Study of voting systems for Santa Clara, CA

Metric Geometry and Gerrymandering Group

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Contents

1 Introduction

LaDonna Yumori-Kaku ("Plaintiff"), an Asian-American citizen of Santa Clara, CA, is suing the City of Santa Clara ("City") for violating the California Voting Rights Act of 2001 (CVRA) through its current election system for City Council. Elections in Santa Clara are currently held at-large, with a Mayor (Seat 1) and six City Councilmembers (Seats 2–7) with four-year terms. Candidates choose an individual seat to run for with no geographical restrictions, and the elections alternate between mayor plus two seats and the four remaining seats. The winner of each seat is selected by plurality. This voting system is well known to disadvantage minority populations, and Plaintiff claims that because of racially polarized voting patterns, the City's Asian population is systematically blocked from electing a candidate of their choice. As evidence, Plaintiff cites the fact that Santa Clara has never had an Asian City Councilmember, despite the fact that nearly 40% of the City's population is Asian (as opposed to 36% White) and Asian candidates regularly run for Council seats.

The Plaintiffs are requesting a remedy that instead creates six single-member districts, each holding plurality elections. The City has proposed an alternative remedy that some call 2×3: in this system, Santa Clara would be cut into two districts, and each would elect three candidates by transferable vote.

Below, we will refer to these as the Current System, the Standard Remedy, and the 2×3 System. After conducting a racially polarized voting analysis (§2), we will argue that all three of these are inferior to several other transferable-vote options, which we call 1×6, 6×1, $1 + 4 + 1$, and $5 + 1$.

While much of this discussion is particular to Santa Clara, we present an Appendix using algorithmic sampling to draw some general conclusions that suggest that jurisdictions with polarized voting and with no extreme patterns of housing segregation should fare better with transferable vote systems than with fully districted plurality systems.

1.1 Demographics of Santa Clara

Two aspects of Santa Clara geography and demography are crucial for the analysis below.

• There is a large swath of non-residential area (negligible census population) cutting through the middle of Santa Clara, dividing the City into two residential areas that are disconnected from each other, as seen in this choropleth. We will refer to the populated areas as North Santa Clara and South Santa Clara.

North Santa Clara contains 20.25% of the City's Census population, but with a much higher concentration of Asian/Pacific Islander (API) population as well as Asian proportion of citizen voting-age population (CVAP). The relevant population statistics are summarized in the table below, which shows data from the 2010 Census (Census) and the 2012–2016 American Community Survey (ACS).
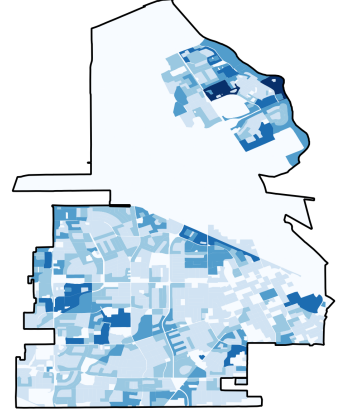
	North Santa Clara	South Santa Clara	Entire city
Total population (Census)	23,354	93,114	116,468
% API in population (Census)	57%	33%	38%
Total population (ACS)	–	–	122,725
% API in population (ACS)	–	–	41%
CVAP (ACS)	12,385	58,912	71,297
% API in CVAP (ACS)	47%	27%	31%

• Secondly, Santa Clara's API population is extremely heterogeneous. The next table shows the breakdown by country of origin from the Census data. In this report we refer collectively to several subgroups as *East Asian*. As we will see below (§2.2), Indian and East Asian voters have very different voting patterns, which will be significant for our analysis. Importantly, CVRA litigation and case law does not differentiate between Asian subgroups. Below, we will discuss significant differences in voting patterns between voters of East Asian and Indian origin; this has no legal impact on findings of a CVRA violation, but is of considerable interest in devising an effective remedy once a violation has been found.

Census population by API subgroup	North Santa Clara	South Santa Clara	Entire city
Indian	21%	11%	13%
East Asian	36%	22%	25%
Chinese	9%	7%	7%
Filipino	14%	4%	6%
Japanese	1%	2%	2%
Korean	3%	3%	3%
Vietnamese	5%	4%	4%
other EA	3%	2%	2%
Pacific Islander	0.2%	0.3%	0.3%
Total API	57%	33%	38%

There is also a significant Hispanic share of Census population in the City (19%), as well as an estimated 3% Black and about 2% American Indian, Mixed Race, or Other, leaving 36% non-Hispanic White residents. (We note that other demographic analyses include residents identified as both White and Asian in the Asian category, thus obtaining slightly higher numbers of Asians.) Asian share of population increased dramatically between the 2000 and 2010 Censuses and may do so again in 2020.

