Roadmap To Ensuring Election Integrity That Voters Can Implicitly Trust

(Roy Minet – Rev. 12/12/20)

Elections are the critical mechanism by which citizens hope to maintain control of their government. **The primary objective of an election is to make the best possible decisions** when choosing the citizens' representatives who will wield the fearsome force of government over everyone's lives. Elections might not be the best possible way to make such important decisions, but we nevertheless use elections so that the decision-making power stays dispersed and does not fall into the hands of a small group or a dictator. Elections *are* democracy; without elections that citizens can implicitly trust, there is no democracy.

Obviously, it is of paramount importance that the integrity of elections be assiduously guarded. Once lost, regaining election integrity is hard to accomplish and unlikely to happen. Election integrity means that outcomes (decisions) must be solely the result of voters freely expressing their sincere opinions through their ballots. **The correct result is the one which maximizes voters' satisfaction (net of dissatisfaction) when summed for all those who voted.**

Citizens should be able to vote on election day and have results promptly (within three or four hours after the polls close). Election integrity must be solid so results can be trusted. **No one should ever think it necessary or worthwhile to question results, insist on recounts or file lawsuits.**

Elections in the United States today are dangerously far from meeting the standards described above. Unfortunately, election integrity has deteriorated somewhat in recent years, primarily caused by attempts to increase participation by making voting easier or more convenient, and by ill-advised uses of newer technology, sometimes without sufficiently rigorous testing. Improvements made possible by new technology definitely should be implemented, but great care must be taken lest they turn out to be steps backward. Hanging chads and direct recording electronic (DRE) voting machines which have no audit trails come to mind.

Achieving airtight integrity of elections actually is quite difficult, and maintaining it requires eternal vigilance. The overall process and every part of it must be carefully thought through. Every step must be engineered to make fraud substantially impossible. It must be extremely difficult and highly unlikely that election results could be nefariously controlled or influenced by any special interest group. If fraudulent influence should nevertheless somehow occur, its detection and correction must be virtually certain. Furthermore, the evidence required for successful prosecution should be available.

On the next page of this document are listed five important areas in which improvement is needed to attain the high level of election integrity to which citizens are entitled. They are shown in priority order. Appendices are referenced which provide the additional detail that will be required.

Five Key Reforms To Achieve Election Integrity

All five of these reforms are needed. Each one by itself will make a large improvement.

1. **Substantially all voters should vote in-person at their neighborhood polling place on election day.** Eliminate use of mail-in voting and early voting. Especially mail-in voting has many serious vulnerabilities. There is plenty of time and opportunity for fraudulent manipulation out in the wide world in the days and weeks before ballots are returned; some kinds of fraud are nearly impossible to catch and prosecute. Therefore, allow only the minimum number of absentee ballots required for voters who apply for them and have a bona fide and compelling reason for not voting at their assigned polling place. Beyond such very limited exceptions, there simply is no valid reason not to vote at a polling place. [See Appendices A and B]

2. **Replace the Plurality voting method with a dramatically better voting method.** It has been known for 250 years that Plurality is a truly awful voting method with very serious problems. It is a contributing cause of the increasing polarization which is reaching uncomfortable, if not dangerous levels. BAWV (Best/Alternate/Worst Voting) is the recommended replacement. AADV (Approve/Approve/Disapprove Voting) is a second choice. [See Appendix C]

3. **Remove artificial barriers to ballot access.** All political parties should be "created equal." Any political party that can demonstrate a modicum of public support (simply defined to be at least 0.05% of statewide voter registration) should be qualified to nominate candidates to appear on general election ballots. Parties may establish their own rules for nominating procedures, primaries and conventions, but must bear all costs of their operations. No taxpayer dollars should ever be spent for the benefit of any private political organization (such as funding primary elections or subsidizing conventions).

4. **Cleanly and simply eliminate any possibility of gerrymandering.** All electoral district boundaries should be drawn using a guaranteed-to-be-completely-impartial geometric procedure called "Precinct-Preserving Splitline" or PPS. [See Appendix D]

5. **Improve polling place procedure and efficiency through careful use of modern computer technology.** Final results can be available within half an hour of poll closing and 100% verification is enabled to ensure unquestionable integrity. [See Appendices E and F]

For those interested in additional detail, much more can be found at: http://royminet.org/ Especially see the "Voting / Elections" page and the "Election Manager Software" pages; or contact:

Roy Minet
623 Skyler Drive
Mount Joy, PA 17552
717-928-6188
Roy.Minet@comcast.net

Appendix A

The Polling Place Is The Essential Control Point

The environment inside a polling place on election day must be carefully controlled. A properly trained Judge of Elections observes, supervises and manages all proceedings. Poll workers assist the Judge and poll watchers from opposing parties are present to observe. A Constable is on-hand in case assistance may be required by the Judge for any matter. Only these people plus voters actively voting are normally present inside. Proselytizing and photography should be prohibited. Polling place procedures, which are carefully designed to ensure the integrity of every step, must be strictly followed.

Inside a polling place, confidence is high that nothing fraudulent can take place, and that should a perpetrator attempt fraud, detection and prosecution are virtually certain. For this reason, ALL critical processes should take place within a polling place on election day. No critical process should be allowed to happen at any other place or time. A separate "polling place" set up for the purpose should canvass and count absentee ballots on election day.

There are many polling places. This is good because anyone attempting to influence an election would have to do it many places simultaneously and without being detected. A problem at an isolated polling place is unlikely to have a significant impact on an election and can be fixed before the next election. A problem at a large central processing point could be a catastrophe.

