism from the public for its failure to ensure that DRE voters checked VVPATs, sloppy time keeping methodology, and other study design problems. Even AIR itself acknowledged multiple limitations of the study, such as its lack of consideration for the impact of voters with disabilities on waiting times.[4] But the fundamental flaw of the AIR study is that it does not address the critical question: *How many voters can use each voting machine in one day?*

The AIR study neither takes account of nor makes any attempt to reconcile the impact of uneven voter arrival rates and the well known problem that a large percentage of voters arrive during the peak periods of the Election Day in the morning and early evening hours. Rather, AIR measures only the time spent by individuals on each voting machine. It then divides this time into the total Election Day (900 minutes) and determines what it calls the "maximum daily rate". But voters do not arrive at the polling place in precisely evenly spaced intervals throughout the day. Peak voting times must be taken into account.

The AIR study results are therefore a large overestimate of the number of voters that can actually use any voting machine without creating long lines. More discussion of the limitations of the AIR study can be found in the NYVV's earlier submission, "Estimating the Number of Voting Machines for New York State's Polling Places" which is reproduced in the Appendix.[5]

Problems with the Board's Formula

The formula used by the State Board to determine the 550 voter per DRE number is simple but critically flawed. It compares the AIR study trimmed mean results of 337 voters per lever voting machine to the current New York State standard of 800 voters per lever machine, and determines a ratio from these numbers. It then takes the AIR trimmed mean results for each DRE in the study and applies the same ratio, which results in 550.

$$\frac{\textbf{[AIR report Lever Machine] }337}{\textbf{[NYS Lever Machine Standard] }800} = \frac{231\textbf{ [AIR report DRE]}}{550\textbf{ [Proposed DRE Standard]}}$$

The concept is that we know two things about lever machines: the number currently mandated by law, 800 registered voters per lever machine; and the AIR result, 337 voters per lever machine. The formula used by the Board attempts to normalize the AIR findings based on the legal and historical 800 registered voters per lever machine.

In essence the Board's formula says this: if the AIR study says a lever machine can serve 337 voters per day, and New York State says a lever machine can serve 800 voters per day, the AIR study results are off

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[2] DG Norris and CA Paulson, American Institutes for Research,
  "New York State Voter System User Rate Assessment Study", 12/11/2006, 2006.
   http://www.elections.state.ny.us/NYSBOE/hava/DRAFTAIRSTUDY.pdf 1/4/2007.

[3] It remains unclear why the State Board decided to leave the AIR study unfinished, particularly as the cost of the study was reported to be nearly $300,000! Why spend this much taxpayer money and then not require that the study be completed?

[4] On page 39 they say that these "estimates [for voters using disability aids] may be misleading" because they don't know if their sample is representative. In fact, they don't have any data on any correlation between the nature of the disability and the voting time.

[5] William A. Edelstein, Ph.D., New Yorkers for Verified Voting
"Estimating the Number of Voting Machines for New York State's Polling Places"
 http://www.nyvv.org/newdoc/VotingMachineNumbersForNYS.pdf

by a factor of 2.75. We can then multiply the AIR results for other voting systems by the same factor to determine the actual number of voters that each of those systems can handle.

While appealing in its simplicity, this formula fails for a number of reasons:

1) As noted above the AIR study results are questionable and take no account of the crucial factor – number of voters arriving at peak voting times. As the well known computing phrase states, "Garbage in, garbage out".

2) The Board's formula assumes that the AIR lever machine results are off by a precisely measurable amount (in this case, 2.75), and that DRE results are off by exactly the same amount. But there is no basis for the assumption that a linear relationship exists between the data gathered for these vastly different voting machines.

3) Few if any New York State lever machines serve the full 800 voters allowed by law. Indeed, it is quite common, particularly in upstate New York, for there to be fewer than 600 registered voters assigned to each lever machine. The current state standard of 800 voters per lever machine is a legal standard that works out in practice because actual voter turnout is much lower than that. The actual number of voters served by a voting machine on Election Day is a practical standard. The Board is using *a legal standard* where *a practical standard* is required.

4) The formula compares apples to oranges. It assumes that voting on a lever machine is identical to voting on a DRE, but this is clearly not the case. Among other tasks not found on mechanical lever machines - DREs require voters to verify the printed VVPAT, verify an electronic review screen, adjust screen factors (font size, color, language), and possibly use accessibility features.

2) Analysis of the Actual Ratio of Voters per DRE Using Queuing Theory

If simplistic formulas cannot provide the answer, how then do we arrive at a reasonable standard for the minimum number of voting machines?

