Written Statement of Charles Stewart III
Kenan Sahin Distinguished Professor of Political Science
Co-Director of the Caltech/MIT Voting Technology Project
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Chairman Hicks, Vice-Chair Masterson, and Commissioner McCormick, thank you for the opportunity to speak today about allocating resources in polling places for in-person voting.

I am a professor of political science at MIT, where I have taught and conducted research about American politics for thirty-one years. For the past decade, I have also been the co-director of the Caltech/MIT Voting Technology Project (VTP).

In its 2014 Report, the Presidential Commission on Election Administration (PCEA) noted that "[t]housands of service-related businesses across the country deal with [challenges similar to running polling places] every day. General knowledge about how to meet these location-specific challenges is well known in the fields of industrial engineering and management science. The challenge is marrying more completely these common management tools with the election process."

This call to marry more completely common management tools with the election process led the PCEA to request that the VTP host on its web site a set of online tools that could be used by election officials to plan how many resources — such as poll books, voting booths, and tabulators — they would need in order to keep lines down to the Commission's benchmark of no longer than 30 minutes. The VTP has continued to maintain these tools, which may be accessed by visiting either web.mit.edu/vtp or www.supportthevoter.gov.

After the Commission issued its report, the Democracy Fund agreed to support a research and dissemination project undertaken by the VTP that is aimed at extending these tools even further, and learning how the techniques of management science might be applied to in-person voting. We call this project the Polling Place of the Future project (PPOTF). Through the Polling Place of the Future project, I have come to understand even more completely how the tools of management science can be helpful in guiding local officials as they seek to manage polling place resources more effectively. It is largely based on the experience I have gained working on the PPOTF project that I make my remarks today. [1]

1. INTRODUCTION

The allocation of resources to polling places came under new scrutiny in the 2012 presidential election, when long lines at the polls on Election Day prompted President Obama to declare, in his Election Night victory speech, that "we have to fix that." Despite considerable effort by election officials and the broader election administration community to tackle the problem of

[1] The Democracy Fund has been very generous in supporting this research and the accompanying outreach, but it bears no responsibility for the content of the project's work or for this written statement.

long lines, news reports from the 2016 presidential primary season raise the possibility that not enough has been done to fix the problem of long lines, despite the common sense recommendations of the PCEA and the national uproar over lines in 2012. The worst-case speculations suggest that Election Day[2] lines in 2016 will be no shorter than in 2012, and in fact, may be longer.

I am more optimistic than many observers of American elections about whether 2016 will be a repeat of 2012, as far as lines are concerned. However, reports of long lines in this current presidential primary season are a wake-up call to everyone — election officials, voters, citizen groups, the political parties, and legislators — about the risks of complacency. The November general election is fast approaching. Yet, it is still possible to do the planning required to deliver the needed resources to in-person polling places in time, and to make sure that the necessary data will be collected in November to make assessment and future planning even more successful.

Systematic planning for polling place resource allocation can be thought of as two processes, pre-election planning and post-election assessment. When it comes to allocating resources that matter most for whether lines are long or short, tremendous progress can be made by focusing on a small number of critical elements.

For pre-election planning, these basic elements are (1) the arrival pattern of voters on Election Day, (2) average times for voters to complete tasks that create bottlenecks (such as casting a ballot), and (3) the number of resources (poll books, voting booths, etc.) available to deploy to each polling place. For post-election planning, these elements are even fewer: (1) the average number of voters waiting in line during the day and (2) the number of voters who cast a ballot during the day.

Of course, it is possible to add complexity and nuance to the data gathered, and thus, the analysis that is done. However, if all local election officials were to commit to the systematic gathering of the data mentioned in the previous paragraph, we would be well on our way to managing the challenges of polling place resource allocation.

I elaborate on how these simple data elements can be used for pre-election planning and post-election assessment below. Before doing that, it is useful to make a distinction between what I call “planning for the predictable” and “planning for the unpredictable.”

2. PLANNING FOR THE PREDICTABLE AND THE UNPREDICTABLE

When lines are long at a polling place, the reason is simple: resources are inadequate to handle the number of voters who have turned out. However, the simplicity of the diagnosis hides the

[2] The issue of polling place resource allocation is relevant whenever there is in-person voting, whether it be on Election Day itself or during an early voting period. The long-term trend has been toward less Election Day voting and more early voting and voting by mail. It is reasonable to predict that between 2/3 and 3/4 of voters who participate in the November 2016 election will do so by showing up in person. My commentary is relevant to both Election Day and early voting. For the sake of simplicity, however, the text of this report refers primarily to voting on Election Day, with the exception of certain comments that are relevant to the transition from Election Day to early voting.

complex reality that resources can be inadequate for many reasons. It is helpful to start by dividing the reasons why resources can be inadequate into the predictable and the unpredictable.