Polling places must be sized and equipped so that wait times do not exceed five or ten minutes, even during peak voting periods. The flow at a normal polling place is:

1. Prior to opening, verify that any equipment is on and functioning correctly. Verify that the ballot box is empty.

2. Voters enter and check in. A poll worker verifies identity and ascertains that the voter is entitled to vote at the polling place (and has not already voted in the current election). It is of obvious importance that voter lists be carefully maintained and purged of those who have died or moved out of the area. A cursory signature comparison (especially by someone who is not a trained handwriting expert) is not a reliable verification of identity. Checking a photo-ID would be the simple and straightforward solution. However, some howl that this is an odious burden for some voters. So, it may be necessary to snap a photo of each voter at check-in which is filed in the registration database along with the voter's signature. The poll worker compares the photo just taken with those from past elections to positively confirm identity. This requires absolutely nothing of the voter and places no additional burden upon him or her.

3. Voters are directed to a voting booth where they will be able to indicate their choices on a ballot in privacy and under no pressure. The ballot may be an old fashioned paper ballot (still the "gold standard") or preferably there is some machine automation to assist the voter in producing a clean unspoiled ballot. Any such machine must produce a clear voter-verifiable ballot that the voter is instructed to check carefully. Nothing that the voter

cannot read and understand should be printed on a ballot the voter is to verify. The secret ballot is a cherished right that must be fiercely guarded. An important aspect of ballot secrecy is ensuring that voters are unable to prove to someone else how they voted. This both protects voters from coercion to vote a particular way and prevents others from fraudulently "buying" votes (bribing voters to vote a certain way). For this reason, photographing a ballot must be prohibited.

4. Only checked-in voters who are actively voting should be in the voting booth area. Upon leaving, voters pass the ballot box and must drop their ballot into it.

5. At closing time, any voters waiting in line are allowed to vote. Upon departure of the last voter, the ballot box is opened and the ballots are tallied. After checking it, a copy of the final results is made. The original tally sheet(s) and all work documents should be sealed with the ballots as a semi-permanent record. A list of all polling place personnel, signed by each, is also included. Note that this final step may be slightly altered by some types of automation [see Appendix E].

Video surveillance of the entire area might be considered to further discourage any attempt at fraud. Of course, this must be done in such a way that ballots cannot be read, but the flow of people and who is where at all times could be seen. The video could be live-streamed and a recording of it sealed with the ballots as additional evidence for any forensic investigation which may later be required.

Appendix B

Why Election Integrity Is Blown By Mail-in Ballots

It is just not possible to guarantee election integrity if mail-in voting is allowed. Period. Face it. Why would anyone ever decide to jeopardize something as important as the integrity of elections when there simply is no compelling reason to use mail-in voting? Mail-in voting is ill-advised (and much stronger adjectives would be more appropriate).

Substantially everyone gets to the grocery store, their job and so many other places on a regular basis. There is absolutely no reason why substantially everyone can't make an extremely infrequent and short trip to a neighborhood polling place. The very few who do have a compelling reason are able to apply for absentee ballots.

If grocery stores and even Disney World can successfully operate during a pandemic by requiring masks and distancing, surely doing the same cannot be an insurmountable problem at a polling place. Certainly, interested, informed and motivated voters will be sure to get to their polling places and vote. It would seem that those are the voters we most want to help make important decisions.

Mail-in ballots float around the countryside for at least days, more likely weeks. They are handled by an unknown and unknowable number of unknown people. When returned, they are handled by more people who validate and count them. There are many opportunities for serious problems.

Bear in mind that there are organizations willing to spend a hundred million dollars just to influence one race through advertising, literature, campaign events, etc. That's a bunch of money and a whole lot of motivation. A lot of pretty healthy bribes would total far less. Tampering with mail-in ballots would be a big cost reduction and is much more "sure-fire" as well. If opportunities exist, they will be exploited sooner or later. And when such opportunities exist, voters can't trust the system. It takes only one such opportunity, but listed below are a few of them.

First, let's talk about processing many thousands of mail-in ballots. It requires large numbers of supposedly well-trained people in a large operation which is hard to supervise and control. Unlike a small polling place, it is very difficult for observers from opposing factions to watch everything that is going on and be sure of catching any irregularities. The processing typically spans several days. Ballots need to be securely protected from tampering 24/7 for the entire period. Ballots must never be handled by anyone without the presence of observers from opposing factions.

The usual way to make sure a ballot came from a specific registered voter is to look up the voter in the database of registered voters and match the signature found there with the one on the returned ballot. This is <u>not</u> a reliable process; it's a crap-shoot, especially when someone who is not a handwriting expert is rushed to do thousands of ballots quickly! Voters do not always sign their names the same way, signatures change over time and may be affected by the

pen used or the writing surface. It actually is pretty difficult to be certain who voted. At best, there will be lots of unintentional mistakes in both directions.

At worst, a strongly partisan worker might undetectably either increase or decrease signature rejections depending upon whether the ballots being processed came from an area known to vote predominantly a certain way. This could be done intentionally, but the worker might even do so unconsciously.

In states (like Pennsylvania) where voter registration data is available to the public, anyone can request a mail-in ballot for any registered voter. At a minimum, this makes it easy for any dead people still on the rolls to vote; ditto for those who may have moved to another location.

