# Expert Report of Amicus Dr. Matthew Petering in Support of Proposed Wisconsin Legislative Map 173\#008 

Clarke v. Wisconsin Elections Commission

January 12, 2024

## Qualifications

I am an Associate Professor of Industrial \& Manufacturing Engineering at the University of Wisconsin-Milwaukee and owner of District Solutions LLC, a Milwaukee-based redistricting consulting firm (DistrictSolutions.net). I was born and raised in Milwaukee County and have a PhD and master's degree, both in Industrial \& Operations Engineering, from the University of Michigan. I also have a BA in Mathematics from Washington University in Saint Louis.

Over the past 20 years, I have developed uniquely specialized knowledge and expertise in the highly technical discipline of mathematical optimization, which can be applied to create rigorously fair Wisconsin voting district maps. I have more than 20 years of experience designing and writing computer algorithms that do complex optimization tasks which are often too difficult for people to do by themselves. During the 2021 redistricting cycle, I was engaged in drafting proposals for modifying the aldermanic districts in the City of Milwaukee.

The details of my academic background and qualifications are included in my curriculum vitae which is attached at the end of this report.

## Executive Summary

This report describes the performance of a map, named 173\#008, that was created by Dr. Matthew Petering's FastMap redistricting algorithm. Two .csv files, containing the assembly and senate district assignments for the 202,510 (non-water) Wisconsin census blocks, have been mailed to the Court-appointed consultants and parties. All metrics below, except the chance of winning a given number of seats, are computed by DavesRedistricting.org (DRA). Additional information regarding the analyses which follow is provided in the appendix.

## 1. Population Equality

Wisconsin's population was $5,893,718$ according to the 2020 Census. Because Wisconsin has 99 assembly and 33 senate districts, the ideal population for each assembly (senate) district is 59,533 (178,598). Table 1 presents the deviation scores for the districts in map 173\#008. Wisconsin has a tradition of adopting maps with an overall range in deviation of $2 \%$ or less. $173 \# 008$ has a $1.98 \%$ ( $1.35 \%$ ) range in population deviation in the assembly (senate).

Table 1. Analysis of population deviation in map 173\#008

| Assembly | Deviation from Ideal Population | Persons | Percent |
| :--- | :--- | :--- | :--- |
|  | Mean Deviation | 274 | 0.460 |
|  | Largest Positive Deviation | 594 | 0.998 |
|  | Largest Negative Deviation | -584 | -0.981 |
|  | Overall Range in Deviation | $\pm 1178$ | $\pm 1.979$ (i.e., 1.98\%) |
| Senate | Deviation from Ideal Population | Persons | Percent |
|  | Mean Deviation | 437 | 0.245 |
|  | Largest Positive Deviation | 1393 | -0.780 |
|  | Largest Negative Deviation | -1023 | $\pm 1.353$ (i.e., $1.35 \%$ ) |
|  | Overall Range in Deviation | $\pm 2416$ |  |

## 2. Political Subdivision Splits

## Split Counties

The assembly map splits 52 counties 134 times. The senate map splits 38 counties 61 times.

## Split Municipalities

The assembly map splits 56 of Wisconsin's 1850 municipalities. The senate map splits 39 municipalities.

## 3. Contiguity

All assembly and senate districts are strictly contiguous except those which include actual islands in Lake Superior, Lake Michigan, Green Bay, and Lake Winnebago. For the few districts that include such offshore islands, the main portion of the district is strictly contiguous.

## 4. Compactness

DRA gives the assembly districts an overall compactness rating of 74 of 100 and the senate districts an overall compactness rating of 56 of 100. According to DRA, the average (Reock, Polsby-Popper) compactness score of the assembly districts is ( $0.4443,0.3747$ ). The average (Reock, Polsby-Popper) compactness score of the senate districts is $(0.3867,0.3233)$.

## 5. Federal Law Compliance

The map adheres to the Equal Protection Clause and the Voting Rights Act (VRA) of 1965.

## Voting Rights Act Compliance

Assembly districts 7-9, 10-12, and 16-18 (and senate districts 3, 4, 6) in 173\#008 are identical to their counterparts in the map used for the Nov. 2022 election (SB621). Thus, 173\#008 and SB621 have equivalent VRA compliance. When SB621 was considered in Johnson v. WEC, Sections II and IV of Dr. John Alford's expert report dated December 15, 2021 demonstrated that assembly districts 7-9, 10-12, and 16-18 (and senate districts $3,4,6$ ) comply with the VRA.

## Compliance with the Equal Protection Clause

All assembly and senate districts besides those mentioned in the previous paragraph were created by a computer algorithm, with only a few manual modifications at the end to ensure strict contiguity. Humans played almost no role in drawing the boundaries of these "non-VRA" assembly and senate districts. No lines were intentionally manipulated in violation of the Equal Protection Clause.

## 6. Community Considerations

Among several communities of interest, one group stands out for its merits and well-defined boundaries: Native American communities. The boundaries of Wisconsin's Native American reservations and tribal lands are clearly depicted at WisconsinFirstNations.org. Of the nine largest Native American reservations and tribal lands in Wisconsin, eight are entirely within assembly districts in map 173\#008. Furthermore, these eight areas are found within a total of three assembly districts-36, 74, and 83. The only Native American reservation not wholly contained in one assembly district is one that spans two counties. In this case, county splitting
considerations superseded community considerations, and the reservation was split into two districts, one for each county.

## 7. Political Neutrality

Political neutrality is evaluated using five metrics: proportionality, efficiency gap, chances of winning a proportional seat share, number of competitive districts, and majority rule. The first four are computed using DRA's 2016-2022 composite election data. The last is computed using the results of recent individual elections.

## Proportionality

DRA gives $173 \# 008$ a proportionality rating of 99 of 100 for the assembly and 100 of 100 for the senate. According to DRA's 2016-2022 composite election data, Democrats have $51.16 \%$ of the statewide, two-party vote in Wisconsin. In a perfectly proportional election this translates to $(.5116)^{\star}(99)=50.65$ assembly and $(.5116)^{\star}(33)=16.88$ senate seats for Democrats. Using a fractional seats approach, DRA predicts Democrats will win 50.73 (16.98) seats in the assembly (senate) if map $173 \# 008$ is used. That is, $173 \# 008$ will result in Democrats winning 0.08 (0.1) more seats in the assembly (senate) than in a perfectly proportional map. This deviation from perfect proportionality is miniscule. For all intents and purposes, the map is strictly proportional in both the assembly and senate.

## Efficiency Gap

According to DRA, the efficiency gap of the assembly and senate maps are $+1.07 \%$ and $+0.85 \%$ respectively. These positive values favor Republicans, but only slightly.

## Chances of Winning a Proportional Seat Share

Another way to evaluate political neutrality is to estimate each party's chances of winning a proportional share of seats. Rounded to the nearest integer, a proportional share of assembly (senate) seats for Democrats is 51 (17) and for Republicans is 48 (16). Using Monte Carlo simulation, the estimation is that Democrats have a $52.3 \%$ chance of winning at least 51 assembly seats and a $64.4 \%$ chance of winning at least 17 senate seats. Meanwhile, Republicans have a $63.5 \%$ chance of winning at least 48 assembly seats and a $65.4 \%$ chance of winning at least 16 senate seats. Thus, both parties have at least a $50 \%$ chance of winning a seat share in proportion to their overall share of the statewide vote in the assembly and senate. Overall, the map gives both parties an equal opportunity for proportional representation in both chambers.

## Number of Competitive Districts

In the assembly, 29 districts are in the $45 \%-55 \%$ competitive range. In the senate, 10 are in this range. The large number of competitive districts gives both parties a substantial opportunity to win additional seats if they field good candidates.

## Majority Rule

We overlaid nine different sets of election data onto the map: the most recent two elections for president, two elections for governor, three elections for U.S. Senate, and two elections for attorney general. Democrats won six of these elections, Republicans three. In eight of the nine elections, the candidate who won the popular vote also carried a majority of assembly and senate districts in the map. In one election, the candidate who won the popular vote carried a majority
of assembly districts but not senate districts. Overall, the map strongly embodies the principle of majority rule.

## Overall Assessment

Map $173 \# 008$ is a politically neutral map. It does not bestow partisan privilege on either political party. It complies with strict legal requirements and has excellent performance for traditional criteria including compactness, county splitting, and municipality splitting.

## Map Images

Figures 1-2 show the assembly and senate districts in map 173\#008.


Figure 1. Assembly districts in map 173\#008


Figure 2. Senate districts in map 173\#008

## Appendix

## 1. Population Equality

Table A1 below shows the population of each assembly district and the deviation in each district's population from the ideal assembly district population of 59,533 . The assembly districts with the highest and lowest populations are highlighted.