In November 2006 New Yorkers for Verified Voting submitted "New Voting Systems for New York – Long Lines and High Cost."[6] Author William Edelstein used computer simulations and the mathematics of queuing theory to calculate the effects of higher voter arrival rates during peak voting times. Queuing theory is the mathematical study of waiting lines:

> "The theory permits the derivation and calculation of several performance measures including the average waiting time in the queue or the system, the expected number waiting or receiving service and the probability of encountering the system in certain states, such as empty, full, having an available server or having to wait a certain time to be served.

> Queuing theory is generally considered a branch of operations research because the results are often used when making business decisions about the resources needed to provide service. It is applicable in a wide variety of situations that may be encountered in business, commerce, industry, public service and engineering. Applications are frequently encountered in customer service situations as well as transport and telecommunication..."[7]

As can be seen, queuing theory is the methodology best suited to predict the effects of high voter arrival times during peak voting hours. In his analysis Dr. Edelstein notes:

> "Queuing theory in this case uses voter arrival rate, the number of available machines, the time for each voter to vote and the machine breakdown rate to predict the probability of forming long lines during Election Day and overtime at the end of the day."

When we account for the effects of peak voting periods our computer simulations predict that New York's DRE to voter ratio must be set no higher than 200 voters per DRE. This is over 2.5 times less than the Board of Elections proposed 550 voters!

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[6] William A. Edelstein, Ph.D., New Yorkers for Verified Voting
"New Voting Systems for New York – Long Lines and High Cost"
http://www.nyvv.org/doc/voterlines.pdf
[7] http://en.wikipedia.org/wiki/Queueing_theory

The NYVV queuing theory analysis makes clear that it is critical that peak voting times and voter arrival rates be considered if unacceptably long voter waiting times are to be prevented. And as will be seen in the following sections, data collected from a New York county and other states confirm that 200 voters per DRE is indeed the only reasonable standard.

3) The Columbia County Study of Voter Arrival Times in the 2006 General Election

Computer simulations are good for making predictions, but we must have confirmation from the real world in order to have confidence that the simulations accurately reflect reality. In the November General Election of 2006 the [Columbia County Board of Elections undertook a study](#) [8] to determine how many voters could be expected during peak times. The study was released in April 2007 and sent to all county election commissioners and the State Board of Elections. The Columbia County study independently confirmed the predictions of the queuing simulations which NYVV had submitted to the State Board of Elections.

The methodology used was simple. Commissioner Ken Dow explains:

> "In order to measure actual voter flow, we asked our inspectors to count and record the number of voters who arrived at each polling place during each 2-hour interval throughout the day at the 2006 General Election. We got data from 56 of our 58 Election Districts."

The Columbia County study is the only New York Board of Elections at the state or county level to gather concrete data on voter arrival rates during an actual election. The comprehensive data is assembled into a [spreadsheet](#) showing voter arrival rates for each two hour period and uses the data to make projections about waiting times and the numbers of machines required to handle peak voting times. [9] The data show some important facts about voter arrival times [*emphasis added*]:

> "*The most important information we learned is that during the 15-hour General Election, between 20 and 25 percent of all voters typically went to the polling place during the peak 2-hour period. A* second important finding was that the results from the different polling places were very consistent with each other. In the great majority of polling places, the peak period was between 4:00 and 6:00 PM. In several polling places the busiest time was between 8:00 and 10:00 AM, and a few polling places peaked at other times."

In an important corroboration of the NYVV analysis cited in the last section the Columbia County study showed the queuing theory prediction of 28 voters per hour at peak voting times was on average, exactly correct.

The results of the Columbia County study give further weight to NYVV's assertion that more than 200 voters per DRE will result in lines, long waits, and voter disenfranchisement. Further evidence supporting our analysis is the experience and practice of other states that have used DREs for years.

4) Voter to DRE ratios used by other states

Since many states have already begun using DREs, it is worth inquiring what voter to machine ratios are being used elsewhere. In May 2007 New Yorkers for Verified Voting submitted to the State Board of Elections a survey of other states titled "[Survey Data on the Number of Voters per DRE in Other State Jurisdictions](#)."[10] Author Marge Acosta notes:

> "Jurisdictions in DRE states report problems with long lines, even those using far fewer voters per DRE than the New York State proposal. In order to get some guidance from the practices of other states already using DREs, I contacted election officials in six jurisdictions – Lincoln, Tennessee; Cheyenne, Colorado; Carson City, Nevada; Esmeralda, Nevada; Clark, Nevada; and Palm Beach, Florida – to determine what ratios of registered voters to DREs they use, the length of time spent waiting in lines at the polls, and other relevant data."