At a polling place, we know exactly how many ballots there must be – exactly one for every voter who came through the door and checked in to vote. There is no way to have any idea how many mail-in ballots there should be. Therefore, there is no way to detect ballots that voters may think they submitted, but which did not arrive to be counted. Anyone in the return chain, a postal worker perhaps, either bribed or a strong partisan working on her own, could simply shred most of the ballots from an area known to vote predominantly the "wrong" way. There is also the phenomenon of several thousand ballots that nobody knew existed suddenly being "discovered." That's a real confidence builder! Counterfeit ballots are not impossible.

The cherished secret ballot is gone with mail-in. Voters can easily prove how they voted. They are subject to vote influence or coercion. At least as important is that the door is wide open to vote buying. How many people would be willing to sell their blank but signed ballot for $100? How about $500? If 20,000 votes will throw a race, $500 times 20,000 is $10 million. Some would consider that a bargain. As an extra added bonus, the purchaser gets 20,000 votes in all the races, not just one.

There have been proposals for utilizing blockchain or other techniques utilizing encryption to improve mail-in security/integrity. Whether or not any such complex uses of technology might help, they should not be used. To do so would violate the "Jones Rule." Professor Douglas Jones (U. of Iowa) stated the Jones Rule some years back: Everything about an election must be completely understandable by a reasonably bright high school student. This actually is quite an important rule. If voters cannot understand the basic process, there is no way they can trust it implicitly. Politicians should not vote for anything they don't completely understand.

Whether or not there actually *is* significant fraud in an election, the fact that there *could have been* will always leave room for doubt. Various factions contesting results is quite divisive and disruptive, as the 2020 election clearly demonstrated. Everyone, especially the losers, must implicitly trust everything about elections.

Why jeopardize the very foundations of democracy for no compelling reason? Let's all vote with our neighbors at our friendly local polling place.

Appendix C

Replace Plurality Voting With BAWV Or AADV

Plurality voting is widely used in most elections. It's simple: the candidate with the most votes wins. Unfortunately, that's too simple. About 250 years ago, two French scholars, Jean-Charles de Borda and the Marquis de Condorcet, pointed out serious flaws and kicked off the quest for a better voting method.

Plurality's first problem is that it doesn't allow voters to provide enough information to enable reliably identifying the correct winner in many elections. More than just each voter's first choice of the candidates is required to consistently choose the correct winner.

Plurality's second big problem is that the first choice information it does collect is often bogus! Voters lie. All too often, there are two very polarizing "main" candidates. Many voters do not really like either, yet they feel strongly compelled to insincerely "vote for the lesser of the two evils," even when they may actually prefer some other candidate. Worse, this effect is so powerful that most voters don't even bother to learn about other candidates who may also be running. If voters did want to learn about other candidates, they can't. The media hardly mentions them and they are excluded from debates!

To see how a better voting method would work, let's start with the simplest possible situation. We just wish to decide whether or not to change our neighborhood's trash pickup day from Wednesday to Thursday. The obvious solution is to hold a "referendum" wherein each affected party can vote either "yea" or "nay." If there are more "yeas" than "nays," the change is approved. Each voter gets to weigh in either for or against. This is a very straightforward, simple and serviceable decision mechanism.

When one candidate is being chosen for an office from several candidates on the ballot, what works really well is to hold a separate "yes" or "no" referendum on each of the candidates. The candidate that wins its referendum by the largest majority is then the overall winner. Voters are able to weigh in both for and against the candidates, just as they did on the trash collection issue.

It has turned out that the "magic ingredient" which enables making better decisions in all kinds of elections is to allow voters to express both their approval and their disapproval, with approvals and disapprovals for each candidate offsetting each other, just as they do in any referendum. Note that candidates with "high negatives" have a much harder time winning, thus strongly encouraging the nomination of candidates more broadly acceptable to most voters.

Each voter's choice of the best candidate and the worst candidate are the most important pieces of information which enable the correct winner to be identified. Thus, voters are able to vote "yea" in the referendum of the candidate they think is best and "nay" in the referendum of the candidate they think is worst. Allowing additional inputs beyond those opens the door to more "strategic" or "garbage" data that degrades decision-making more than it helps.

Plurality's first big problem is now well solved, but one additional feature is necessary to fix strategic voting for the lesser evil.

If a voter fears that her best choice may not win and is tempted to vote instead for the lesser evil, she may designate an "alternate best choice." An "Alternate" does absolutely nothing unless and until the candidate she marked "Best" is eliminated. Candidates are eliminated one by one, always eliminating the weakest candidate, until only the strongest (the winner) remains. If a voter's "Best" candidate is eliminated, the "Alternate" candidate (if any) is thereafter counted exactly as though it had originally been marked "Best." Votes are retotaled immediately following the elimination of each candidate.