Table A1. Population of each assembly district and deviation from ideal district population

| District | Population | Deviation | District | Population | Deviation | District |  | Population Deviation |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 59487 | -46 | 34 | 60003 | 470 | 67 | 59523 | -10 |
| 2 | 59294 | -239 | 35 | 59259 | -274 | 68 | 60024 | 491 |
| 3 | 59200 | -333 | 36 | 60008 | 475 | 69 | 59122 | -411 |
| 4 | 59139 | -394 | 37 | 59828 | 295 | 70 | 59900 | 367 |
| 5 | 59840 | 307 | 38 | 59557 | 24 | 71 | 59563 | 30 |
| 6 | 59395 | -138 | 39 | 60053 | 520 | 72 | 59789 | 256 |
| 7 | 59603 | 70 | 40 | 60038 | 505 | 73 | 58953 | -580 |
| 8 | 59362 | -171 | 41 | 59877 | 344 | 74 | 59002 | -531 |
| 9 | 59571 | 38 | 42 | 60076 | 543 | 75 | 59663 | 130 |
| 10 | 59503 | -30 | 43 | 59320 | -213 | 76 | 59467 | -66 |
| 11 | 59565 | 32 | 44 | 59441 | -92 | 77 | 59646 | 113 |
| 12 | 59351 | -182 | 45 | 60042 | 509 | 78 | 59800 | 267 |
| 13 | 59538 | 5 | 46 | 59580 | 47 | 79 | 59735 | 202 |
| 14 | 59049 | -484 | 47 | 60111 | 578 | 80 | 59598 | 65 |
| 15 | 59543 | 10 | 48 | 59528 | -5 | 81 | 59210 | -323 |
| 16 | 59714 | 181 | 49 | 58954 | -579 | 82 | 59214 | -319 |
| 17 | 59435 | -98 | 50 | 59900 | 367 | 83 | 59998 | 465 |
| 18 | 59346 | -187 | 51 | 59672 | 139 | 84 | 59728 | 195 |
| 19 | 59604 | 71 | 52 | 59280 | -253 | 85 | 59515 | -18 |
| 20 | 58980 | -553 | 53 | 59927 | 394 | 86 | 59739 | 206 |
| 21 | 59150 | -383 | 54 | 59662 | 129 | 87 | 59847 | 314 |
| 22 | 59045 | -488 | 55 | 59192 | -341 | 88 | 59771 | 238 |
| 23 | 59848 | 315 | 56 | 59365 | -168 | 89 | 58977 | -556 |
| 24 | 59993 | 460 | 57 | 59984 | 451 | 90 | 59604 | 71 |
| 25 | 59743 | 210 | 58 | 59072 | -461 | 91 | 59355 | -178 |
| 26 | 59217 | -316 | 59 | 59773 | 240 | 92 | 59355 | -178 |
| 27 | 59306 | -227 | 60 | 59659 | 126 | 93 | 59354 | -179 |
| 28 | 60073 | 540 | 61 | 58949 | -584 | 94 | 60127 | 594 |
| 29 | 60076 | 543 | 62 | 59179 | -354 | 95 | 59035 | -498 |
| 30 | 59409 | -124 | 63 | 59544 | 11 | 96 | 59487 | -46 |
| 31 | 59181 | -352 | 64 | 59011 | -522 | 97 | 59001 | -532 |
| 32 | 59445 | -88 | 65 | 59377 | -156 | 98 | 60037 | 504 |
| 33 | 59591 | 58 | 66 | 59187 | -346 | 99 | 59575 | 42 |

Table A2 below shows the population of each senate district and the deviation in each district's population from the ideal senate district population of 178,598 . The senate districts with the highest and lowest populations are highlighted.

Table A2. Population of each senate district and deviation from ideal district population

| District | Population | Deviation | District | Population | Deviation | District | Population | Deviation |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 177981 | -617 | 12 | 179270 | 672 | 23 | 178669 | 71 |
| 2 | 178374 | -224 | 13 | 179438 | 840 | 24 | 179252 | 654 |
| 3 | 178536 | -62 | 14 | 179991 | 1393 | 25 | 177618 | -980 |
| 4 | 178419 | -179 | 15 | 178803 | 205 | 26 | 178913 | 315 |
| 5 | 178130 | -468 | 16 | 179219 | 621 | 27 | 178543 | -55 |
| 6 | 178495 | -103 | 17 | 178526 | -72 | 28 | 178940 | 342 |
| 7 | 177734 | -864 | 18 | 178869 | 271 | 29 | 179101 | 503 |
| 8 | 178886 | 288 | 19 | 178541 | -57 | 30 | 178352 | -246 |
| 9 | 178266 | -332 | 20 | 178504 | -94 | 31 | 178064 | -534 |
| 10 | 179558 | 960 | 21 | 177672 | -926 | 32 | 178649 | 51 |
| 11 | 178217 | -381 | 22 | 177575 | -1023 | 33 | 178613 | 15 |

## 2. Political Subdivision Splits

## Split Counties

The assembly map splits 52 counties 134 times. Table A3 below shows which counties are split in the assembly map, the number of pieces each county is split into (i.e., the number of assembly districts that overlap with the county), and the number of times the county is split (which is one less than the preceding value).

Table A3. List of split counties in the assembly map and number of times each is split

| County | No. Split <br> Pieces | No. Times <br> Split | County | No. Split <br> Pieces | No. Times <br> Split |
| :--- | :---: | :---: | :--- | :---: | :---: |
| Adams County | 3 | 2 | Milwaukee County | 18 | 17 |
| Barron County | 2 | 1 | Monroe County | 3 | 2 |
| Bayfield County | 2 | 1 | Oconto County | 2 | 1 |
| Brown County | 7 | 6 | Outagamie County | 5 | 4 |
| Burnett County | 2 | 1 | Ozaukee County | 4 | 3 |
| Calumet County | 2 | 1 | Pierce County | 2 | 1 |
| Chippewa County | 3 | 2 | Polk County | 2 | 1 |
| Clark County | 2 | 1 | Portage County | 2 | 1 |
| Columbia County | 3 | 2 | Price County | 2 | 1 |
| Crawford County | 2 | 1 | Racine County | 5 | 4 |
| Dane County | 15 | 14 | Richland County | 2 | 1 |
| Dodge County | 4 | 3 | Rock County | 4 | 3 |
| Dunn County | 3 | 2 | Rusk County | 2 | 1 |
| Eau Claire County | 4 | 3 | Sauk County | 2 | 1 |
| Fond du Lac County | 4 | 3 | Shawano County | 3 | 2 |
| Forest County | 2 | 1 | Sheboygan County | 2 | 1 |
| Grant County | 2 | 1 | St. Croix County | 3 | 2 |
| lowa County | 2 | 1 | Vilas County | 2 | 1 |
| Jackson County | 2 | 1 | Walworth County | 4 | 3 |
| Jefferson County | 3 | 2 | Washburn County | 2 | 1 |
| Juneau County | 2 | 1 | Washington County | 4 | 3 |
| Kenosha County | 4 | 3 | Waukesha County | 10 | 9 |
| La Crosse County | 3 | 2 | Waupaca County | 2 | 1 |
| Manitowoc County | 2 | 1 | Waushara County | 4 | 3 |
| Marathon County | 6 | 5 | Winnebago County | 4 | 3 |
| Marquette County | 2 | 1 | Wood County | 3 | 2 |
| Sum |  |  |  | 72 |  |

The senate map splits 38 counties 61 times. Table A4 below shows which counties are split in the senate map, the number of pieces each county is split into (i.e., the number of senate districts that overlap with the county), and the number of times the county is split (which is one less than the preceding value).

Table A4. List of split counties in the senate map and number of times each is split

| County | No. Split <br> Pieces | No. Times <br> Split | County | No. Split <br> Pieces | No. Times <br> Split |
| :--- | :---: | :---: | :--- | :---: | :---: |
| Adams County | 2 | 1 | Monroe County | 2 | 1 |
| Brown County | 3 | 2 | Outagamie County | 2 | 1 |
| Burnett County | 2 | 1 | Ozaukee County | 2 | 1 |
| Calumet County | 2 | 1 | Price County | 2 | 1 |
| Chippewa County | 2 | 1 | Racine County | 4 | 3 |
| Crawford County | 2 | 1 | Richland County | 2 | 1 |
| Dane County | 7 | 6 | Rock County | 2 | 1 |
| Dodge County | 4 | 3 | Rusk County | 2 | 1 |
| Dunn County | 3 | 2 | Sauk County | 2 | 1 |
| Eau Claire County | 2 | 1 | Shawano County | 3 | 2 |
| Fond du Lac County | 2 | 1 | St. Croix County | 2 | 1 |
| Forest County | 2 | 1 | Walworth County | 2 | 1 |
| Jackson County | 2 | 1 | Washburn County | 2 | 1 |
| Jefferson County | 2 | 1 | Washington County | 2 | 1 |
| Juneau County | 2 | 1 | Waukesha County | 6 | 5 |
| Kenosha County | 2 | 1 | Waupaca County | 2 | 1 |
| Marathon County | 2 | 1 | Waushara County | 3 | 2 |
| Marquette County | 2 | 1 | Winnebago County | 3 | 2 |
| Milwaukee County | 7 | 6 | Wood County | 2 | 1 |
| Sum |  |  |  | 28 |  |

## Split Municipalities

The assembly map splits 56 municipalities 98 times. Table A5 below shows which municipalities are split in the assembly map, the number of pieces into which each municipality is split (i.e., the number of assembly districts that overlap with the municipality), and the number of times the municipality is split (which is one less than the preceding value).

Table A5. List of split municipalities in the assembly map and number of times each is split.

| Municipality | No. Split Pieces | No. Times Split | Municipality | No. Split Pieces | No. Times Split |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Appleton city | 4 | 3 | Mequon city | 2 | 1 |
| Bellevue village | 3 | 2 | Middleton city | 2 | 1 |
| Brookfield city | 2 | 1 | Middleton town | 2 | 1 |
| Brown Deer village | 2 | 1 | Milwaukee city | 14 | 13 |
| Caledonia village | 2 | 1 | Mount Pleasant village | 2 | 1 |
| Dunn town (Dane Co.) | 2 | 1 | Neenah city | 2 | 1 |
| Eau Claire city | 3 | 2 | New Berlin city | 4 | 3 |
| Fond du Lac town | 2 | 1 | North Prairie village | 2 | 1 |
| Fox Crossing village | 2 | 1 | Oak Creek city | 3 | 2 |
| Franklin city | 3 | 2 | Oconomowoc city | 2 | 1 |
| Grand Chute town | 3 | 2 | Oshkosh city | 2 | 1 |
| Green Bay city | 4 | 3 | Pewaukee city | 3 | 2 |
| Greenfield city | 3 | 2 | Racine city | 3 | 2 |
| Harrison village | 2 | 1 | Salem Lakes village | 2 | 1 |
| Hortonia town | 2 | 1 | Sheboygan town | 2 | 1 |
| Janesville city | 3 | 2 | Somers town | 2 | 1 |
| Jefferson city | 2 | 1 | Stettin town | 2 | 1 |
| Kaukauna city | 2 | 1 | Stockton town | 2 | 1 |
| Kenosha city | 3 | 2 | Sun Prairie city | 4 | 3 |
| La Crosse city | 3 | 2 | Vandenbroek town | 2 | 1 |
| La Prairie town | 2 | 1 | Watertown city | 2 | 1 |
| Lake Geneva city | 2 | 1 | Waukesha city | 5 | 4 |
| Lawrence town (Brown Co.) | 2 | 1 | Waukesha town | 3 | 2 |
| Lyons town | 2 | 1 | Wauwatosa city | 3 | 2 |
| Madison city | 7 | 6 | West Allis city | 2 | 1 |
| Madison town | 3 | 2 | Weston village | 2 | 1 |
| Medary town | 2 | 1 | Whitewater city | 2 | 1 |
| Menomonee Falls village | 2 | 1 | Wrightstown village | 2 | 1 |
| Sum |  | 46 |  |  | 52 |

The senate map splits 39 municipalities 50 times. Table A6 below shows which municipalities are split in the senate map, the number of pieces into which each municipality is split (i.e., the number of senate districts that overlap with the municipality), and the number of times the municipality is split (which is one less than the preceding value).

Table A6. List of split municipalities in the senate map and number of times each is split.

| Municipality | No. Split <br> Pieces | No. Times <br> Split | Municipality | No. Split <br> Pieces | No. Times <br> Split |
| :--- | :---: | :---: | :--- | :---: | :---: |
| Appleton city | 2 | 1 | Milwaukee city | 6 | 5 |
| Bellevue village | 2 | 1 | Mount Pleasant village | 2 | 1 |
| Brookfield city | 2 | 1 | New Berlin city | 2 | 1 |
| Brown Deer village | 2 | 1 | North Prairie village | 2 | 1 |
| Dunn town (Dane Co.) | 2 | 1 | Oak Creek city | 2 | 1 |
| Fond du Lac town | 2 | 1 | Oconomowoc city | 2 | 1 |
| Fox Crossing village | 2 | 1 | Oshkosh city | 2 | 1 |
| Franklin city | 2 | 1 | Pewaukee city | 3 | 2 |
| Grand Chute town | 2 | 1 | Racine city | 2 | 1 |
| Green Bay city | 2 | 1 | Salem Lakes village | 2 | 1 |
| Greenfield city | 2 | 1 | Stettin town | 2 | 1 |
| Harrison village | 2 | 1 | Sun Prairie city | 2 | 1 |
| Jefferson city | 2 | 1 | Waukesha city | 4 | 3 |
| Lawrence town (Brown Co.) | 2 | 1 | Waukesha town | 2 | 1 |
| Madison city | 5 | 4 | Wauwatosa city | 3 | 2 |
| Madison town | 2 | 1 | West Allis city | 2 | 1 |
| Menomonee Falls village | 2 | 1 | Weston village | 2 | 1 |
| Mequon city | 2 | 1 | Whitewater city | 2 | 1 |
| Middleton city | 2 | 1 | Wrightstown village | 2 | 1 |
| Middleton town | 2 |  |  |  | 27 |
| Sum |  |  |  |  | 2 |

## 3. Contiguity

All assembly districts except those listed below are strictly contiguous.

- Assembly district 55 is not strictly contiguous because it includes an island in Lake Winnebago that is offshore from the main portion of the district. The main portion of assembly district 55 is strictly contiguous.
- Assembly district 61 is not strictly contiguous because it includes an island in Lake Michigan that is offshore from the main portion of the district. The main portion of assembly district 61 is strictly contiguous.
- Assembly district 73 is not strictly contiguous because it includes an island in Lake Superior that is offshore from the main portion of the district. The main portion of assembly district 73 is strictly contiguous.
- Assembly district 74 is not strictly contiguous because it includes the Apostle Islands in Lake Superior that are offshore from the main portion of the district. The main portion of assembly district 74 is strictly contiguous.
- Assembly district 83 is not strictly contiguous because it includes an island in Green Bay that is offshore from the main portion of the district. The main portion of assembly district 83 is strictly contiguous.
- Assembly district 84 is not strictly contiguous because it includes islands in Green Bay that are offshore from the main portion of the district. The main portion of assembly district 84 is strictly contiguous.
- Assembly district 88 is not strictly contiguous because it includes an island in Green Bay that is offshore from the main portion of the district. The main portion of assembly district 88 is strictly contiguous.
- Assembly district 89 is not strictly contiguous because it includes islands in Green Bay and Lake Michigan that are offshore from the main portion of the district. The main portion of assembly district 89 is strictly contiguous.

All senate districts except those listed below are strictly contiguous.

- Senate district 19 is not strictly contiguous because it includes an island in Lake Winnebago that is offshore from the main portion of the district. The main portion of senate district 19 is strictly contiguous.
- Senate district 21 is not strictly contiguous because it includes an island in Lake Michigan that is offshore from the main portion of the district. The main portion of senate district 21 is strictly contiguous.
- Senate district 25 is not strictly contiguous because it includes islands in Lake Superior that are offshore from the main portion of the district. The main portion of senate district 25 is strictly contiguous.
- Senate district 28 is not strictly contiguous because it includes islands in Green Bay that are offshore from the main portion of the district. The main portion of senate district 28 is strictly contiguous.
- Senate district 30 is not strictly contiguous because it includes islands in Green Bay and Lake Michigan that are offshore from the main portion of the district. The main portion of senate district 30 is strictly contiguous.


## 4. Compactness

According to DRA, the average (Reock, Polsby-Popper) compactness score of the assembly districts is ( $0.4443,0.3747$ ). Table A7 below shows the Reock and Polsby-Popper compactness scores of the individual assembly districts.

Table A7. Reock and Polsby-Popper compactness scores of the assembly districts

| District | Reock | Polsby- <br> Popper | District | Reock | Polsby- <br> Popper | District | Reock | Polsby- <br> Popper |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 0.5488 | 0.486 | 34 | 0.3937 | 0.2153 | 67 | 0.4497 | 0.4124 |
| 2 | 0.355 | 0.4325 | 35 | 0.3775 | 0.4097 | 68 | 0.3019 | 0.3119 |
| 3 | 0.5275 | 0.5125 | 36 | 0.5237 | 0.5087 | 69 | 0.5577 | 0.4899 |
| 4 | 0.3889 | 0.3505 | 37 | 0.5022 | 0.3625 | 70 | 0.4673 | 0.4646 |
| 5 | 0.3192 | 0.2845 | 38 | 0.2707 | 0.3297 | 71 | 0.4269 | 0.5115 |
| 6 | 0.5608 | 0.3411 | 39 | 0.6044 | 0.3013 | 72 | 0.4099 | 0.3544 |
| 7 | 0.1822 | 0.1364 | 40 | 0.4017 | 0.4336 | 73 | 0.4564 | 0.3588 |
| 8 | 0.5885 | 0.3623 | 41 | 0.4918 | 0.4315 | 74 | 0.4458 | 0.1351 |
| 9 | 0.4328 | 0.235 | 42 | 0.4191 | 0.3526 | 75 | 0.4395 | 0.4082 |
| 10 | 0.3775 | 0.1621 | 43 | 0.4775 | 0.4768 | 76 | 0.4472 | 0.5163 |
| 11 | 0.3803 | 0.2403 | 44 | 0.5938 | 0.4734 | 77 | 0.6551 | 0.4188 |
| 12 | 0.4844 | 0.3411 | 45 | 0.4249 | 0.4358 | 78 | 0.5067 | 0.4609 |
| 13 | 0.432 | 0.3909 | 46 | 0.297 | 0.392 | 79 | 0.5623 | 0.2963 |
| 14 | 0.4109 | 0.2629 | 47 | 0.6282 | 0.3502 | 80 | 0.3771 | 0.3801 |
| 15 | 0.5161 | 0.4939 | 48 | 0.5304 | 0.352 | 81 | 0.33 | 0.3369 |
| 16 | 0.4728 | 0.3586 | 49 | 0.3307 | 0.3153 | 82 | 0.3938 | 0.3005 |
| 17 | 0.3518 | 0.3222 | 50 | 0.3839 | 0.2496 | 83 | 0.4367 | 0.3267 |
| 18 | 0.2679 | 0.2115 | 51 | 0.425 | 0.4834 | 84 | 0.5554 | 0.4716 |
| 19 | 0.2346 | 0.1467 | 52 | 0.5449 | 0.5015 | 85 | 0.4013 | 0.4216 |
| 20 | 0.423 | 0.345 | 53 | 0.494 | 0.3492 | 86 | 0.4919 | 0.3051 |
| 21 | 0.5163 | 0.5057 | 54 | 0.289 | 0.3699 | 87 | 0.6016 | 0.6375 |
| 22 | 0.5035 | 0.3478 | 55 | 0.484 | 0.326 | 88 | 0.4765 | 0.424 |
| 23 | 0.4928 | 0.4874 | 56 | 0.5746 | 0.5629 | 89 | 0.1537 | 0.1082 |
| 24 | 0.4964 | 0.4124 | 57 | 0.2979 | 0.2364 | 90 | 0.3097 | 0.2089 |
| 25 | 0.4088 | 0.4543 | 58 | 0.3348 | 0.4185 | 91 | 0.5399 | 0.5571 |
| 26 | 0.4524 | 0.3825 | 59 | 0.3435 | 0.2393 | 92 | 0.4921 | 0.4582 |
| 27 | 0.571 | 0.5319 | 60 | 0.3858 | 0.4568 | 93 | 0.3838 | 0.3105 |
| 28 | 0.4219 | 0.4251 | 61 | 0.2254 | 0.2515 | 94 | 0.5327 | 0.3256 |
| 29 | 0.6085 | 0.5359 | 62 | 0.3341 | 0.2609 | 95 | 0.5127 | 0.386 |
| 30 | 0.4916 | 0.5024 | 63 | 0.3414 | 0.2825 | 96 | 0.4092 | 0.4313 |
| 31 | 0.5735 | 0.5121 | 64 | 0.2651 | 0.1866 | 97 | 0.5187 | 0.2771 |
| 32 | 0.5268 | 0.5335 | 65 | 0.4821 | 0.3795 | 98 | 0.525 | 0.2732 |
| 33 | 0.4317 | 0.3407 | 66 | 0.5944 | 0.4655 | 99 | 0.5961 | 0.4704 |

According to DRA, the average (Reock, Polsby-Popper) compactness score of the senate districts is ( $0.3867,0.3233$ ). Table A8 below shows the Reock and Polsby-Popper compactness scores of the individual senate districts.

Table A8. Reock and Polsby-Popper compactness scores of the senate districts

| District | Reock | Polsby- <br> Popper | District | Reock | Polsby- <br> Popper | District | Reock | Polsby- <br> Popper |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 0.5901 | 0.4861 | 12 | 0.4417 | 0.4379 | 23 | 0.3444 | 0.3711 |
| 2 | 0.3866 | 0.3482 | 13 | 0.3121 | 0.2521 | 24 | 0.3864 | 0.4209 |
| 3 | 0.3888 | 0.2888 | 14 | 0.4236 | 0.4032 | 25 | 0.2568 | 0.1492 |
| 4 | 0.3373 | 0.231 | 15 | 0.469 | 0.5754 | 26 | 0.5034 | 0.4462 |
| 5 | 0.3938 | 0.1865 | 16 | 0.1752 | 0.1673 | 27 | 0.2565 | 0.2531 |
| 6 | 0.3978 | 0.2314 | 17 | 0.3855 | 0.3857 | 28 | 0.5009 | 0.2632 |
| 7 | 0.2866 | 0.244 | 18 | 0.3471 | 0.3126 | 29 | 0.4978 | 0.4005 |
| 8 | 0.5121 | 0.33 | 19 | 0.354 | 0.1849 | 30 | 0.1334 | 0.087 |
| 9 | 0.3823 | 0.4368 | 20 | 0.307 | 0.2786 | 31 | 0.3689 | 0.3069 |
| 10 | 0.4098 | 0.3759 | 21 | 0.3612 | 0.3322 | 32 | 0.4776 | 0.4809 |
| 11 | 0.4866 | 0.3524 | 22 | 0.3993 | 0.4063 | 33 | 0.4886 | 0.2432 |

## 5. Federal Law Compliance

Table A9 below shows the demographic information for assembly districts 7-9, 10-12, and 16-18 and senate districts 3,4 , and 6 in map 173\#008. This information is identical to the map that was used for the November 2022 election (SB621). Thus, 173\#008 and SB621 have equivalent VRA compliance.

Table A9. Racial and ethnic data for assembly districts 7-9, 10-12, and 16-18 and senate districts 3, 4, and 6 for maps 173\#008 and SB621 (same for both maps).

| DISTRICT | PERSONS | $\begin{array}{\|c\|} \hline \text { PERSONS } \\ 18 \end{array}$ | WHITE <br> 18 | $\begin{gathered} \text { BLACK } \\ 18 \end{gathered}$ | HISPANIC <br> 18 | $\begin{array}{\|c\|} \hline \text { ASIAN } \\ \hline 18 \\ \hline \end{array}$ | AMINDIAN <br> 18 | $\begin{array}{\|c} \hline \text { PISLAND } \\ 18 \end{array}$ | $\begin{array}{\|c\|} \hline \text { OTHER } \\ 18 \\ \hline \end{array}$ | OTHERMLT 18 | \%Black VAP | \%Hisp VAP |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Asm 7 | 59603 | 46329 | 30268 | 3130 | 9201 | 2213 | 841 | 35 | 460 | 181 | 6.8\% | 19.9\% |
| Asm 8 | 59362 | 40439 | 8022 | 3432 | 26651 | 1417 | 485 | 22 | 214 | 196 | 8.5\% | 65.9\% |
| Asm 9 | 59571 | 42238 | 13084 | 3330 | 22371 | 2439 | 514 | 22 | 292 | 186 | 7.9\% | 53.0\% |
| Asm 10 | 59503 | 45220 | 19708 | 20700 | 2284 | 1497 | 280 | 13 | 376 | 362 | 45.8\% | 5.1\% |
| Asm 11 | 59565 | 41166 | 5961 | 29420 | 1838 | 3089 | 194 | 14 | 242 | 408 | 71.5\% | 4.5\% |
| Asm 12 | 59351 | 42610 | 12652 | 23644 | 2233 | 3167 | 274 | 14 | 289 | 337 | 55.5\% | 5.2\% |
| Asm 16 | 59714 | 45615 | 14609 | 23985 | 3231 | 2737 | 292 | 22 | 363 | 376 | 52.6\% | 7.1\% |
| Asm 17 | 59435 | 43760 | 12734 | 26333 | 1948 | 1771 | 265 | 30 | 305 | 374 | 60.2\% | 4.5\% |
| Asm 18 | 59346 | 43972 | 15861 | 22337 | 2781 | 1831 | 371 | 29 | 373 | 389 | 50.8\% | 6.3\% |
| Sen 3 | 178536 | 129006 | 51374 | 9892 | 58223 | 6069 | 1840 | 79 | 966 | 563 | 7.7\% | 45.1\% |
| Sen 4 | 178419 | 128996 | 38321 | 73764 | 6355 | 7753 | 748 | 41 | 907 | 1107 | 57.2\% | 4.9\% |
| Sen 6 | 178495 | 133347 | 43204 | 72655 | 7960 | 6339 | 928 | 81 | 1041 | 1139 | 54.5\% | 6.0\% |

When SB621 was considered by the Court in Johnson v. Wisconsin Elections Commission, Sections II and IV of Dr. John Alford's expert report dated December 15, 2021 demonstrated that assembly districts 7-9, 10-12, and 16-18 (and senate districts $3,4,6$ ) complied with the VRA at the time.

The results of the August 9, 2022 primary elections also support this conclusion. Among all contests in the Democratic primary, four involved at least one minority candidate and at least one White candidate. These four contests-for U.S. Senate, Milwaukee County Sheriff, Milwaukee County Clerk, and Assembly District 10 Representative-all featured at least one Black candidate and at least one White candidate. In the contest for U.S. Senate, the Black candidate Mandela Barnes overwhelmingly won every one of the assembly districts 10-12 and 16-18 and senate districts 4 and 6. In the contest for Milwaukee County Sheriff, the Black candidate Denita Ball won every one of the assembly districts 10-12 and 16-18 and senate districts 4 and 6 . In the contest for Milwaukee County Clerk, the Black candidate Anna Maria Hodges won every one of the assembly districts 10-12 and 16-18 and senate districts 4 and 6 . In the final contest, the Black candidate Darrin Madison carried the only assembly district involved in the contest: district 10. To our knowledge, no contest in the August 9, 2022 primary involved at least one Hispanic candidate and at least one non-Hispanic candidate.

Overall, the evidence points to the conclusion that assembly districts 7-9, 10-12, and 16-18 and senate districts 3,4 , and 6 in map 173\#008 will perform for Black and Hispanic voters.

## 6. Community Considerations

The boundaries of Native American reservations and tribal lands in Wisconsin are clearly depicted at WisconsinFirstNations.org/current-tribal-lands-map-native-nations-facts. Figure A1 shows the map of these communities of that can be downloaded from this website.


Figure A1. Map of Native American reservations and tribal lands in Wisconsin
Of the communities depicted above, nine are particularly large. Table A10 lists these nine communities and shows the assembly and senate districts with which they overlap. Of these nine communities, eight are entirely within individual assembly districts. Furthermore, these eight communities are found within a total of three assembly districts-36, 74, and 83-that have Native American voting age population (VAP) percentages of $12.01 \%$, $14.88 \%$, and $3.35 \%$ respectively.

The only Native American reservation not wholly contained within an assembly district is the Oneida reservation which spans two counties. In this case, the western and eastern portions of the reservation were assigned to different districts, one for each county, to reduce the amount of county splitting in the map.

Table A10. Consideration of Native American communities in map 173\#008

| Community of Interest | Overlapping <br> Assembly <br> District(s) | \% Native American <br> VAP in Assembly <br> District(s) | Overlapping <br> Senate <br> District(s) |
| :--- | :---: | :---: | :---: |
| Menominee Reservation <br> Stockbridge-Munsee Reservation | 36 | $12.01 \%$ | 12 |
| Red Cliff Ojibwe Reservation <br> Bad River Ojibwe Reservation <br> Lac Courte Oreilles Ojibwe Reservation <br> Lac du Flambeau Ojibwe Reservation | 74 | $14.88 \%$ | 25 |
| Mole Lake Ojibwe Reservation <br> Forest County Potawatomi Trust Lands | 83 | $3.35 \%$ | 28 |
| Oneida Reservation | 6,82 | $4.83 \%, 5.38 \%$ | 2,28 |

## 8. Political Neutrality

For a swing state like Wisconsin, most measures of political neutrality are generally consistent. John F. Nagle \& Alec Ramsay, On Measuring Two-Party Partisan Bias in Unbalanced States, 20 Election Law Journal 116 (2021). Thus, the following evaluation of political neutrality focuses on the metrics that are most direct and easiest to understand. Exceptional performance for these metrics indicates exceptional performance for other metrics of political neutrality.

Table A11 shows the number of votes received by Democrats and Republicans in each proposed assembly district, averaged over the six recent statewide elections that comprise the 2016-2022 composite election data used by DRA: 2022 governor, 2022 U.S. Senate, 2022 attorney general, 2020 president, 2018 U.S. Senate, and 2016 president. Table A12 shows the number of votes received by Democrats and Republicans in each proposed senate district, averaged over the same six elections. Similar tables for individual elections can easily be compiled using the "export district data" feature in DRA.

Table A11. DRA 2016-2022 composite election data for the assembly districts in map 173\#008

| Dist. | Dem <br> Votes | Rep Votes | Dem Vote\% | Rep Vote\% | Dist. | Dem <br> Votes | Rep Votes | Dem Vote\% | Rep Vote\% | Dist. | Dem Votes | Rep Votes | Dem Vote\% | Rep Vote\% |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 11234 | 14681 | 43.3\% | 56.7\% | 34 | 12470 | 12410 | 50.1\% | 49.9\% | 67 | 14446 | 13148 | 52.4\% | 47.6\% |
| 2 | 12839 | 16532 | 43.7\% | 56.3\% | 35 | 10957 | 18728 | 36.9\% | 63.1\% | 68 | 15547 | 12923 | 54.6\% | 45.4\% |
| 3 | 10081 | 19886 | 33.6\% | 66.4\% | 36 | 9755 | 16887 | 36.6\% | 63.4\% | 69 | 13348 | 11701 | 53.3\% | 46.7\% |
| 4 | 10607 | 18818 | 36.0\% | 64.0\% | 37 | 9505 | 20196 | 32.0\% | 68.0\% | 70 | 9455 | 15213 | 38.3\% | 61.7\% |
| 5 | 13311 | 14263 | 48.3\% | 51.7\% | 38 | 16147 | 14077 | 53.4\% | 46.6\% | 71 | 16309 | 12927 | 55.8\% | 44.2\% |
| 6 | 9901 | 19016 | 34.2\% | 65.8\% | 39 | 24634 | 5333 | 82.2\% | 17.8\% | 72 | 11954 | 16945 | 41.4\% | 58.6\% |
| 7 | 13990 | 8926 | 61.0\% | 39.0\% | 40 | 14539 | 12816 | 53.1\% | 46.9\% | 73 | 15032 | 13390 | 52.9\% | 47.1\% |
| 8 | 8310 | 1820 | 82.0\% | 18.0\% | 41 | 13599 | 12870 | 51.4\% | 48.6\% | 74 | 14897 | 14169 | 51.3\% | 48.7\% |
| 9 | 10800 | 3957 | 73.2\% | 26.8\% | 42 | 17298 | 13115 | 56.9\% | 43.1\% | 75 | 13589 | 19962 | 40.5\% | 59.5\% |
| 10 | 23275 | 3835 | 85.9\% | 14.1\% | 43 | 15182 | 11241 | 57.5\% | 42.5\% | 76 | 18580 | 12493 | 59.8\% | 40.2\% |
| 11 | 17621 | 2056 | 89.6\% | 10.4\% | 44 | 15219 | 11228 | 57.5\% | 42.5\% | 77 | 24763 | 4369 | 85.0\% | 15.0\% |
| 12 | 16534 | 4260 | 79.5\% | 20.5\% | 45 | 12534 | 9769 | 56.2\% | 43.8\% | 78 | 26285 | 6875 | 79.3\% | 20.7\% |
| 13 | 14851 | 14296 | 51.0\% | 49.0\% | 46 | 16362 | 13613 | 54.6\% | 45.4\% | 79 | 26264 | 8641 | 75.2\% | 24.8\% |
| 14 | 19413 | 14480 | 57.3\% | 42.7\% | 47 | 30316 | 6127 | 83.2\% | 16.8\% | 80 | 24600 | 3798 | 86.6\% | 13.4\% |
| 15 | 13679 | 12005 | 53.3\% | 46.7\% | 48 | 12744 | 23298 | 35.4\% | 64.6\% | 81 | 14903 | 13044 | 53.3\% | 46.7\% |
| 16 | 17078 | 1638 | 91.2\% | 8.8\% | 49 | 12780 | 13079 | 49.4\% | 50.6\% | 82 | 13064 | 16521 | 44.2\% | 55.8\% |
| 17 | 21252 | 3779 | 84.9\% | 15.1\% | 50 | 27240 | 7695 | 78.0\% | 22.0\% | 83 | 9767 | 19120 | 33.8\% | 66.2\% |
| 18 | 19377 | 3566 | 84.5\% | 15.5\% | 51 | 14435 | 12418 | 53.8\% | 46.2\% | 84 | 9524 | 20254 | 32.0\% | 68.0\% |
| 19 | 24592 | 5526 | 81.7\% | 18.3\% | 52 | 10014 | 17684 | 36.2\% | 63.8\% | 85 | 11002 | 15036 | 42.3\% | 57.7\% |
| 20 | 15436 | 12264 | 55.7\% | 44.3\% | 53 | 8156 | 20178 | 28.8\% | 71.2\% | 86 | 11180 | 19094 | 36.9\% | 63.1\% |
| 21 | 10821 | 20833 | 34.2\% | 65.8\% | 54 | 13449 | 14839 | 47.5\% | 52.5\% | 87 | 7605 | 16471 | 31.6\% | 68.4\% |
| 22 | 11482 | 22362 | 33.9\% | 66.1\% | 55 | 13449 | 12008 | 52.8\% | 47.2\% | 88 | 11123 | 9013 | 55.2\% | 44.8\% |
| 23 | 9265 | 24371 | 27.5\% | 72.5\% | 56 | 14656 | 12459 | 54.1\% | 45.9\% | 89 | 14575 | 17734 | 45.1\% | 54.9\% |
| 24 | 13950 | 19943 | 41.2\% | 58.8\% | 57 | 13595 | 11991 | 53.1\% | 46.9\% | 90 | 13162 | 10625 | 55.3\% | 44.7\% |
| 25 | 10700 | 15362 | 41.1\% | 58.9\% | 58 | 9602 | 21761 | 30.6\% | 69.4\% | 91 | 14199 | 14831 | 48.9\% | 51.1\% |
| 26 | 12481 | 11348 | 52.4\% | 47.6\% | 59 | 21716 | 13402 | 61.8\% | 38.2\% | 92 | 11001 | 15143 | 42.1\% | 57.9\% |
| 27 | 10891 | 20906 | 34.3\% | 65.7\% | 60 | 13998 | 20004 | 41.2\% | 58.8\% | 93 | 10073 | 17102 | 37.1\% | 62.9\% |
| 28 | 10501 | 17687 | 37.3\% | 62.7\% | 61 | 16574 | 11586 | 58.9\% | 41.1\% | 94 | 15529 | 12375 | 55.7\% | 44.3\% |
| 29 | 10705 | 17207 | 38.4\% | 61.6\% | 62 | 13525 | 12962 | 51.1\% | 48.9\% | 95 | 14268 | 12390 | 53.5\% | 46.5\% |
| 30 | 9806 | 17522 | 35.9\% | 64.1\% | 63 | 13587 | 9551 | 58.7\% | 41.3\% | 96 | 15020 | 12417 | 54.7\% | 45.3\% |
| 31 | 10850 | 15208 | 41.6\% | 58.4\% | 64 | 11447 | 9573 | 54.5\% | 45.5\% | 97 | 12211 | 13763 | 47.0\% | 53.0\% |
| 32 | 9942 | 16995 | 36.9\% | 63.1\% | 65 | 13789 | 12738 | 52.0\% | 48.0\% | 98 | 14159 | 19997 | 41.5\% | 58.5\% |
| 33 | 10749 | 23664 | 31.2\% | 68.8\% | 66 | 13822 | 11137 | 55.4\% | 44.6\% | 99 | 12889 | 22357 | 36.6\% | 63.4\% |

Table A12. DRA 2016-2022 composite election data for the senate districts in map 173\#008

| Dist. | Dem <br> Votes | Rep <br> Votes | Dem <br> Vote\% | Rep <br> Vote\% | Dist. | Dem <br> Votes | Rep <br> Votes | Dem <br> Vote\% | Rep <br> Vote\% | Dist. | Dem <br> Votes | Rep <br> Votes | Dem <br> Vote\% | Rep <br> Vote\% |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 34154 | 51099 | $40.1 \%$ | $59.9 \%$ | 12 | 33182 | 48025 | $40.9 \%$ | $59.1 \%$ | 23 | 43341 | 37772 | $53.4 \%$ | $46.6 \%$ |
| 2 | 33819 | 52097 | $39.4 \%$ | $60.6 \%$ | 13 | 50286 | 39606 | $55.9 \%$ | $44.1 \%$ | 24 | 37718 | 45085 | $45.6 \%$ | $54.4 \%$ |
| 3 | 33100 | 14703 | $69.2 \%$ | $30.8 \%$ | 14 | 45436 | 38801 | $53.9 \%$ | $46.1 \%$ | 25 | 43518 | 47521 | $47.8 \%$ | $52.2 \%$ |
| 4 | 57430 | 10151 | $85.0 \%$ | $15.0 \%$ | 15 | 42935 | 32238 | $57.1 \%$ | $42.9 \%$ | 26 | 69628 | 23737 | $74.6 \%$ | $25.4 \%$ |
| 5 | 47943 | 40781 | $54.0 \%$ | $46.0 \%$ | 16 | 59422 | 43038 | $58.0 \%$ | $42.0 \%$ | 27 | 65767 | 25483 | $72.1 \%$ | $27.9 \%$ |
| 6 | 57707 | 8983 | $86.5 \%$ | $13.5 \%$ | 17 | 54455 | 33192 | $62.1 \%$ | $37.9 \%$ | 28 | 32355 | 55895 | $36.7 \%$ | $63.3 \%$ |
| 7 | 50849 | 38623 | $56.8 \%$ | $43.2 \%$ | 18 | 31619 | 52701 | $37.5 \%$ | $62.5 \%$ | 29 | 29787 | 50601 | $37.1 \%$ | $62.9 \%$ |
| 8 | 34697 | 66676 | $34.2 \%$ | $65.8 \%$ | 19 | 41700 | 36458 | $53.4 \%$ | $46.6 \%$ | 30 | 38860 | 37372 | $51.0 \%$ | $49.0 \%$ |
| 9 | 34072 | 47616 | $41.7 \%$ | $58.3 \%$ | 20 | 45316 | 55167 | $45.1 \%$ | $54.9 \%$ | 31 | 35273 | 47076 | $42.8 \%$ | $57.2 \%$ |
| 10 | 31012 | 52416 | $37.2 \%$ | $62.8 \%$ | 21 | 43686 | 34099 | $56.2 \%$ | $43.8 \%$ | 32 | 44817 | 37182 | $54.7 \%$ | $45.3 \%$ |
| 11 | 31541 | 55867 | $36.1 \%$ | $63.9 \%$ | 22 | 39058 | 33448 | $53.9 \%$ | $46.1 \%$ | 33 | 39259 | 56117 | $41.2 \%$ | $58.8 \%$ |

Importantly, every metric for political neutrality can be analyzed using either a "fractional seats" or "past-the-post" approach, and the two approaches can lead to different predictions and assessments of political neutrality. In past-the-post accounting, the predicted number of seats won by Party A equals the number of districts where Party A voters outnumber Party B voters. In fractional seats accounting, Party A's share of the (two-party) vote in each district is converted to a fractional value between 0 and 1 which is both the predicted number of seats Party A wins in the district and the chance that Party A wins the district. These "fractional seat" values are then summed over all districts to give the predicted number of seats won by Party A.

Figures A2 and A3 show the difference between the past-the-post and fractional seats approaches to analyzing political neutrality. Each figure considers Party A's share of the twoparty vote in a single district. As shown in Figure A2, past-the-post accounting allocates one seat to the party with more voters in a district no matter if the district is lopsided or closely contested. If the district is perfectly tied, each party is assumed to win 0.5 seats in it.


Figure A2. In past-the-post accounting, a district is categorized as a complete loss (win) if a party has less (more) than $\mathbf{5 0 \%}$ of the two-party vote in the district.

On the other hand, fractional seats accounting assumes a district is a total win or loss only if it is lopsided. If the district is competitive, each party is assumed to have a non-zero probability of winning it, i.e., a fractional predicted number of victories in it between 0 and 1. For example, DavesRedistricting.org assumes that a party with a two-party vote share of (50,52,54,56,58, 60 ) percent in a district has a (50.0, 69.1, 84.1, 93.3, 97.7, 99.4) percent chance of winning it and is therefore predicted to win ( $0.5,0.691,0.841,0.933,0.977,0.994$ ) seats in the district. Figure A3 shows this relationship. (In precise mathematical terms, Figure A3 shows the cumulative distribution function of a normally distributed random variable with mean 0.5 and standard deviation 0.04.)


Figure A3. In fractional seats accounting, a district is assumed to be a complete win or loss only if it is lopsided. If a district is competitive, each party is assumed to have a fractional, non-zero probability of winning it (i.e., a fractional, non-zero predicted number of seats it wins in the district).

Clearly, the fractional seats and past-the-post approaches can lead to different predictions and assessments of political neutrality. For example, in a state with eight districts in which Party A has $52 \%$ of the vote share in every district, the fractional seats approach predicts that Party A wins $0.691^{*} 8=5.53$ districts whereas the past-the-post approach predicts that it wins 8.00 districts. Another example showing how these approaches lead to different predictions is provided in Section I.C. 3 of my amicus curiae brief dated November 8, 2023.

Overall, fractional seats accounting is more reasonable than past-the-post accounting because it is neither extremely sensitive nor insensitive to changes in voter preferences; the smoothness of the curve in Figure A3 shows that fractional seats predictions change modestly-with no sudden thresholds-when a party's vote share in a district changes within the range from $40 \%$ and $60 \%$. On the other hand, Figure A2 shows that past-the-post predictions are entirely unresponsive when a party's vote share in a district changes from $40 \%$ to $49.9 \%$; hyper responsive when a party's vote share in a district changes from $49.9 \%$ to $50.1 \%$; and entirely unresponsive when a party's vote share in a district changes from $50.1 \%$ to $60 \%$. Fractional seats accounting is conceptually more sound than past-the-post accounting because it considers the uncertainty inherent in campaigns and elections and it is not extremely sensitive to minor changes in a few voters' preferences.

But is fractional seats accounting better than past-the-postaccounting at predicting actual election results? Yes, according to a study of state legislative elections included in my amicus curiae brief dated November 8, 2023. Therefore, the following analysis of political neutrality will be done mostly through the lens of fractional seats accounting. This type of accounting is built into the political neutrality metrics used by DavesRedistricting.org.

Next, the political neutrality of map 173\#008 is evaluated using five metrics: proportionality, efficiency gap, chances of winning a proportional seat share, number of competitive districts, and majority rule. The first three metrics are computed via the fractional seats methodology; the final two are computed via simpler, past-the-post accounting. The first four metrics are computed using the composite data in Tables A11 and A12, and the last metric is computed using the results of recent individual elections.

## Proportionality

The sum of the values in the "Dem Votes" and "Rep Votes" columns in Table A11 are 1,413,742 and 1,349,626 respectively. Overall, Democrats have received 1,413,742/(1,413,742 + $1,349,626)=51.16 \%$ of the two-party vote in Wisconsin in recent elections. In a perfectly proportional election this translates to $(.5116)^{\star}(99)=50.65$ assembly and $(.5116)^{\star}(33)=16.88$ senate seats for Democrats. Meanwhile, Republicans have received 48.84\% of the two-party vote. In a perfectly proportional election this translates to $(.4884)^{\star}(99)=48.35$ assembly and $(.4884)^{*}(33)=16.12$ senate seats for Republicans.

After using Figure A3 to convert each value in the "Dem Vote\%" column in Table A11 to a predicted number of fractional seats won by Democrats in each district and then summing the totals for all districts, the prediction is that map 173\#008 will result in Democrats winning 50.73 seats in the assembly. Using the same procedure applied to Table A12, we predict that Democrats will win 16.98 seats in the senate if map 173\#008 is used. (DRA computes these fractional seat totals automatically.) The values of 50.73 and 16.98 are 0.08 and 0.10 seats higher than the values in the previous paragraph for a perfectly proportional map: 50.65 and 16.88 respectively. Thus, Democrats are predicted to win 0.08 (0.10) more seats in the assembly (senate) than in a perfectly proportional map. This deviation from perfect proportionality slightly favors Democrats. However, the deviation is insignificant. For all intents and purposes, the map is strictly proportional in both the assembly and senate. For this reason, DRA gives 173\#008 proportionality ratings of 99 of 100 for the assembly and 100 of 100 for the senate.

## Efficiency Gap

According to DRA, the efficiency gap of the assembly and senate maps are $+1.07 \%$ and $+0.85 \%$ respectively. These positive values favor Republicans, but only slightly.

## Chances of Winning a Proportional Seat Share

Another way to evaluate political neutrality is to estimate each party's chances of winning at least a proportional share of seats. Rounded to the nearest integer, a proportional share of assembly (senate) seats for Democrats is 51 (17) and for Republicans is 48 (16).

After using the relationship in Figure A3 to convert the "Dem Vote\%" and "Rep Vote\%" values in Tables A11 and A12 into probabilities that each party wins each district, we simulated 1,000,000 assembly elections and 1,000,000 senate elections using Monte Carlo simulation and noted the number of districts each party won in each election. The number of simulated elections in which
each party won at least its proportional share of seats was then computed. This was then divided by $1,000,000$ to compute the percentage of elections in which each party won at least its proportional share of seats. This percentage can also be interpreted as the likelihood that each party will win at least its proportional share of seats in a future election. According to this procedure, the estimation is that Democrats have a $52.3 \%$ chance of winning at least 51 assembly seats and a $64.4 \%$ chance of winning at least 17 senate seats if map $173 \# 008$ is used. Meanwhile, Republicans have a $63.5 \%$ chance of winning at least 48 assembly seats and a $65.4 \%$ chance of winning at least 16 senate seats. Overall, both parties have at least a 50\% chance of winning a seat share in proportion to their overall share of the statewide vote in both the assembly and senate.

## Number of Competitive Districts

Looking at Table A11, 29 of the 99 assembly districts are in the 45\%-55\% competitive range. According to Table A12, 10 of the 33 senate districts are in the $45 \%-55 \%$ competitive range. Overall, there are a substantial number of competitive districts in both the assembly and senate. This gives both parties a significant opportunity to win additional seats if they field good candidates.

## Majority Rule

Nine different sets of election data, like that shown in Tables A11 and A12, were overlaid onto map 173\#008 to see its performance for nine recent statewide elections: the most recent two elections for president, two elections for governor, three elections for U.S. Senate, and two elections for attorney general. Democrats won six of these elections, Republicans three. After doing so, the number of assembly and senate districts in map 173\#008 that were carried by the winning candidate in each election was computed. In eight of the nine elections, the candidate who won the popular vote also carried a majority of assembly and senate districts in the map. In one election-the 2022 election for U.S. Senate-the candidate who won the popular vote carried a majority of assembly districts but not senate districts. In this election, Senator Ron Johnson defeated challenger Mandela Barnes by about 1\% of the vote. However, Ron Johnson only carried 16 of the 33 senate districts in map 173\#008. Overall, the map strongly embodies the principle of majority rule.

## Comparison with Other Maps

Map 173\#008 significantly outperforms SB621 regarding contiguity, political neutrality, compactness, competitiveness, and county splitting, but not municipality splitting. Map 173\#008 also outperforms the map (155\#176) that accompanied the amicus curiae brief I submitted to the Court on Nov. 8, 2023. According to the scoring methodology I proposed in that brief, maps 173\#008, 155\#176, and SB621 have total penalty scores of 2173, 2227.4, and 3453.9 respectively. Maps with lower penalty scores are better, so 173\#008 is the best and most appropriate of the three maps. A detailed breakdown of the scoring is shown below. Full descriptions of subcriteria 5A-9A and 5S-9S and the metrics used to score them are provided in the brief.

Table A13. Detailed scoring of maps 173\#008, 155\#176, and SB621

| Subcriterion | Weight | $173 \# 008$(strictly contiguous) |  | $155 \# 176$(strictly contiguous) |  | SB 621(not contiguous) |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Penalty Score | Weighted Penalty Score | Penalty Score | Weighted Penalty Score | Penalty Score | Weighted Penalty Score |
| 5A | 50 | 0.08 | 4 | 0.02 | 1 | 9.80 | 490 |
| 6A | 1000 | 0.5557 | 555.7 | 0.5447 | 544.7 | 0.6418 | 641.8 |
| 7A | 5 | 70 | 350 | 70 | 350 | 83 | 415 |
| 8A | 1 | 134 | 134 | 142 | 142 | 156 | 156 |
| 9 A | 1 | 56 | 56 | 98 | 98 | 51 | 51 |
| 5 S | 150 | 0.10 | 15 | 0.07 | 10.5 | 4.05 | 607.5 |
| 6 S | 1000 | 0.6133 | 613.3 | 0.5792 | 579.2 | 0.6316 | 631.6 |
| 7 S | 15 | 23 | 345 | 25 | 375 | 24 | 360 |
| 8 S | 1 | 61 | 61 | 65 | 65 | 71 | 71 |
| 9 S | 1 | 39 | 39 | 62 | 62 | 30 | 30 |
|  |  | Total Penalty $=2173$ |  | Total Penalty $=2227.4$ |  | Total Penalty = 3453.9 |  |

Matthew E. H. Petering, Ph.D.<br>Associate Professor<br>Department of Industrial \& Manufacturing Engineering<br>College of Engineering \& Applied Science<br>University of Wisconsin-Milwaukee<br>www.uwm.edu/engineering/people/petering-matthew

## EDUCATION

| Univ. Michigan-Ann Arbor | Industrial \& Operations Engineering | Ph.D. 2007 |  |
| :--- | :--- | :--- | :--- |
| Univ. Michigan-Ann Arbor | Industrial \& Operations Engineering | M.Sc. 2003 |  |
| Washington Univ. (St. Louis) | Mathematics | B.A. | 1999 |

## POSITIONS HELD

| 06/14-present | Associate Professor with Tenure, Industrial \& Manufacturing Engineering <br> Department, University of Wisconsin-Milwaukee (UWM) |
| :--- | :--- |
| $10 / 10-07 / 11$ | Associate Professor, Department of Logistics, The KLU, Hamburg, Germany |
| $08 / 07-06 / 14$ | Assistant Professor, Industrial \& Manufacturing Engineering Department, UWM |
| $09 / 06-04 / 07$ | Teaching Assistant, Industrial \& Operations Engineering Dept., University of Michigan |
| $11 / 05-07 / 06$ | Research Engineer, The Logistics Institute-Asia Pacific, National Univ. of Singapore |
| $06 / 05-09 / 05$ | Intern, Operations Planning Dept., PSA Corporation, Port of Singapore, Singapore |
| $01 / 04-03 / 05$ | Research Fellow, Industrial \& Systems Engineering Dept., National Univ. of Singapore |
| $09 / 03-12 / 03$ | Teaching Assistant, College of Engineering, University of Michigan |
| $09 / 02-04 / 03$ | Teaching Assistant, Industrial \& Operations Engineering Dept., University of Michigan |
| $05 / 02-08 / 02$ | Research Assistant, Industrial \& Operations Engineering Dept., University of Michigan |
| $02 / 01-06 / 01$ | Full-time substitute teacher for grades K-12 in Madison, Wisconsin |
| $02 / 00-06 / 00$ | Full-time substitute teacher for grades K-12 in Milwaukee, Wisconsin |
| $06 / 99-08 / 99$ | Cryptologic Mathematician, U.S. Dept. of Defense, National Security Agency, Maryland |
| $05 / 97-08 / 97$ | Intern, Actuarial Dept., Northwestern Mutual Life Insurance Co, Milwaukee, Wisconsin |

## NEWS COVERAGE

1. "Lawmakers are redrawing Wisconsin's legislative map. How does this computer-generated version compare to one drawn by committee?" Milwaukee Journal Sentinel front-page story, January 10, 2024. https://www.jsonline.com/story/news/politics/2024/01/09/computer-algorithim-or-peoples-committee-comparing-proposed-wisconsin-redistricting-maps/72108910007.
2. "The state supreme court minority's view of gerrymandering," Urban Milwaukee, December 27, 2023. https://urbanmilwaukee.com/2023/12/27/data-wonk-the-state-supreme-court-minoritys-view-of-gerrymandering.
3. "UW-Milwaukee professor creates computer algorithm to take humans out of redistricting process," TMJ4 Milwaukee 6 o'clock News, WTMJ-TV Milwaukee, December 12, 2023. https://www.tmj4.com/news/local-news/uw-milwaukee-professor-creates-computer-algorithm-to-take-humans-out-of-redistricting-process.
4. "Can we get fair political districts in Wisconsin?" Shepherd Express, December 7, 2023. https://shepherdexpress.com/news/features/can-we-get-fair-political-districts-in-wisconsin.
5. "How the gerrymander wastes votes," Urban Milwaukee, November 29, 2023. https://urbanmilwaukee.com/2023/11/29/data-wonk-how-the-gerrymander-wastes-votes.
6. "Why that 'Iowa' redistricting plan was unfair," Urban Milwaukee, October 4, 2023. https://urbanmilwaukee.com/2023/10/04/data-wonk-why-that-iowa-redistricting-plan-was-unfair.
7. "Redistricting maps by humans gerrymandered Wisconsin. Powerful algorithms could do better." Milwaukee Journal Sentinel, Sunday print edition Opinion Section main story, October 1, 2023. https://www.jsonline.com/story/opinion/2023/09/25/wisconsin-supreme-court-redraw-electoral-maps-computer-algorithms-redistricting/70919652007.
8. "New Milwaukee board Game, Distrix, teaches people how gerrymandering works," WUWM 89.7 Milwaukee Lake Effect radio program, February 2, 2021. https://www.wuwm.com/podcast/lake-effect-segments/2021-02-02/new-milwaukee-board-game-distrix-teaches-people-how-gerrymandering-works
9. "Board game tackles real-world problem of gerrymandering," UWM Report, January 14, 2021. https://uwm.edu/news/board-game-tackles-real-world-problem-of-gerrymandering

## COURT DOCUMENTS FILED

Amicus brief showing how computer algorithms can make fair legislative maps in Wisconsin, Clarke v. Wisconsin Elections Commission, Wisconsin Supreme Court case number 2023AP1399, November 8, 2023.

## PATENT APPLICATIONS

"Districting strategy game," M.E.H. Petering, USPTO document number US-20200276493-A1, September 3, 2020.

## BOARD GAMES

Distrix, M.E.H. Petering, Distrix Games (2020). Best Abstract Game at the 2021 UK Games Expo (Judges' Award Winner). Silver medal winner at the 2020 Serious Play Tabletop Game Competition.

## BOOKS

The Distrix Puzzle Book, M.E.H. Petering, Distrix Games (2020). Winner, Spring 2021 Academics' Choice Smart Book Award.

## JOURNAL PUBLICATIONS

1. "Responsive production planning and replenishment consolidation scheduling for a two-echelon supply chain," S. Alavi, M.E.H. Petering, and A. Ross, forthcoming in International Journal of Logistics Systems and Management.
2. "Learning with supervised data for anomaly detection in smart manufacturing," M. He, M.E.H. Petering, P. LaCasse, W. Otieno, and F. Maturana, International Journal of Computer Integrated Manufacturing, 36 (2023) 1331-1344.
3. "A mathematical modeling approach to university course planning," M. Khamechian and M.E.H. Petering, Computers and Industrial Engineering, 168 (2022), article number 107855. [corresponding author]
4. "The multi-spreader crane scheduling problem: Partitions and supersequences," C.T. Cheng, M.E.H. Petering, and Y. Wu, Discrete Applied Mathematics, 289 (2021) 207-218.
5. "Real-time location-positioning technologies for managing cart operations at a distribution facility," C.-H. Cheng, Y.-H. Kuo, H. Lam, and M.E.H. Petering, Applied Sciences, 11 (2021), article number 4049.
6. "Inventory control with flexible demand: Cyclic case with multiple batch supply and demand processes," M.E.H. Petering, X. Chen, and W. Hsieh, International Journal of Production Economics, 212 (2019) 60-77. [corresponding author]
7. "The two-echelon open location routing problem: Mathematical model and hybrid heuristic," K. Pichka, A.H. Bajgiran, M.E.H. Petering, J. Jang, and X. Yue, Computers and Industrial Engineering, 121 (2018) 97-112. [corresponding author]
8. "A survey of dial-a-ride problems: Literature review and recent developments," S.C. Ho, W.Y. Szeto, Y.-H. Kuo, J.M.Y. Leung, M.E.H. Petering, and T.W.H. Tou, Transportation Research Part B, 111 (2018) 395-421.
9. "Discrete event simulation analysis of a reservation-based, one-way car sharing system," $\mathrm{L} . \mathrm{Li}$ and M.E.H. Petering, Journal of Simulation, 12 (2018) 1-22. [corresponding author]
10. "Sequencing dual-spreader crane operations: Mathematical formulation and heuristic algorithm," S. Lashkari, Y. Wu, and M.E.H. Petering, European Journal of Operational Research, 262 (2017) 521-534. [corresponding author]
11. "Real-time container storage location assignment at a seaport container transshipment terminal: Dispersion levels, yard templates, and sensitivity analyses," M.E.H. Petering, Y. Wu, W. Li, M. Goh, R. de Souza, and K.G. Murty, Flexible Services and Manufacturing Journal, 29 (2017) 369402. [corresponding author]
12. "Mixed integer programming for railway capacity analysis and cyclic, combined train timetabling and platforming," M.E.H. Petering, M. Heydar, and D. Bergmann, Transportation Science, 50 (2016) 892-909. [corresponding author]
13. "Strategic evacuation planning with pedestrian guidance and bus routing: A mixed integer programming model and heuristic solution," M. Heydar, J. Yu, Y. Liu, and M.E.H. Petering, Journal of Advanced Transportation, 50 (2016) 1314-1335.
14. "Scheduling multiple yard cranes with crane interference and safety distance requirement," Y. Wu, W. Li, M.E.H. Petering, M. Goh, and R. de Souza, Transportation Science, 49 (2015) 9901005.
15. "Real-time container storage location assignment at an RTG-based seaport container transshipment terminal: Problem description, control system, simulation model, and penalty scheme experimentation," M.E.H. Petering, Flexible Services and Manufacturing Journal, 27 (2015) 351-381. [corresponding author]
16. "Simulation analysis of hospital intensive care unit reimbursement policies from the triple bottom line perspective," M.E.H. Petering, O.T. Aydas, K. Kuzu, and A. Ross, Journal of Simulation, 9 (2015) 86-98. [corresponding author]
17. "A new mixed integer program and extended look-ahead heuristic algorithm for the block relocation problem," M.E.H. Petering and M. Hussein, European Journal of Operational Research, 231 (2013) 120-130. [corresponding author]
18. "Mixed integer programming for minimizing the period of a cyclic railway timetable for a single track with two train types," M. Heydar, M.E.H. Petering, and D. Bergmann, Computers and Industrial Engineering, 66 (2013) 171-185. [corresponding author]
19. "A continuous time model for multiple yard crane scheduling with last minute job arrivals," W. Li, M. Goh, Y. Wu, M.E.H. Petering, R. de Souza, and Y.C. Wu, International Journal of Production Economics, 136 (2012) 332-343.
20. "Decision support for yard capacity, fleet composition, truck substitutability, and scalability issues at seaport container terminals," M.E.H. Petering, Transportation Research Part E, 47 (2011) 85-103. [corresponding author]
21. "Development and simulation analysis of real-time, dual-load yard truck control systems for seaport container transshipment terminals," M.E.H. Petering, OR Spectrum, 32 (2010) 633-661. [corresponding author]
22. "Effect of block width and storage yard layout on marine container terminal performance," M.E.H. Petering, Transportation Research Part E, 45 (2009) 591-610. [corresponding author]
23. "Effect of block length and yard crane deployment systems on overall performance at a seaport container transshipment terminal," M.E.H. Petering and K.G. Murty, Computers and Operations Research, 36 (2009) 1711-1725. [corresponding author]
24. "Development and simulation analysis of real-time yard crane control systems for seaport container transshipment terminals," M.E.H. Petering, Y. Wu, W. Li, M. Goh, and R. de Souza, OR Spectrum, 31 (2009) 801-835. [corresponding author]
25. "Discrete time model and algorithms for container yard crane scheduling," W. Li, Y. Wu, M.E.H. Petering, M. Goh, and R. de Souza, European Journal of Operational Research, 198 (2009) 165172.
26. "Performance analysis of a multiple vehicle tandem system with inter-vehicle buffers and blocking," M.E.H. Petering, J. Seo, and C. Lee, Computers in Industry, 58 (2007) 3-11. [author who did correspondence]

## CONFERENCE PUBLICATIONS

1. "Linear penalty relation and genetic algorithms for the block relocation problem with weights," M. Hussein and M.E.H. Petering, 2013 IIE Annual Conference, San Juan, Puerto Rico, May 2013.
2. "Genetic algorithm-based simulation optimization of stacking algorithms for yard cranes to reduce fuel consumption at seaport container transshipment terminals," M. Hussein and M.E.H. Petering, 2012 IEEE Congress on Evolutionary Computation, Brisbane, Australia, June 2012 ("A" rated computer science conference).
3. "Global retrieval heuristic and genetic algorithm in the block relocation problem," M. Hussein and M.E.H. Petering, 2012 IIE Annual Conference, Orlando, Florida, May 2012.
4. "Evacuating highly populated urban zones during an emergency: a transit-based solution and optimal operational strategies," M. