IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF GEORGIA
ATLANTA DIVISION

DONNA CURLING, ET AL., **Plaintiffs,** **v.** **BRAD RAFFENSPERGER, ET AL.,** **Defendants.**	**Civil Action No. 1:17-CV-2989-AT**

DECLARATION OF ANDREW W. APPEL
IN SUPPORT OF MOTION FOR PRELIMINARY INJUNCTION

ANDREW W. APPEL, declares, under penalty of perjury, pursuant to 28 U.S.C. § 1746, that the following is true and correct:

1. My name is Andrew W. Appel.

2. My background, qualifications, and professional affiliations are set forth in my curriculum vitae, which is attached as Exhibit A. I have over 40 years' experience in computer science, and 15 years' experience studying voting machines and elections.

3. I am the Eugene Higgins Professor of Computer Science at Princeton University, where I have been on the faculty since 1986 and served as Department Chair from 2009-2015. I have also served as Director of Undergraduate Studies, Director of Graduate Studies, and Associate Chair in that department. I have

served as Editor in Chief of ACM Transactions on Programming Languages and Systems, the leading journal in my field. In 1998 I was elected a Fellow of the Association for Computing Machinery, the leading scientific and professional society in Computer Science.

4. I received an A.B. (1981) from Princeton University *summa cum laude* in Physics, and a PhD (1985) from Carnegie Mellon University in Computer Science.

5. I have taught undergraduate and graduate courses at Princeton University in programming, programming languages, software engineering, election machinery, software verification, and formal methods.

6. I have testified on election technology before the U.S. House of Representatives (subcommittee on information technology, 2016), the New Jersey legislature (several committees, on several occasions 2005-2018), the Superior Court of New Jersey (Mercer County, 2009; Cumberland County, 2011), the New York State Board of Elections (2019), the Freeholders of Mercer County (2017 and 2019) and Essex County (2019).

7. I have published over 100 scientific articles and books, including many papers on computer security and several papers on voting machines, election technology, and election audits.

8. I have served as a peer-review referee for the Usenix Electronic Voting Technology workshop.

9. I am not being compensated for my work related to this matter. I expect that my expenses, if any, will be reimbursed.

10. I have read the Declaration of Juan E. Gilbert in this case, dated 13 November 2019. His Declaration is remarkable for what he does *not* say.

11. Between November 2018 and March 2019 I conducted a research collaboration with Professor Rich DeMillo of Georgia Tech and Professor Philip Stark of U.C. Berkeley, leading to the publication of our joint paper, "Ballot Marking Devices (BMDs) cannot assure the will of the voters," (by Appel/DeMillo/Stark) released in April 2019. Our research analyzes the consequences of an important study by DeMillo, Kadel, and Marks released December 2018 entitled "What Voters are Asked to Verify Affects Ballot Verification: A Quantitative Analysis of Voters' Memories of Their Ballots."

12. Professor Stark's Declaration focuses on the scientific results of these two papers. Professor Gilbert does not attempt to rebut the key findings of these papers: BMD-marked ballots are not adequately voter-verified, and thus BMD-for-all-voters elections are not secure.

13. The DeMillo/Kadel/Marks paper describes two different studies, two separate aspects of the same question. (1) Do voters review the ballot-cards produced by BMDs before they insert those cards in the optical scanner? and (2) How much can they remember about what contests were on the ballot?

Measurements of real voters in a real polling place in Tennessee answered question 1 as, "47% of voters are seen *not to look at the paper at all,* and the other 53% look at the paper *for an average of 3.9 seconds, even though there were 18 contests on the ballot."* Interviews with those same voters outside the polling place showed that the answer to question 2 is, "not very accurately."

14. In our April 2019 paper we analyze the consequences of Finding 1, that most voters hardly examine the BMD-marked paper ballot at all. Finding 2 was interesting but not consequential to our analysis.