In what follows, we will use the term White as shorthand for non-Hispanic White. It is possible to include Hispanic voters as a separate group in our polarized voting analysis (§2), but we have found qualitatively similar results. The current lawsuit is focused on Asian voters, so we have not included the details on Hispanic voters here, but these results are available upon request.

1.2 Types of voting systems

Districted systems

Municipalities across California are being sued under the CVRA. Pressure to move to a districted system comes from two sources. On one hand, districting has been a traditional remedy when minorities are found to be fenced out from representation. Secondly and importantly, the CVRA's "Safe Harbor" provision signed into law in 2016 caps attorneys' fees at $30,000 if municipalities quickly move to a districted system.

However, districted systems have the inherent disadvantage of requiring line-drawing, which can be delicate, time-consuming, liable to manipulation, and often produces boundaries that are subject to challenge. If the lines must be carefully crafted to produce certain desirable outcomes, then the properties are also unstable over time as demographics shift. And Santa Clara's unique geography (§1.1) also makes division into two, three, or six districts extremely awkward. Since North Santa Clara has about one-fifth of the city population, any such districting plan has to jump the population gulf and combine populations separated by several miles. This goes against traditional redistricting principles (namely, respect for communities and political geography).

More than that, we will argue below that the moderate level of clustering of the Asian population—as opposed to more extreme housing segregation of a minority subgroup found in other jurisdictions—means that districts work especially poorly in the standard remedy, where they elect a single member by plurality vote. This is discussed below in §3.2, with the conclusions supported in the Appendix by algorithmic sampling techniques.

The Santa Clara Charter Review Committee expressed other reservations about single-member districts. Among other things, the committee worried that splitting the City into six districts and requiring the candidates from each district to reside there would unnecessarily limit the talent pool, since no two people from the same neighborhood could be elected simultaneously. Although CVRA compliance is paramount in this analysis, this is a legitimate concerns that should be taken into account.

Transferable vote systems

Below we will use the umbrella term **transferable vote** for systems that are sometimes called single transferable vote (STV) or instant-runoff voting (IRV)—those terms are nearly interchangeable, except that STV selects multiple members and IRV selects one. Transferable vote systems require voters to rank candidates in the order of their preference, so that winner selection may take into account second choices and beyond. Several California municipalities already use transferable vote, including San Francisco, Oakland, Berkeley, and San Leandro. There are several different mathematical possibilities for exactly how to conduct the vote transfers, but none of those precise differences will matter in the analysis below.

The major advantage of transferable vote systems is clear: they are designed to produce outcomes that are in better proportional correspondence with the preferences of the population. In the presence of racially polarized voting, therefore, transferable vote can be expected to significantly improve minority representation.

The main drawback commonly cited is the burden on voters, as it is sometimes argued that ranked choice voting is confusing or overwhelming. For instance, Santa Clara voters now face two to five choices on their ballot, of whom they must select one person; in a citywide at-large transferable system (§3.4) they might face as many as eighteen choices on the ballot, among whom they can rank six or more. Learning about all the candidates running for six seats at once may be a daunting task and demand more time and effort than many people are able to commit. However, a frequent finding in public opinion research is that American voters tend to like the voting system they are accustomed to. We feel that the voter burden problem can be mitigated by an education campaign (telling people for instance that ranking just two or three candidates is still a valid ballot, though more likely to result in a wasted vote) and a careful transitional period.

Voting literature from New Zealand offers some insight into the challenges of introducing transferable vote into a new jurisdiction. In 2004, some local elections commenced transferable voting while others retained a plurality system with multi-member districts. Vowles shows that STV had no impact on the proportion of valid votes cast in 2004 [3]. Although these elections continued a trend of lower turnout for local than for statewide elections, Zvulun concludes that there was no significant difference in jurisdictions using STV, and in some elections STV stopped the decline compared to the traditional system [4].

We note that districting and transferable voting are not mutually exclusive, and several systems discussed below combine them (§3.3,3.5,3.6).