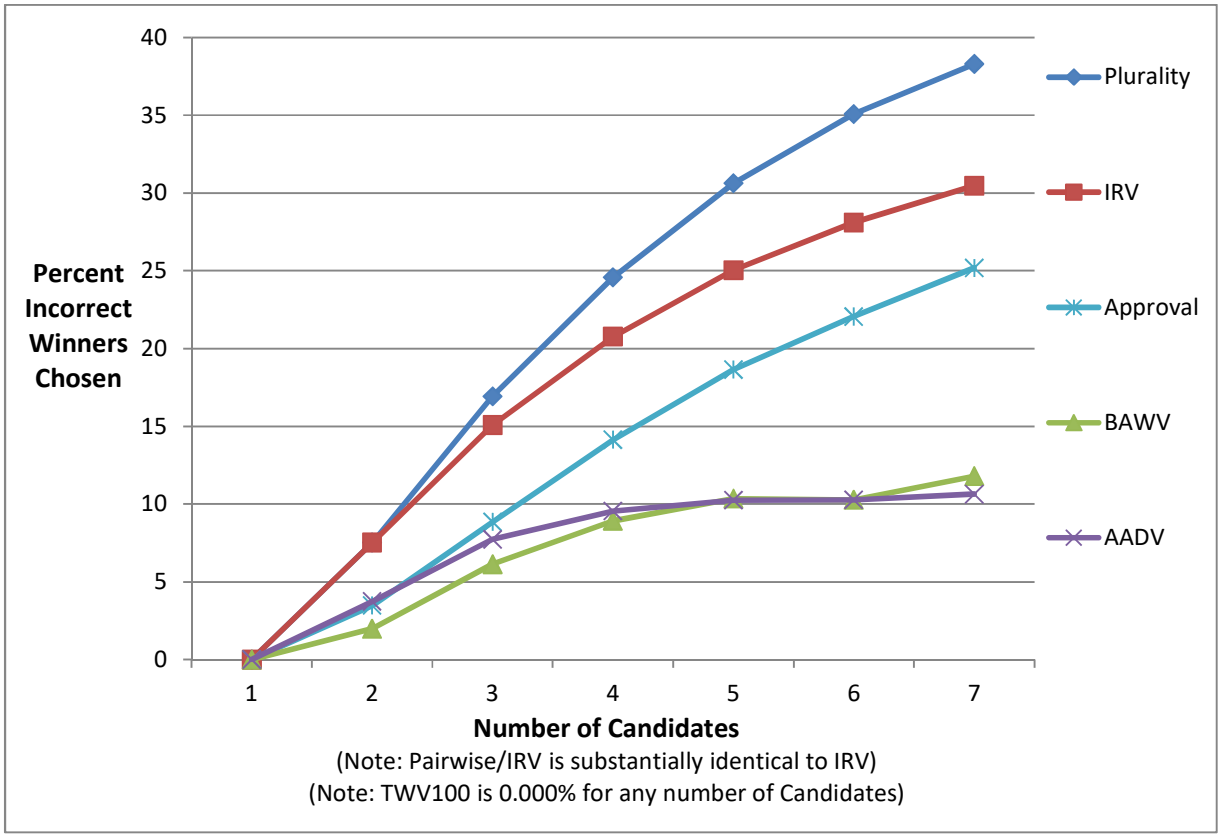
The acronym, BAWV (Best/Alternate/Worst Voting), is descriptive of this method. The acronym AADV (Approve/Approve/Disapprove) stands for a similar method that is almost as good. Both these methods are simple for voters, but the process for tallying BAWV is somewhat more complex than that for AADV. BAWV is better in that it is more resistant to insincere or strategic voting. AADV allows voters to "Approve" of either one or two candidates and to "Disapprove" of one; it is simple in all respects.

Finding the best voting method turned out to be much trickier than anyone anticipated (hence, the 250-year quest). In recent decades, there have been two main "camps." One camp advocates the Approval Voting or AV method, where voters may optionally approve of any number of candidates. The other camp advocates Instant Runoff Voting or IRV (which is just one of more than fifty ranked-choice methods).

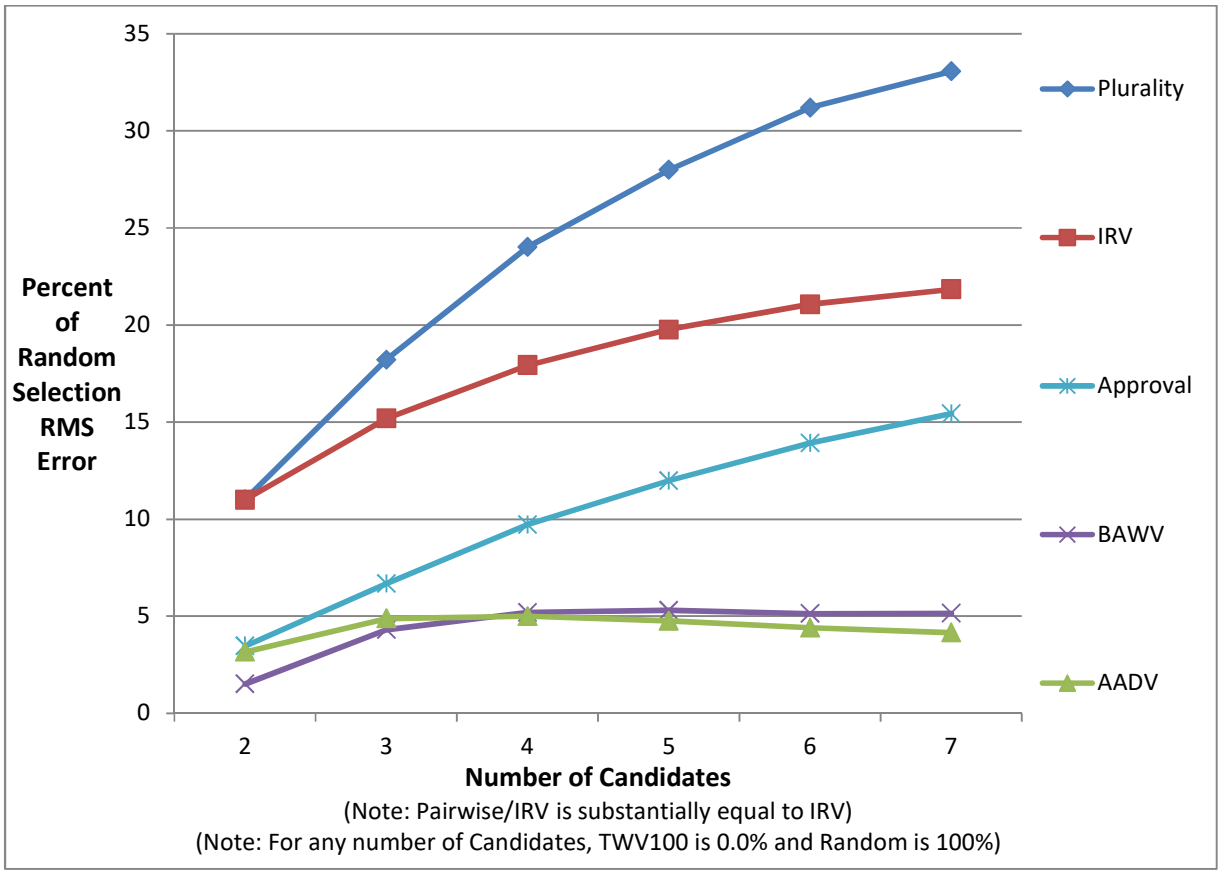
Two large election simulation projects, one in 2019 and one in 2020, have provided the clarity needed to make an intelligent choice. The ability of many different kinds of voting method to identify the correct winner in millions of all types of elections was statistically quantified so that the methods could be meaningfully compared. IRV was shown to be only a very small improvement over Plurality. AV is noticeably better, but still is not great. However, both BAWV and AADV are able to achieve the dramatic improvement over Plurality that is desperately needed.

The charts on the next page show the results for some of the voting methods evaluated. The first chart shows the percentages of incorrect choices made in all types of elections where voters voted sincerely. (The correct choice is the one which results in the highest satisfaction total for all those who voted.) The second chart shows how well the various methods do when compared to just randomly choosing a winner. From the second chart and for four-candidate elections:

	% of Random Selection Error	Improvement Over Plurality
Plurality	24.0%	1.00 x Better
IRV	17.9%	1.34 x Better
Approval	9.7%	2.47 x Better
AADV	5.0%	4.80 x Better (3.58 x Better Than IRV)
BAWV	5.2%	4.62 x Better



(Note: Pairwise/IRV is substantially identical to IRV)
(Note: TWV100 is 0.000% for any number of Candidates)



(Note: Pairwise/IRV is substantially equal to IRV)
(Note: For any number of Candidates, TWV100 is 0.0% and Random is 100%)

Appendix D

How Best To Impartially Define Electoral Districts

One of many techniques politicians use to keep themselves and their parties in power is the process known as "gerrymandering." That is, deliberately drawing the lines of electoral districts to favor themselves, or their political party. The practice has rightly been bemoaned for decades. It is way past time to fix it.

Many approaches have been proposed which are messy, not totally satisfying and fail to hit the nail squarely on the head. It turns out that a really good and clean solution does exist which should be implemented as soon as possible.

As usual, the first step toward determining the best solution is to correctly identify the requirements and write them down clearly and in order of importance:

1. **One Person, One Vote –** It is a hard requirement that each of multiple districts must contain, as nearly as is reasonably possible, the same number of eligible electors. This is an obvious good thing, and the SCOTUS has decreed it.
2. **Impartial –** The process by which districts are determined must not give any systematic advantage or disadvantage to any political party, group or faction.
3. **Understandable –** The process by which districts are drawn should be understandable by a reasonably bright high school student. (In fact, anything having to do with voting and elections should meet this requirement.)
4. **Verifiable –** It should be possible for reasonably equipped and motivated citizens or organizations to independently verify that districts have been correctly drawn. It is a bonus if a rough verification can be done quickly just by visually inspecting the map.
5. **Well-defined and Stable –** The process should be clearly and publicly spelled out. It should not be changeable on a whim or when different people are implementing it. Enshrining the process in the state or even the U.S. Constitution would be a good idea.
6. **Preserve Precinct Atomicity –** Precincts are very small areas of roughly 600 to 1,800 voters which are determined locally based upon available polling places and their proximity to voters. It is unnecessarily disruptive if redistricting requires redrawing precinct boundaries. Therefore, each precinct should be entirely contained within a single district. (If precincts straddling a district boundary should need to be merged, the merged precinct lands in the district from which most of its voters came until the next redistricting is done.)
7. **Contiguous –** It is required in many jurisdictions that voting districts be geographically contiguous, and that no district be completely contained within any other district. This requirement tends to support requirements 3 and 4.
8. **Compact –** Compactness can have several definitions. It is nice, but not critically important. Compactness does make it easier for candidates who must repeatedly traverse the district for campaign purposes and easier for elected representatives to commune with constituents. But primarily, compactness is believed to be desirable today mainly because it is felt to be an indication that the district has not been gerrymandered. However, this requirement does support requirements 3 and 4.

One thing NOT part of the requirements is "fairness." People sling the word "fair" around all the time, but the criteria by which they judge fairness can vary radically. Without a detailed definition and understanding of the criteria, the word is meaningless and should not be used.

Popular proposed solutions seem to revolve around establishing an unbiased commission which figures out how to draw boundaries. No semi-intelligent individual is completely unbiased, so what that means is a commission on which it is lightheartedly hoped that opposing factions hold each other in check. How commission members are selected becomes very important and is quite problematic. A commission does not guarantee requirement 2 and definitely does not satisfy requirements 3, 4 and 5. Also, it doesn't seem very sensible to make a commission re-invent the redistricting wheel (with somewhat variable and unpredictable results) every time a redistricting is needed.

A much superior approach is to clearly define a *procedure* that satisfies all requirements. It doesn't matter who (or what) executes the procedure, the same impartial boundaries are the result.

A procedure which well satisfies all requirements (except 6) was proposed circa 2002 by Warren D. Smith. It is called "splitline." The splitline procedure very simply divides a state into two sections having the desired populations using the shortest possible line. If more than two districts are needed, the process is repeated (as many times as necessary) to subdivide one or both of the two sections until the desired number of equal population districts has been drawn.

There is a three-minute YouTube video which very clearly illustrates the procedure. Also, maps are viewable online which show the splitline Congressional districts for each state. (See https://www.youtube.com/watch?v=kUS9uvYyn3A and https://rangevoting.org/SplitLR.html)

The pure splitline algorithm is ruthless. Not only does it not give a rip about political boundaries, but it can even split residences. Special rules apply to determine which side of the line to put split residences (so as to not split families into different electoral districts).

In order to meet requirement 6, "the shortest possible line" of the splitline method is changed to "the shortest distance along precinct boundaries." Because of precinct granularity, this will introduce small errors in population (completely inconsequential for large districts, perhaps 1% for very small districts containing only 25 or 30 precincts). Some further small tweaks to the algorithm can further reduce population errors. Call this the Precinct-Preserving Splitline or PPS algorithm. Obviously, the annoyance of splitting residences, etc. is also eliminated automatically.

PPS districts are always contiguous and geometrically compact. They are based *only* on the boundaries and populations of precincts; no voting history or registration data are ever used (nor should they be). The overall operation of PPS is easy to understand. If you're familiar with the state's population distribution, you can see that the lines have to be pretty much correct by just looking at them on a map. Lots of individuals and organizations are capable of independently verifying the boundaries. Also, it should be obvious that this one simple procedure can be used for any kind of district: Congressional, State Senator, State

Representative, etc. Finally, it also should be obvious that PPS can be done in minutes by a computer at near-zero cost. What's not to like?

No matter how straightforward and impartial PPS may be, there still will be objections. The first probably will be that PPS is necessarily going to ignore geographic features and political boundaries (other than precincts). Chalk that up as part of being impartial. It definitely will divide cities and counties. But this is not an actual problem. It's more a vague "feel good" notion in people's heads. As proof, we've lived just fine for decades with many of the craziest such divisions which were introduced by gerrymandering. Quite a few splits of political entities will be inevitable just to achieve the equal population requirement, no matter what method may be used. If it's OK some places, it won't hurt to do it other places as well. (One could even argue that it's "fairer" to do it everywhere.) Certainly, it is conceivable that geographic features (e.g., a river) could make traversing a district somewhat less convenient, but as a practical matter, this cannot be a large problem, especially when precincts are preserved. Maintaining the integrity of precincts significantly alleviates this minor complaint.

The second objection will be that some faction or another doesn't receive fair (!) representation. Well, what faction did you have in mind? There are so many. Factions might be defined by various political philosophies, religions, races, etc.; there are many factions of each type. And, of course, the smallest and most important faction is the individual. So, good luck! Whether a real or imagined issue, it is certainly not something that can be solved by playing around with district boundaries; wrong mechanism. Other remedies to consider which may partially address such concerns are multiple-representative districts, proportional representation and replacing plurality with a better voting method (BAWV or AADV, but <u>not</u> IRV). These definitely are good things to think about, but they don't have anything to do with impartially defining equal-population electoral districts.

Finally, the most often heard concern needs to be addressed head on: Many people say that boundaries should be drawn so as to not split up "communities of interest." This is a nebulous term without a clear and actionable definition, but it surely must be a feel-good concept that many people have firmly stuck in their heads. If they are asked, "So, you mean that a community of interest is a group or faction of people who share the same or similar values and interests," most will answer, "Yes, yes, that's what we mean!" "And you want districts to consist predominantly of people who share a set of values and interests so they can elect a representative who <u>truly</u> represents them." "Yes, yes, exactly," they say. "So the faction that shares the set of values and interests will be able to consistently outvote the minority who may have other values and interests." Now a few of the more astute may begin to see their folly: Drawing districts to preserve so-called "communities of interest" (however someone may succeed in defining them) is exactly the same as gerrymandering, just for factions which may or may not happen to align with political parties!

<u>The Actual PPS Algorithm</u>

In all cases where a political entity (e.g., a state) is entitled to elect multiple representatives, the (sometimes iterative) procedure defined here (Precinct-Preserving Splitline) must be used to

draw the electoral district boundaries for such representatives. If the population of the political entity is p and the number of districts to be drawn is n, follow these steps:

1. If n is 1, no subdivision is necessary and this is a final district. If n > 1, then define two new numbers i = n/2 rounded up and j = n/2 rounded down to the nearest integer. (Note that i + j always equals n, and if n is even, i obviously will equal j.)
2. Draw the shortest possible (great circle) line dividing the area into two sections so that one section has a population equal to p multiplied by i/n, while the population of the other section has a population equal to p multiplied by j/n. If there is more than one equally short line, use the line closest to a north-south orientation and if there is still a tie, use the westernmost line. For irregularly shaped political entities, it is possible that a line could enter, then exit and then re-enter the entity; the length of the line is defined to be the total distance between the two most distant points of intersection which lie on the boundary of the area being subdivided.
3. Make a list of just the voting precincts that the great circle line of step 2 traverses.
4. Any of the traversed precincts on the list which have 75% or more of their area on one side of the line are then assigned to the section on that same side of the line.
5. If any precincts remain on the list, assign the largest to the section which needs the most people to hit its population target. Repeat this step until all precincts have been assigned.
6. Then draw the final boundary accordingly.
7. For each of the two sections separately, go back to step 1 using the section's population for p and either i or j (whichever was associated with the section) as n.

Appendix E

Modern Technology Improves Efficiency And Integrity

There is no reason not to take advantage of modern technology as long as it is done carefully so that election integrity is not jeopardized. The cardinal rule is that **it simply cannot be guaranteed that any machine of at least the complexity of a paper stapler will work correctly all of the time.** There is always some possibility that an unintentional "bug" or defect could exist, or that someone intent on affecting the results has intentionally introduced a malicious "defect."

The solution is to engineer the process so that any and all the outputs of a machine can be (and actually are) verified. Also, a durable (paper or other hard copy) audit trail must be created which is the final authority on voters' intents so that after-the-fact audits are possible.

If/when any corruption of data should occur (either unintentional or intentional), it must be certain that it will be both detected and corrected. Finally, sufficient documentation should be available to enable either fixing an unintentional problem or successfully prosecuting the perpetrator. This may seem obvious, but apparently it is not. The direct recording electronic (DRE) voting machine gained approval somehow. The DRE machines were not verifiable and did not produce an audit trail, so there was no alternative but to trust the machine.

There is no reason to depart from the basic in-person voting procedure which has served so well for 200 years. Namely:

1. Voters enter the controlled environment of a polling place and their identities are verified.
2. In the privacy of a voting booth, voters indicate their choices on a paper ballot.
3. Voters deposit their ballots in a ballot box on the way out.
4. The ballots are the final authority on voters' intents and are tallied when the polls close.

Computer technology can be of significant help with steps 1, 2 and 4.

For step 1, a cursory signature comparison (especially by someone who is not a trained handwriting expert) is not sufficiently reliable. A more positive picture ID would be a straightforward solution. However, if that is not acceptable, capture a picture of each voter at each election and compare it with those from previous elections stored in the registered voter database. This places absolutely no burden or inconvenience upon the voter and can be done quite quickly.

For step 2, a clear and simple touch-screen computer system assists the voter in selecting candidates, avoiding any possibility of a spoiled or ambiguous ballot. Instructions are on-screen and more detailed instructions can be popped up if desired. When each voter has finished making and double-checking selections for all races, a crystal clear paper ballot is printed for the voter to check and verify before dropping it into the ballot box. Internally, the computer assigns a 7-digit random number to track each ballot. Ballots are instantaneously and always stored in random order so there is no way for anyone to associate a ballot with a voter. The machine outputs (the ballots) are checked and verified immediately by each voter.

For step 4, the computer is able to tally the votes for the polling place. Of course, the ballots can also be hand counted if desired. However, the intended normal mode of operation is that the computer will produce a tamper-protected detailed text file showing all the ballots in random order (sorted by their random ballot numbers) and including all of each voter's choices. The text file can be read either by humans or by computers. The text file is verified (either immediately after poll closing or later) by matching each ballot from the ballot box to each ballot in the text file. Obviously, there must be an exact one-to-one correspondence.

The text file is posted publicly online as soon as the polls close. A centrally located computer reads the files from all polling places and tallies them to provide accurate and final results within half an hour after polls close. Anyone else anywhere (using the same software or any other method they like) can verify the tally and the winners by totaling the ballots in the files from all polling places. Note that efficiency, speed and computer accuracy is gained while making sure that every machine output can be and actually is verified in full detail. Substantially no one would attempt fraud when it is certain to be detected, corrected and prosecuted.

The computer software to implement the entire system as just described is available today. It is called Election Manager. There is no cost for any non-commercial use (like public elections). The software can be run on a wide selection of standard, mass-produced, reasonable-cost hardware. No expensive custom equipment is required. [See Appendix F]

Finally, it is important to discuss just a few of the many options Election Manager offers when setting up an election – those which control the printing of ballots. Ballot size can be either 8.5" x 11" or 8.5" x 14" but of more importance is the setting called "Ballot Number Printing." There are two choices:

- Print Ballot Number – The 7-digit random number that identifies the ballot will be printed on each ballot. This setting obviously makes matching the ballots from the ballot box to the output file's list of ballots super simple and straightforward. If the voter remembers or jots down the ballot number, it will be possible to look up her or his ballot when the file is posted online to verify that it is indeed present and correct. Some may think this an appealing feature. However, this setting is not recommended. It surely is possible for voters to keep their ballots secret if they wish to do so; but it does enable them to prove to someone else how they voted if they wish to do that. Thus the complete secrecy of the ballot is compromised and the door is open to vote coercion and/or vote buying (see the discussion of this in Appendix B).
- Print Reference Number – This setting is strongly recommended as it enables us to have our cake and eat it too. When each ballot is cast, two random numbers are generated instead of one. The first is the official ballot number by which it will be sorted and identified in the output file. The second is a reference number for each ballot which is printed on the voter's ballot. Knowing the reference number does not enable voters to look up their ballots online; they cannot prove to someone else how they voted. Complete ballot secrecy is guaranteed. However, when the polls close, the computer is able to furnish the polling place crew with a cross reference of reference numbers to ballot numbers (the process actually is more automated). Matching the ballots to the output file at the polling place is again easy. 100% verification of output files is practical and strongly encouraged.

Appendix F

Election Manager – Frequently Asked Questions

What Is Election Manager?

Election Manager is a publicly available, integrated software system that can be utilized to automate all phases of any election in a transparent, secure and auditable manner. It may be used free of charge for any non-commercial application. It is a "Swiss Army knife" for elections that can be used to:

- Flexibly define the various jurisdictions for elections anywhere on Earth
- Flexibly define elections with their political parties, races, candidates and aliases
- Supervise and control voting in the polling places and voting booths; print voter-verifiable paper ballots
- Electronically tally the results of an entire election so that accurate results can be available within minutes after the polls close

Why Is Election Manager Important and Needed?

Electing the classmate most likely to succeed probably won't affect the course of world events, but electing those who will wield government power over citizens lives is of critical importance. The laborious marking and counting of paper ballots begs for automation utilizing modern technologies. However, it makes absolutely no sense to put the fundamental democratic process of voting at risk just for the sake of some time-saving automation. There have been many attempts at using various technologies to make the voting process more efficient, but substantially all of them have sacrificed transparency, security and/or auditability. Election Manager attempts to comprehend the entire voting process and achieve the desired high efficiency while actually *improving* transparency, security and auditability over hand-marked paper ballots.

In a Nut Shell, How Does Election Manager Work?

After setting up whatever jurisdictions may be required, an election (or multiple elections) may be flexibly defined. An entire election setup can be exported as an XML file (with security fingerprint) that can be loaded from a CD to automatically set up each precinct. On election day, voters check in as usual. For each authorized voter, a voting booth is enabled and the voter is directed to it. The voter presses a "Begin Vote" button and the races for which s/he is entitled to vote appear on the display. The voter may quickly select candidates for each race from a pop-up list or write in any name. When the voter has made choices in any or all races and reviewed them, s/he presses the "Cast Ballot" button which electronically casts the ballot as well as printing a voter-verifiable paper ballot. After checking the printed ballot, the voter drops it into a traditional ballot box on the way out. When the polls close, a text file of the randomly ordered ballots is produced (using standard XML). The judge of elections and poll observers certify the results file as well as its security fingerprint. The results file can be printed and posted at the polling place, and should be posted publicly on the Internet. Election Manager will tally the votes cast at the polling place, and of course, the ballot files from all polling places are tallied by a central copy of Election Manager which then reports results for the entire election.

What Approach Was Used for the Software?

All of Election Manager's source code is written in Java so that it is highly portable. Either the EM server or the EM client software will run identically on substantially any combination of hardware and operating system. Inexpensive standard PC hardware can be used to keep everything non-proprietary, open and low-cost. A simple and user-friendly GUI (graphical user interface) with touch-screen voting is employed.

Does Election Manager Support "Internet Voting"?

Absolutely not! No system that uses the Internet for voting can guarantee acceptable security and the door is opened to other problems as well. Voting booth clients within each polling place should always be connected to the server via hard-wired Ethernet cables (no RF). However, clients can connect over the Internet to a central server while setting up jurisdictions and elections. During voting, there must be no connection to any other network, and certainly not the Internet.

What Election Options Are Supported?

For each election, the following can be independently selected:

- Election date and times that the polling places open and close
- Primary election (requires parties) or general election
- Races can be a referendum or elect 1, 2, 3, etc. candidate(s)
- Voting method for each race can be either standard Plurality, AADV (Approve/Approve/Disapprove Voting) or BAWV (Best/Alternate/Worst Voting)
- Pop-up candidate list can be either specific to each race or consolidated
- Voter-verifiable ballot printing off or on (either 8.5" x 11" or 8.5" x 14" ballots)
- Either a reference number (recommended) or the actual ballot number can be printed.
- Any number of approved aliases can be set up for each candidate (aliases are automatically comprehended, properly handled and reported in the tally process)

How Does Election Manager Achieve Greater Transparency and Security?

Everything about voting should be completely transparent and public, except, of course, that the secrecy of each voter's ballot must be fiercely guarded.

Election Manager is written entirely in Java, perhaps the most widely used and most portable programming language to-date. Both the source code and executable jar files are made publicly available. Election Manager can run on a wide selection of readily available, well understood, standard, inexpensive hardware and operating systems. Anyone can independently run and test the system. Ballots are instantaneously and always maintained and reported in a random order. The text file of results from each polling place is standard, well-understood XML in a format matching published schema. XML editors and readers (including most browsers) are widely available. The files are also human readable. The secure and redundant output file contains all ballot choices in three different sort orders.

No one can guarantee that any machine at least as complicated as a paper stapler is working correctly all the time. For that reason, every output must be verifiable and actually be verified. Voters verify their printed ballots. The XML output can be easily verified using the printed ballots, so any "glitches" whether intentional or accidental **will** be caught and **can** be corrected. Anyone anywhere can independently verify election totals and results using the publicly-available output files and Election Manager (or any other method) to tally the ballots. Complete integrity is assured.