15. Our analysis asks: if few voters examine their BMD-marked paper ballots, then what? Surely *a few* voters will examine their ballot, so that if the BMDs have been hacked to steal 10% of the votes, and 10% of the voters carefully examine their ballots, and half of those voters are not too timid to alert a pollworker when they notice something wrong, then only *1 in 200 voters* will alert a pollworker. You might think, "these voters caught the BMD cheating red-handed, surely there will be consequences!" But our analysis demonstrates that there can be no consequences: the BMD will have succeeded in stealing many votes; election officials cannot invalidate elections just because a few voters claimed their ballot was wrongly marked.

16. Professor Gilbert, in paragraph 63 of his Declaration, calls the DeMillo/Kadel/Marks paper a "flawed" study, and *all* of his criticisms of it

concern Finding 2. He does not address or dispute Finding 1 at all: most voters don't even look at the paper. It is Finding 1 that is most important, and on which we based our further analysis.

17. Some of Professor Gilbert's own very recent research is motivated by exactly these problems that the Appel/DeMillo/Stark paper and the DeMillo/Kadel/Marks paper identified in Ballot-Marking Devices. In April 2019 he publicly proposed a "ballot-marking verification protocol"[1] and in May 2019 proposed a "transparent interactive printing interface for voting."[2]

18. *Both of Professor Gilbert's new studies are premised on the existence of a real problem with voter verification of BMD-marked ballots.* Professor Gilbert avoids criticizing Finding 1 of the DeMillo/Kadel/Marks paper, and he does not address the Appel/DeMillo/Stark paper at all, even though this result is a central point of Professor Stark's Declaration, and Professor Gilbert does address other points of that Declaration.

19. These two of Professor Gilbert's research projects have not yet produced results that are usable in real elections, but they illustrate that he takes seriously the problem that we identified with BMDs, and that he did not rebut in his declaration.

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[1] Ballot Marking Verification Protocol, by Juan E. Gilbert, Ph.D., http://www.juangilbert.com/BallotMarkingVerificationProtocol.pdf The document is undated but I first saw it on April 13, 2019.

[2] Transparent Interactive Printing Interface for Voting, by Juan E. Gilbert, Ph.D., https://hxr.cise.ufl.edu/PrimeIII/TIPI/TransparentInteractivePrintingInterfaceForVoting.pdf The document is undated but I first saw a version of it on May 12, 2019.

20. This absence of rebuttal—from an expert demonstrably familiar with the substance of both papers—speaks volumes. There is a real problem with BMD-marked paper ballots: voters don't inspect them, and if a voter says there's an error, there's no way to prove it.

21. In paragraphs 72-75, Professor Gilbert addresses the "Curling Plaintiffs' Exhibit 4: Paper authored by Appel, DeMillo, and Stark." In these paragraphs he states that he disagrees with our *policy conclusions* (that voters who can hand-mark an optical-scan paper ballot should be permitted to do so), but he does not say that he disagrees with our *scientific conclusion:* "Risk-limiting audits of a trustworthy paper trail can check whether errors in tabulating the votes *as recorded* altered election outcomes, but there is no way to check whether errors in how BMDs *record* expressed votes altered election outcomes. The outcomes of elections conducted on current BMDs therefore cannot be confirmed by audits."[3]

22. In paragraph 59, Professor Gilbert is simply and obviously wrong. He is responding to Professor Stark's statement that "Bugs, misconfiguration, or malicious hacking can cause the BMD to print something other than the selections the voter made on the touchscreen or accessible interface. Hand-marked paper ballots do not have that vulnerability." Professor Gilbert writes, "This is simply not true." But it very simply is true, on the face of it. Bugs, etc. cannot cause a BMD to print wrong

[3] This is a direct quotation from the abstract of the paper.

selections on a hand-marked paper ballot. Hand-marked paper ballots do not have that vulnerability.

23. In paragraph 61, Professor Gilbert writes, "I disagree with Dr. Stark that hand-marked paper ballots are 'strongly software independent.' " We can simply look at the definition. Rivest defines[4]: "A voting system is *software independent* if an undetected change or error in its software cannot cause an undetectable change or error in an election outcome." They define, "A voting system is strongly software-independent if an undetected change or error in its software cannot cause an undetectable change or error in an election outcome, and moreover, a detected change or error in an election outcome (due to change or error in the software) can be corrected without re-running the election."

24. Hand-marked paper ballots are software independent because no change or error in *software* can affect what the voter marks on the paper, and no change or error in *software* can affect what the human recounters or auditors see on the paper. Professor Gilbert is simply wrong on this point.

25. In paragraph 62 Professor Gilbert points out that badly designed paper ballots can lead to substantial unintended undervoting by voters, as in Broward County,

[4] Rivest, Ronald L. "On the notion of 'software independence' in voting systems." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 366.1881 (2008): 3759-3767.

Florida. This is true; I've written about this myself.[5] He neglects to mention that badly designed touchscreen ballots can *also* lead to substantial unintended undervoting, as in Sarasota, Florida.[6] There are Federally recognized guidelines for good ballot design;[7] whether for hand-marked ballots or for BMD touchscreen layout, election administrators would be wise to follow them.

26. In paragraph 38 Professor Gilbert writes, "In theory, a scanner could be programmed to reject an overvoted ballot…" This is more than just theory, it is the practice in many states (e.g., New York) that use precinct-count optical scan of hand-marked ballots. Voters *are* protected against overvote mistakes; BMDs have no accuracy advantage in this respect.

27. In paragraph 39 Professor Gilbert claims that BMDs have advantages in "Auditability, Recounts, and Voter Intent", but several of his specific examples are inapposite or simply wrong.

28. In paragraph 39A Professor Gilbert opines that hand-marked paper ballots cannot be audited because some voters might make imperfect marks, but many states can and do successfully perform audits of hand-marked paper ballots (Colorado,

[5] Florida is the Florida of Ballot-Design Mistakes, by Andrew W. Appel, November 14, 2018. https://freedom-to-tinker.com/2018/11/14/florida-is-the-florida-of-ballot-design-mistakes/

[6] What Happened in Sarasota County? by David Jefferson, December 3, 2008. National Academy of Engineering: https://www.nae.edu/19582/Bridge/VotingTechnologies/WhatHappenedinSarasotaCounty.aspx

[7] Effective Designs for the Administration of Federal Elections, Section 3: Optical scan ballots. U.S. Election Assistance Commission, 2007. https://www.eac.gov/assets/1/1/Effective%20Designs%20for%20the%20Administration%20of%20Federal%20Elections%20-%20Optical%20Scan%20Ballots.pdf

California, Ohio, Rhode Island, just to name a few of which I have personal knowledge.)

29. In Paragraph 39B he suggests that hand-marked paper ballots cannot be recounted because some voters make imperfect marks, and he specifically names Florida's 2000 Presidential Election and the 2008 Minnesota Senate Race. But Florida's 2000 Presidential Election used punched cards, not optical-scan ballots; punchcards are a grossly inferior technology and have no implication for the auditability of paper ballots. The 2008 Minnesota Senate race was successfully recounted; I wrote an analysis of that case at the time, showing that only a tiny percentage of the paper ballots were ambiguously marked.

30. In Paragraph 39C he writes, "Ambiguous marks cannot occur on a BMD: the voter's intent is clear in the ballot summary…" but *completely* ignores voter-intent problems such as miscalibrated touchscreens and the fact that most voters do not look at the ballot summary.

31. In Paragraph 39F he speculates about future technology; even assuming his speculation someday becomes relevant to what the State purchases and implements, he has neglected to analyze the consequences of the fact that a QR-based audit trail can also be hacked.

32. BMD-marked paper ballots are insecure because: BMDs, like any computers, can be hacked (by alteration of their software program to cheat); if

hacked, they can systematically change votes from what the voter indicated on the touchscreen when printed on the paper ballot; few voters will notice, and those that notice have *only* the mitigation that they might be able to correct their own ballots, not their neighbors; and finally, recounts or audits will see only the fraudulently marked paper. This is the central point of Professor Stark's and Professor Halderman's Declarations; and Professor Gilbert avoids disputing these central facts.

ANDREW W. APPEL

December 13, 2019
Princeton, NJ