Optimal ballot size for transferable vote

Because the burden on voters under ranked-choice voting increases with the number of choices, most jurisdictions around the world have districts that elect only three to five candidates. Still, systems with more choices are sometimes successfully implemented: for instance, Cambridge, MA uses ranked-choice voting to elect all nine of its Councilmembers at once.

Political scientists John Carey and Simon Hix argue that the optimum number of representatives per district is three to eight when prioritizing proportional outcomes, but three to six when considering voter experience [1]. They base their conclusions on an analysis of 609 elections in 81 countries from 1945 to 2006. Citing work by cognitive psychologists, they concede that voters' ability to rank candidates diminishes dramatically once the number of members to be elected becomes too large, but assert that voter behavior in districts with up to six members elected should resemble those for voters in single-member districts.

We conclude that asking voters to rank choices for six seats at once is feasible but on the high end of the preferred range.

Predicting system performance: the problem of second choices

A major confounding issue in predicting the outcomes of various voting systems is that past Santa Clara election returns only report one vote per voter, so it is impossible to infer how voters' second choices behave, which is essential to any detailed predictive analysis of transferable vote systems. We investigated election outcomes from some Bay Area transferable vote races, such as the Oakland mayor's race, but these were inconclusive because we could not find examples with leading API candidates from different Asian subgroups in order to study how the votes were reallocated when one candidate was eliminated. (For instance, the most recent Oakland mayoral race had one viable Chinese-American candidate, and then more minor candidates of Chinese and Iranian ancestry.)

One hypothesis is that voters from different Asian subgroups are likely to rank candidates from their own subgroup first, followed by candidates from other Asian subgroups, followed by White and Hispanic candidates. Another hypothesis is that White candidates would be frequent second choices for Korean voters, say, rather than Chinese or Filipino alternatives. And similar questions about Hispanic voters, who make up nearly 20% of voters, could have a very significant impact; if Hispanic voters are likely to prefer Hispanic, then Asian, then White candidates, this will sizably boost Asian performance in transferable vote systems. The analysis below is made with conservative assumptions about second choices and we look forward to more data in the future as transferable vote systems catch on in local elections around the country.

2 Racially polarized voting

2.1 Ecological Inference

The leading technique for establishing racially polarized voting is Gary King's Ecological Inference (EI) method, which produces numerical estimates for the levels of voting by subgroup as well as confidence intervals.

The standard way of reporting EI outcomes when studying voting patterns of a group within a larger population is to make binary divisions: consider whether voters belong to the group or not, and consider candidates one at a time to see whether the precincts with higher levels of voters from the group being considered tended to support a given candidate at a higher rate. This is sometimes called 2×2 EI. Of the City Council races we analyzed in this way using Census race data (with surname analysis of voters as a secondary data source), Seat 2 2014 and Seat 5 2014 show statistically significant polarization effects. This diagram shows estimated preferences in those two races.
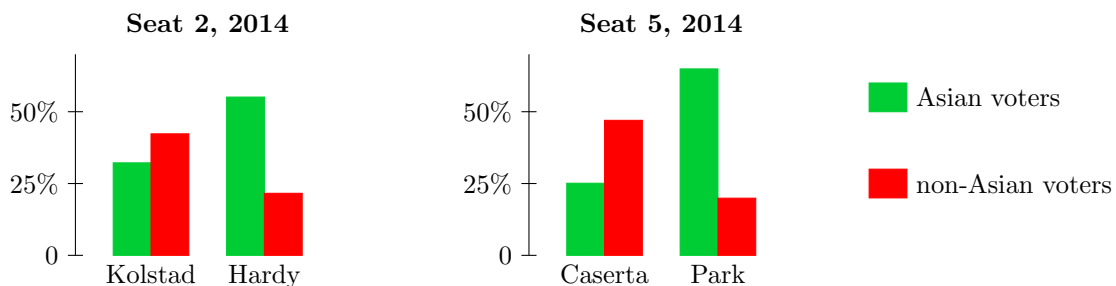
In both cases, the Asian-preferred candidate is not elected. In Seat 2 2014, the Asian voters prefer one White candidate while the non-Asian voters prefer another White candidate. This is notable as an instance of Asian voters not being able to elect their candidate of choice even when the candidate is White.