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[8] "Study of Voter Flow at the 2006 General Election, Columbia County, NY"
  Ken Dow, Commissioner of Elections, Columbia County
  http://www.nyvv.org/newdoc/county/StudyOfVoterFlowAtThe2006GeneralElection04-27.pdf
[9] http://www.nyvv.org/newdoc/county/VoterFlowStudy2006GE-Final.xls
[10] "Survey Data on the Number of Voters per DRE in Other State Jurisdictions"
  Marge Acosta, NYVV Long Island Representative
  http://www.nyvv.org/newdoc/StateTimingData.pdf

Once again, the survey results confirm both the queuing theory analysis and the Columbia County voter arrival rate study. Of the six jurisdictions surveyed, 5 used voter to DRE ratios of less than 213 per voter, with one as low as 74. The sole outlier was Lincoln, Tennessee which used a standard of 328 voters, still 222 less than the New York State Boards proposal of 550 voters per DRE!

The usage data is compelling as observed in the following table from the study:

County and State	Registered Voters	Vendor and DRE	VVPAT	Average Number of Registered Voters per DRE
Lincoln, TN	18,000	ES&S iVotronic	No	328
Cheyenne, CO	1277	Hart eSlate	Yes	213
Carson City, NV	25,000	Sequoia AVC Edge	Yes	184
Clark, NV	803,808	Sequoia Edge II	Yes	179
Esmeralda, NV	667	Sequoia Edge	Yes	74
Palm Beach, FL	779,748	Sequoia Edge	No	175

Again we see data consistent with the idea that New York State must set the minimum number of voting machines to be no more than 200 voters for DRE systems.

5) Conclusions

Consider the consequences of assigning too many voters to a DRE voting machine. At the peak hours in the morning and evening rush, lines begin to form early and quickly get longer and longer. Voters become increasingly agitated as the waiting times go past a half hour to an hour, then an hour and a half. Machine breakdowns, all too common with DREs, cause further delays and force voters who have already waited too long to the back of other lines. Many who have come to vote can wait no longer and must return to pick up children or go to work, leaving the line angry that they have been denied their right to vote by an insufficient supply of machines. The results of the election are called into question, and the candidates and parties mount legal challenges which may keep the election undecided for months.

This doesn't have to happen. But if the New York State Board of Elections adopts the current proposal of 550 voters per DRE, it inevitably will. As demonstrated in this report, the formula used to determine the Board proposal is fatally flawed, a simplistic formulation using uncertain data and erroneous assumptions to arrive at an unjustifiable conclusion.

On the other hand, computer simulations based on mathematical models of waiting lines and real world data from a New York county and other states around the nation show that no more than 200 voters should be assigned to each DRE. The theory predicts it, and the real world data confirms it. There can be no mistake.

If the State Board of Elections gets this decision wrong it will be responsible for what will be seen as the worst disaster in New York State voting history. The evidence is clear and there is no room for error. It now falls to the New York State Board of Elections to evaluate the data, reject simplistic answers, and require an ample number of voting machines in each polling place. If they get it wrong in spite of the compelling evidence, they will have to answer to the public, and to history.

Appendix A

Previous Submissions to the New York State Board of Elections

and Supplemental Materials

As noted in the text, New Yorkers for Verified Voting has made several earlier submissions to the Board on the subject of the minimum numbers of voting machines. These earlier submissions are included again as part of this paper. The document with the full text of all submitted reports and supplementary material is available for download here:

http://www.nyvv.org/newdoc/NYVVMinNumberVotingMachines091507FULL.pdf

Due to the large download size of the full submission, we provide this smaller version which lists only the online links to these documents.

1) NYVV Submission to the New York State Board of Elections
   November 2006
   William A. Edelstein, Ph.D., New Yorkers for Verified Voting
   "New Voting Systems for New York – Long Lines and High Cost"

   http://www.nyvv.org/doc/voterlines.pdf

2) NYVV Submission to the New York State Board of Elections
   January 2007
   William A. Edelstein, Ph.D., New Yorkers for Verified Voting
   "Estimating the Number of Voting Machines for New York State's Polling Places"

   http://www.nyvv.org/newdoc/VotingMachineNumbersForNYS.pdf

3) NYVV Submission to the New York State Board of Elections
   March 2007
   "New York State BOE Proposal for Numbers of Voters per Machine Guarantees
   Long Lines and Voter Disenfranchisement"

   http://www.nyvv.org/doc/Resp070326.pdf

4) NYVV Submission to the New York State Board of Elections
   May 2007
   "Survey Data on the Number of Voters per DRE in Other State Jurisdictions"
   Marge Acosta, NYVV Long Island Representative

   http://www.nyvv.org/newdoc/StateTimingData.pdf

5) Columbia County Board of Elections Study
   May 2007
   "Study of Voter Flow at the 2006 General Election, Columbia County, NY"
   Ken Dow, Commissioner of Elections, Columbia County

   http://www.nyvv.org/newdoc/county/StudyOfVoterFlowAtThe2006GeneralElection04-27.pdf

   http://www.nyvv.org/newdoc/county/VoterFlowStudy2006GE-Final.xls