A predictable reason for a long line might be that the only available public building within the geography of a precinct is too small to hold an adequate number of poll books and voting booths — so small that even perfectly executed planning couldn't keep lines under control. Another predictable reason might be that the amount of time to check in a voter or the amount of time it takes to fill out a ballot has been significantly underestimated. The tool kit provided by management science is especially good for managing these types of predictable issues.

While my focus in this statement is on planning for the predictable, a word must be said about planning for the unpredictable.

Even if an election official has rationally identified and analyzed all the factors that go into assigning resources to precincts, has proposed a plan to minimize lines, has gotten that plan funded, and then has implemented the plan flawlessly on Election Day, we can still predict that something unpredictable will happen. (By "unpredictable" in this context, I mean something that falls outside the models used by industrial engineers to manage queues.) A bomb scare or a fire alarm might empty the school where the voting occurs. A candidate's get-out-the-vote effort might deliver a busload of voters to the wrong precinct. Half of a precinct's workers might contract an aggressive virus on election eve. An electronic poll book might not boot-up.

Even though such "predictably unpredictable" circumstances always arise on Election Day, they can still be anticipated and managed as a general matter. For example, local election officials might believe it's highly probable that some fraction of their precincts will experience a significant malfunction, they just don't which ones until the polls actually open. By systematically gathering information about the number and type of polling place crises that produce significant service interruptions, local officials can plan by at least setting aside a certain number of resources to be deployed as needed when unpredictable difficulties unfold on Election Day.

Recognizing that all election officials must plan for contingencies that are inconceivable before they happen, most of what happens on Election Day is quite conceivable. It is to these more regular dynamics that I address the rest of my statement.

3. PLANNING FOR THE UPCOMING GENERAL ELECTION

If we divide the analytical portion of resource allocation into two parts, pre-election planning and post-election assessment, then the first thing to consider is pre-election planning.

As I mentioned in the introduction to this statement, the VTP has posted on its Web site a suite of tools that local election officials can use to help them determine the number of basic resources, like poll books, that are needed to keep wait times down to below the PCEA-set benchmark of 30 minutes. In addition, last November we released a report that discussed these tools, both their intellectual justifications and their practical applications. This report, *Managing*

Polling Place Resources, may be downloaded at:
http://web.mit.edu/vtp/Managing%20Polling%20Place%20Resources.pdf.

As the *Managing Polling Place Resources* report notes, so-called M/M/c queuing models are well adapted for guiding local officials to calculate the number of resources needed to manage the influx of voters likely to arrive on Election Day. (M/M/c models are explained in *Managing Polling Place Resources.*) The Web tools references above, particularly the "Graves-Yuan" and the "Pelczarski" tools on the site, allow officials to generate precise recommendations about the resources needed at their polling place based on just a few inputs.

However, it should also be said that in my experience, local officials often do not have a good handle on all of the elements needed to make maximum use of these tools. The most common missing link is knowing how long it takes voters to accomplish certain tasks, such as checking in, casting a ballot, and scanning a ballot. The *Managing Polling Place Resources* report provides some suggestions about how these quantities might be estimated by local officials.

The important point is that successful planning depends on estimating service times with some precision. It is insufficient simply to arrive at estimates using rules of thumb. Precision matters.

This point is illustrated by Figure 1, which is attached. In this figure, I use the Graves-Yuan planning tool from the VTP Web site to estimate the average wait time for a voter who is checking in at a precinct that expects an arrival rate of 100 voters per hour and that has two poll books to handle the load. I have shown four different check-in times: 40 seconds (0.67 minutes), 50 seconds, (0.83 minutes), 60 seconds, and 70 seconds (1.17 minutes). Note that when the average check-in time is 50 seconds, the average wait time is 0.8 minutes. When the average check-in time grows to 60 seconds, average wait time grows to 2.3 minutes. But, when the check-in time grows by another 10 seconds, to 70 seconds, the average wait time balloons to 22.5 minutes, and over a quarter of voters wait more than 30 minutes to check in to vote.

As Figure 1 clearly illustrates, measuring service times with precision is a critical task to be performed by election officials when they plan for Election Day. Simply applying seat-of-the-pants estimates will be inadequate, especially in those cases where the jurisdiction is teetering on the edge of having enough resources to manage expected turnout.

4. LEARNING FROM THE PAST ELECTION

Just as important as planning for an election is assessing how well things went after the election. It is clear that one of the reasons it has been so difficult to get long lines under control is that line length is not regularly measured by local jurisdictions. Very few local officials have programs in place to systematically assess how long lines were on Election Day. As a consequence, there is scarce evidence about exactly which precincts have the worst problems. This, in turn, makes it virtually impossible to identify the factors that lead to long lines, particularly the "predictably unpredictable" problems I identified above.

In the absence of precise data, the world of election administration has had to make do with limited or, even worse, misleading data.

In the realm of limited, but useful data, I would place the Survey of the Performance of American Elections (SPAE), which I have administered since 2008.[3] The SPAE asks respondents (200 registered voters from each state) how long they waited in line to vote in the most recent federal election. From such a survey, we can gain important information about waiting in line at a very general level.[4]

Information that is the least useful, from the perspective of understanding what leads to long lines and how they might be created, are news stories, which are often accompanied by a photo of people waiting to vote. While news coverage of long lines can be helpful in exposing the problem of long lines, news stories are typically anecdotal, and are likely to focus on unusual circumstances surrounding lines, rather than the commonalities.

If local officials are to assess after an election whether they had a problem with long lines, there is no substitute for actually measuring the length of lines at polling places. While this might seem like a daunting task, I have worked with counties across the country that have implemented programs to track directly the length of lines. It doesn't create an undue burden to have a poll worker record, on the hour, how many people are standing in line to vote. With that data recorded, coupled with data about how many people voted on Election Day, one can use Little's Law to calculate precisely how long the average voter waited in line to vote. (Little's Law is probably the most fundamental mathematical law within the field of queuing theory.) Little's Law tells us that the average time waiting to check in is equal to the average queue length divided by the arrival rate of voters.

Figure 2 reproduces a coding form that is being used in Virginia for the 2016 elections. The form can be adapted for the times when polls open and close in other states. I recommend that all jurisdictions to adopt this form and to commit to requiring poll workers to fill it out.

5. ACTIONS THAT LOCAL OFFICIALS CAN TAKE NOW TO BECOME MORE SYSTEMATIC ABOUT ALLOCATING RESOURCES TO POLLING PLACES

I conclude by noting the actions, and the accompanying data, all local officials should be taking to plan for the upcoming federal election and then to assess how well things went afterwards.

All local officials should check, well before the November election, that they have allocated enough poll books, voting booths, scanners, and voting machines to each precinct so that virtually every voter can vote in less than 30 minutes. The online tools that appear on the VTP Web site, which were identified above, can be used to conduct this check.

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[3] The Pew Charitable Trusts has generously funded the SPAE since its inception. Pew bears no responsibility for the analysis of the SPAE that I provide in this statement.

[4] The following New York Times data graphic summarizes some of the most important general findings about long lines during the 2012 presidential election: http://www.nytimes.com/interactive/2013/02/05/us/politics/how-long-it-took-groups-to-vote.html?_r=0.

What most local officials will find challenging about conducting this pre-election assessment is getting reliable estimates of service times at bottlenecks, such as the check-in table and voting booths. This challenge can be overcome with a little additional planning and outreach to the community. Local officials should run mock elections with representative groups of citizens in their community and measure how long it takes to perform election-related tasks such as checking in and casting ballots. There is no substitute for doing direct observation and using a stopwatch to do the timing.

All local officials should also implement a system of data gathering on Election Day to capture the length of lines on a regular basis — at least hourly, and even more frequently, if possible. This involves including coding sheets, such as the one reproduced in Figure 2, in the materials that are distributed to precinct workers on Election Day, and also including the data-gathering process in pre-election poll worker training. After the election, this data can readily be entered into a spreadsheet and analyzed to find average line lengths and, ultimately, the average waiting time for each precinct.

In closing, I thank the EAC for helping to draw attention to the simple steps that localities can take, even at this seemingly late date, to ensure that polling place resources are adequate to handle the surge of voters we expect on Election Day. I am personally committed to lending my assistance to the EAC in its future work on this matter, especially in its efforts to encourage the use of data and systematic analysis to manage polling place resources.

Figure 1. Example of how small changes in service times can lead to large changes in the length of lines at polling places.

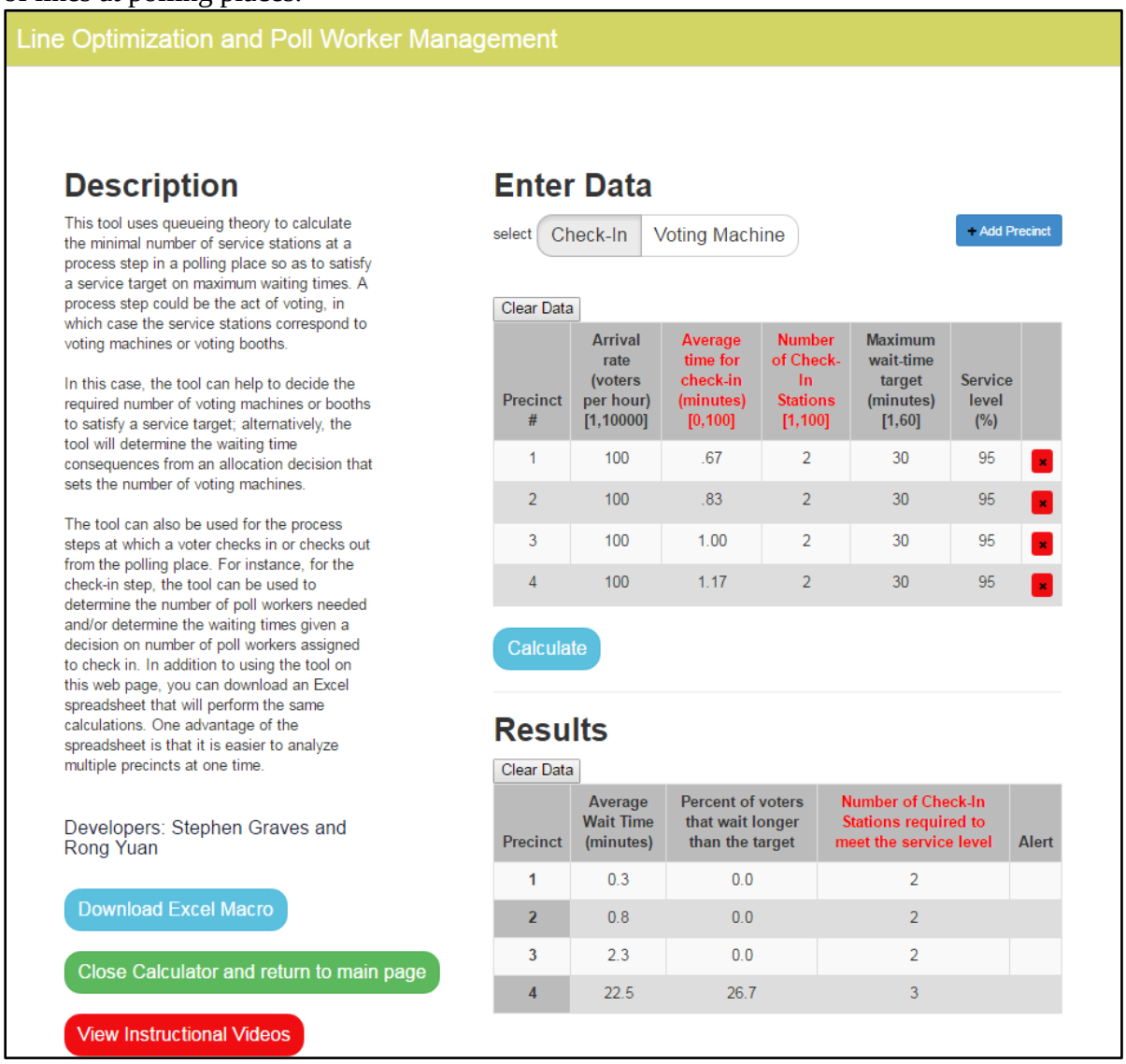

Figure 2. Coding form for gathering data about line lengths, to be used in Virginia in November 2016.

Form 1

Line Length Data Collection Sheet
[Jurisdiction]
[Date]

Precinct number/name: _____

Instructions. Please use this sheet to record the number of people standing in line to check in to vote *plus* the number checking in at the indicated times, along with the number of poll books available to accept voters to check in.

If there is no one standing in line at the indicated time *and* no one checking in, please enter a zero ("0").

If you are unable to record the line length at a particular time, enter an "X" in the corresponding space.

Time	Number in line†	Number of poll books
When polls open*		
7:00 a.m.		
8:00 a.m.		
9:00 a.m.		
10:00 a.m.		
11:00 a.m.		
12:00 noon		
1:00 p.m.		
2:00 p.m.		
3:00 p.m.		
4:00 p.m.		
5:00 p.m.		
6:00 p.m.		
7:00 p.m.		

†Include the number checking in at that time.

At what time did the last voter check in to vote? _____

*If the polls opened at some time other than 6:00 a.m., indicate that time here: _____

[Instructions for returning the form]