Though this is enough to assert racially polarized voting in many expert analyses, there is good reason to think that it actually understates the extent of racial polarization in this case. This way of grouping the voters makes it hard to detect the major differences in voting patterns by subgroups, particularly between Indian and East Asian voters. When we attempt a three-group $R \times C$ EI analysis, the error bars overwhelm the differences in findings. (This is because of the structure of EI, and not because the polarization has disappeared.) We thus turn to a second method to corroborate the findings of polarized voting by studying it at the subgroup level. As noted above, the subgroup analysis has no legal bearing on the success of a CVRA challenge, but will be of considerable value in devising an effective remedy.

2.2 Ecological Regression

We analyzed results from the six most recent elections using Goodman's Ecological Regression (ER), which is a second common technique cited to establish racially polarized voting. One well-known difficulty with ER is that it does not give good numerical estimates for the voting preferences of a particular group when the proportion of that group has low variance across precincts. This may cause ER-based estimates to indicate that over 100% or under 0% of a certain group voted for a particular candidate. Therefore we do not report specific numerical estimates, which may be specious, but only report a difference when we can be confident at a statistically significant level. For example, ER can give only a very rough estimate of what percentage of East Asian voters voted for each candidate in the election for Seat 2, but we can be confident that more of them voted for Hardy than for any other candidate. When it is uncertain which of two candidates was the most frequent choice of a group, we report both; for instance, the table below reports that Indian voters for Seat 7 might have preferred Rafah or O'Neill first overall, but clearly chose each of those two in greater numbers than they chose Park.

In order to consider East Asian and Indian subgroups separately, we used the detailed breakdown by country of origin provided in the Census, as well as surname data on voters from the Statewide Database. All entries in the following table are based on comparisons that are statistically significant at the $p < .05$ level. In all six cases, the preferred candidate of non-Asian voters won the election.

ELECTION	Race of candidates	first choice of Indian voters	first choice of EA voters	first choice of non-Asian voters (and winner)
Seat 2, 2014	**2 W, 1 Ind**	**Nadeem (Ind)**	**Hardy (W)**	**Kolstad (W)**
Seat 5, 2014	**2 W, 1 EA**	**Park (EA)**	**Park (EA)**	**Caserta (W)**
Seat 3, 2016	2 W	Davis (W)	Davis (W)	Davis (W)
Seat 4, 2016	**2 W, 1 Ind, 1 H**	**Chahal (Ind)**	**Mahan (W)**	**Mahan (W)**
Seat 6, 2016	2W, 2 Ind, 1 H	Nadeem (Ind)/Watanabe (W)	Watanabe (W)	Watanabe (W)
Seat 7, 2016	1 W, 1 Ind, 1 EA	Rafah (Ind)/O'Neill (W)	Park (EA)/O'Neill (W)	O'Neill (W)

(W = White, Ind = Indian, EA = East Asian, Hisp = Hispanic)

Thus, we have clear evidence of racially polarized voting in three of the six races (shown in **bold**), while only one of the six races (Seat 3, 2016) shows a clearly consistent choice across the three groups. At the same time, there is not a monolithic Asian voting bloc. Indian voters do support Indian candidates whenever possible, but in no case was an Indian candidate the preferred candidate of East Asian voters, even in the absence of East Asian alternatives. In fact, in three of the four elections that had an Indian candidate, East Asian voters supported the Indian candidates at a definitely lower rate than non-Asian voters did, and therefore at a lower rate than White voters in particular. (In the fourth case, the difference is not statistically significant.)

We note here once again that there is a possible confusion to be carefully avoided: the second-most-frequent choice of a subgroup must not be confused with the most common second choice of voters from that subgroup. The question of second choices (discussed in §1.2) is still opaque.

3 Analysis of voting system performance in Santa Clara

3.1 Current System: 1×6, separate seats with plurality vote

Bottom line: Demonstrably blocks Asian voters from electing a candidate of choice.

The preferred candidate of non-Asian voters wins in every case. Asian voters are sometimes observed to have a different candidate of choice, and that person is never elected. This is the case for well-established structural reasons; Asian candidates can't get close to the 50% threshold for election in a city in which they make up a large minority and receive only a modest number of crossover votes.

3.2 Standard Remedy: 6×1, plurality vote

Bottom line: Better than current system, but effects are unclear.

This system—several single-member districts conducting plurality elections—is the most common remedy when local at-large elections are found to violate citizens' voting rights. However, in this case, it is not sure to produce *any* Asian representation and we can be fairly certain that at most one Asian candidate of choice will be elected. The first major contributor to the underperformance of a 6×1 remedy is that the population is too dispersed to make a comfortable Asian majority in any single district. All of North Santa Clara has only 47% AVAP, and that is quite uniform across precincts. A sampling analysis detailed in the Appendix struggled to create one of six districts with 50% AVAP even within North Santa Clara. Since Asian-American share typically drops off at each stage—from share of Census population to CVAP to registered voters to voters—we conclude that it it is likely not possible to create one of six districts with 50%-plus-one Asian voter share.

Clearly, districts might still offer Asians an opportunity to elect a candidate of choice even without a numerical majority. In the two 2014 City Council elections, the preferred candidates of Asian voters were defeated overall; however, in both cases, the preferred candidates of Asian voters won in North Santa Clara. It is straightforward to draw a district completely contained in North Santa Clara where these candidates would have won as well. (North Santa Clara has 20.25% of the City's population and a district would have about 16.7% in this scenario.) At first glance, this provides strong evidence that dividing the City into six single-member districts would indeed be effective. But this does not take into account the second major contributor to the uncertainty of a 6×1 remedy: there is high potential for vote-splitting in the likely case that multiple Asian candidates run in the most heavily Asian district. Since plurality systems shut out communities that split their votes among subgroups, we conclude that this remedy may be ineffective overall.

3.3 City's Proposed Remedy: 2×3, transferable vote

**Bottom line: Better than current system, but effects are unclear.**

This proposal would create two districts, each electing three Councilmembers by transferable vote. A subgroup with a consistent voting preference needs 25% of the vote share to elect a candidate in this situation, and both the City and FairVote agree that 30% is a safer threshold. It will be difficult for either district to reach this threshold. To see why, recall that Asians constitute 31% of the CVAP in Santa Clara. However, we estimate that 6-11% of the Santa Clara's CVAP is Indian and that East Asians account for only 20-25%. This is either below or precariously close to the quota of 25% required to elect, considering the lack of evidence that Indian voters would rank East Asian candidates above White candidates most of the time. This makes it particularly hard to predict what would happen under transferable voting when one subgroup (in this case East Asians) is close to the quota.

Normally, the creation of geographical districts can help minority groups achieve representation by ensuring that one or more districts has a critical mass of minority population. However, the East Asian population is not sufficiently concentrated to easily draw two districts in which one has a substantially higher proportion of East Asians than the City overall. While North Santa Clara does have a more concentrated East Asian population, it has only a fifth of the City population, so it accounts for less than half of a district in this 2×3 scenario. In South Santa Clara, the Asian population is fairly uniformly distributed.

The FairVote report [2], which endorses a 2×3 system, depicts a boundary demarcating what the two districts might be. The Asian CVAP in their two proposed districts is reported to be 28.9% and 32.5%. This means that the East Asian CVAP will be below 30% in both districts, which gives their 2×3 proposal a serious chance of continuing to produce an all-White city council.

How to draw two districts

We have used both sampling methods and construction by hand to attempt to devise a different 2-district plan that maximizes the share of East Asians among registered voters, but were unable to get comfortably above 30% without district appearances that would probably be considered unacceptable by most observers, such as the division depicted below.
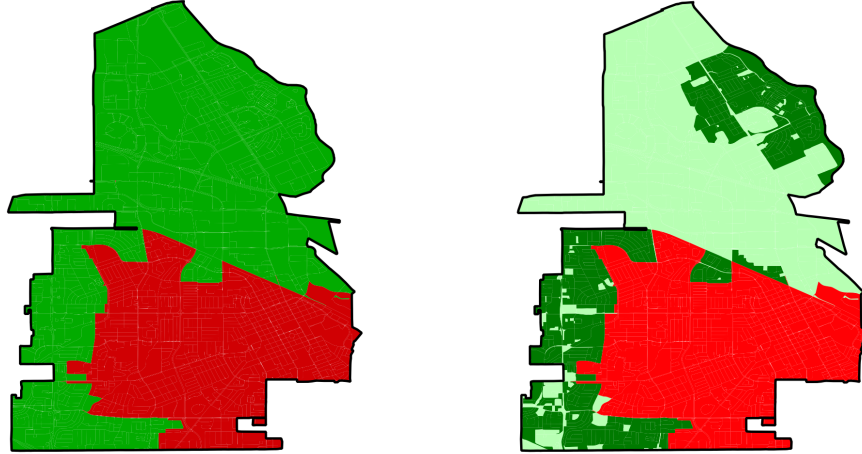
Any two-district plan creating a high API concentration has to take
significant advantage of empty space to be plausibly contiguous.

Keeping in mind that populations shift over time, this is certainly a solution that would require delicate line-drawing to maintain any likelihood of securing Asian representation.

3.4 Citywide At-Large: 1×6, transferable vote

Bottom line: At least one candidate of choice for Asians, plus influence opportunities with other candidates.

One viable alternative is a single Citywide election, with all six Councilmembers chosen simultaneously by transferable vote. While this is an at-large system like the Current System, the use of transferable voting rather than plurality makes an enormous difference: by this method, a candidate would need the support of only 1/7 (14.3%) of the voters to be elected. The East Asian CVAP is certainly large enough to elect one candidate and to contribute to the election of a second; thus, as a CVRA remedy for Asian voters, this system should work better than 6×1 plurality (the Standard Remedy).

In addition to avoiding artificial geographical divisions, this method has another very desirable property: because of its low quota (14.3%), not only East Asians but smaller subgroups as well can have a more significant impact on the election. For example, Indian voters can contribute a significant proportion of the votes needed to elect a candidate. Since some Indian candidates (such as Mohammed Nadeem in 2016) are able to draw substantial White support, an Indian candidate would have a much better chance of being elected under this system than under any six-district system. Similarly, Hispanic voters (15% of Santa Clara's CVAP) may well be able to elect a candidate with sufficiently cohesive voting, whereas under the Standard Remedy, they would have no such opportunity.

Note, however, that this system would not allow the City to stagger its elections as it currently does: all six candidates would have to be elected at once. Since Councilmembers can serve two terms this would not necessarily mean a complete turnover of membership every four years. Simultaneous election for all six seats might even have some advantages; for instance, having City Council elections on the same years as presidential elections would increase turnout. But it is a change that the City would certainly need to take into account in deciding which system they prefer.

Another disadvantage is that having to elect six candidates in a single election is slightly more than the recommended three to five candidates for manageable ballots.

3.5 Alternative Districted Scheme: 6×1, transferable vote

Bottom line: At least one candidate of choice for Asians, plus influence opportunities with other candidates.

This six-district option improves significantly on the Standard Remedy by controlling for the vote-splitting potential if multiple Asian candidates run in the most heavily Asian of six districts. It retains the geographical awkwardness of all six-district schemes, but it makes Asian representation fairly certain.

3.6 Custom Plans: $1 + 4 + 1$ or $5 + 1$, transferable vote

Bottom line: At least one candidate of choice for Asians, plus influence opportunities with other candidates.

These systems are designed specifically for Santa Clara, taking into account its unique geography and demography and the preferences of both the Plaintiff and the City.

$1 + 4 + 1$ plan

Here, one Councilmember is elected by North Santa Clara, four by South Santa Clara, and one at-large Citywide, all by transferable vote. This creates two effective districts: North Santa Clara and South Santa Clara, the natural geographic pieces of the City. Since North Santa Clara currently constitutes almost exactly one-fifth of the City, this accords with the Constitutional principle of One Person, One Vote. (Of course, that could be vulnerable to population shifts over time, but is most likely sound at least until the 2030 Census.)

The advantage of this system is that it combines the properties of the Standard Remedy and the proposed 2×3 scheme that are most important to their proponents (the Plaintiff and the City respectively). The Standard Remedy creates a single-member district contained in North Santa Clara in an attempt to provide an opportunity district for Asian voters. This system improves on the Standard Remedy both by making the performance of the North Santa Clara district more certain (via transferable vote) and by not needing to artificially separate a small group of North Santa Clara voters from their community and attach them to a different district in the South. Moreover, this system gives a far better opportunity for Asian voters in South Santa Clara to elect a candidate of their choice. It is unlikely that any single-member district in South Santa Clara will have anything approaching an Asian majority. In contrast, the quota in a 4-member district is only 20%. Since we estimate Asian CVAP in South Santa Clara to be 33%, an Asian candidate would need only a modest number of crossover votes to get elected, even without assuming that East Asian and Indian voters will vote cohesively.

At the same time, this system limits the line-drawing to just the one natural geographical division, which goes a long way towards mitigating the concerns of the Santa Clara Charter Review Committee. Most of the City would elect its Councilmembers by transferable vote, as in the 2×3 scheme that the Committee recommended (and with a district size of four, which is also in the recommended range). Just as in the current system, elections could be staggered, with South Santa Clara elections held in one cycle and North Santa Clara plus at-large in the next.

A possible concern about this system is that it would create two kinds of Councilmembers: district-specific and at-large. This arrangement would certainly represent a change, but it would not be unique to Santa Clara. For instance, the City of Oakland currently has a mayor and eight Councilmembers, with seven representing individual districts and one elected at-large. However, we note that this $1 + 4 + 1$ system also has the unusual property that residents vote for different numbers of Councilmembers: there would be two Councilmembers elected by North Santa Clara, but five elected by South Santa Clara.

$5 + 1$ plan

This option is similar but with five districts drawn; one district equals North Santa Clara, while South Santa Clara is divided into four districts, with the last City Councilmember elected at-large. This version will require much less work in public education and confidence-building than the previous custom plan, but sacrifices some of the representational benefits of multi-member balloting.

4   Recommendations

For the reasons detailed above, we find the Current System to be obviously problematic and we find the Standard Remedy and the proposed 2×3 Remedy to be inadequate to address any possible CVRA violation.

This leaves four possibilities discussed in this report, ordered here from requiring the least line-drawing to the most.

> A: Citywide at-large transferable (1×6)
> B: Custom transferable $(1 + 4 + 1)$
> C: Custom transferable $(5 + 1)$
> D: Districted transferable (6×1)

Some of their strengths and weaknesses have been discussed above, and can be summarized as follows:

- **Achieves Asian representation**: A, B > C, D

- **Respect for geography**: A,B,C > D

- **Voice for smaller minorities (Indian, Hispanic)**: A > B, C, D

- **Maintains staggered elections**: C, D (any), B (4/2), but not A (6 at once)

- **Tractable ballot size**: C, D (choose 1) > B (choose 1 or 4) > A (choose 6)

We note that besides having much improved chances to win a seat outright,[1] both Indian (13%) and Hispanic (19%) residents will have greatly increased opportunities to influence the election in all four of these plans as compared to the current system or the Standard Remedy.

Overall, these systems have various strengths and weaknesses, but we find A, B, and C to be the best options, particularly since achieving Asian representation is a paramount concern and respect for geography is a traditional districting principle. The choice between these should be made on political, legal, and practical, rather than mathematical, grounds.

We therefore endorse either **citywide at-large transferable voting** or a **custom transferable voting plan** as the best remedy for the alleged CVRA violations in Santa Clara City Council elections.

Contributors

Researchers contributing to the material and presentation in this report include Mira Bernstein, Moon Duchin, Tommy Ratliff, and Stephanie Somersille. We thank Assaf Bar-Natan for providing adept GIS support for this study. MGGG accepts responsibility as an organization for the opinions expressed in this report.

References

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[3] Jack Vowles, *Comparing District Magnitude Effects under Ordinal and Nominal Ballot Structures in Non-partisan Elections: The 2004 Local Elections in New Zealand.* Representation, Vol. 43, No. 4, 2007, 289–306.

[4] Jacky Zvulun, *The Single Transferable Vote and Voter Turnout in the 2004 Local Elections.* Journal of Political Marketing, Vol 11, No. 3, 2012, 123–142.

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[1]Hispanic residents in particular do have a small enclave in the geographical center of the City and would have a chance at winning a seat outright in a South Santa Clara district under plans C or D. This is comparable to the estimated effects in Plan B, but Plan A does slightly better because of the lower threshold for election.

5 Appendix: Evidence from algorithmic sampling

General case

Below, we created an 18×18 grid and placed 31% green squares to model the situation that a minority population has 31% of the population, which is the situation with Asian CVAP in Santa Clara estimated from the most recent ACS (§1.1). It is quite intuitive that a very **uniform** distribution of green squares, such as you might find in a city with no housing segregation, will make it difficult to create a district with a distinctly higher proportion of greens than the city as a whole. The **clustered** distribution, modeling clear housing segregation, can clearly be partitioned more easily to produce a majority-green district. What is not apparent is whether a **semi-clustered** distribution (which may best model populations without a clear geographical enclave) might behave more like the uniform or more like the clustered treatment.

Uniform   Semi-Clustered   Clustered

We performed algorithmic searches for districting plans cutting this grid into six contiguous districts (of 54 squares each), and then considered how many majority-green districts each plan would produce. Our algorithm runs for 100,000 steps in less than 20 seconds on a standard laptop and generates approximately 30,000 distinct districting plans. The findings are clear: the semi-clustered setup is not at all different from the uniform setup, and majority-green districts are extremely hard to produce.

To be precise, here are the findings from five separate runs.

Question:	Run	Uniform	Semi-Clustered	Clustered
What proportion of randomly sampled	1	0.7%	0.1%	54.9%
six-district plans provide likely plurality	2	0.3%	0.4%	72.2%
representation for the green minority?	3	0.6%	0.6%	56%
(i.e., some district ≥ 50% green)	4	0.9%	1.2%	61.7%
	5	1.2%	0.3%	43.1%

The runs presented above proceed by starting with an initial plan (or *seed*) and making many small modifications at random. For those five runs, the seed was simple rectangular districts. In order to consider whether the random walk is mixing well in the space of possible plans, one double-check is to confirm that runs from a different seed are producing similar results. To check this, we initialized other runs with a carefully crafted plan that has *two* green districts (each with a comfortable 54% margin in the semi-clustered distribution). In three runs from that seed, the share of sampled plans with *at least one* green district in the semi-clustered distribution is 1.4%, 1.5%, and 0.3%, an essentially identical outcome to the runs from the prior seed.

Conclusion: if you assume (a) polarized voting, and (b) no extremely clustered patterns of housing segregation, then it is difficult for a fully districted plurality voting system to produce stable representation for a minority subgroup. **Transferable voting should therefore be strongly preferred in this situation.**

Geography-specific

A similar analysis is possible taking into account the geography and demographics of any particular jurisdiction by choosing units from which to build plans (say precincts or census blocks) and randomly sampling plans as follows.

Step 0 Begin with a shapefile showing the jurisdiction decomposed into the chosen units.

Step 1 Build a *dual graph* of those units that has one vertex for each unit and has edges when the units are adjacent. (See figures below.) The graph data should include both total Census population and estimated CVAP of the group of interest for every node, so that the sampling can limit population deviation and report the CVAP statistics of the districting plans it creates.

Step 2 Choose a seed: fix an initial districting plan for your graph into the desired number of districts with a tolerable level of population deviation.
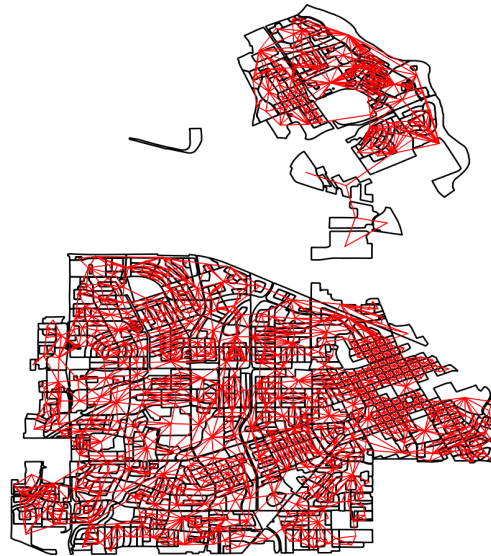
Step 3 Run a random walk that builds an ensemble of plans by considering flipping units from one district into another. Only accept a proposed change if the new plan maintains contiguity and satisfies any other principles you would like to be maintained (e.g., population deviation below a threshold, compactness above a threshold).

Step 4 Report the subgroup CVAP by district in the ensemble of plans produced on each run.

In this way, it is possible to search for districting plans and see how often the subgroup CVAP meets the quota for election under the system being considered.

Precinct-level dual graph   Block-level dual graph

The findings of this analysis were that in the 6-district plans in these ensembles, the district with the highest Asian concentration always had 47.7-48.9% AVAP, dropping off very quickly to below 40% in the second most Asian district. This corroborates the finding above that a plan with six single-member districts might fail to elect even a single Asian representative if plurality elections are conducted in each district.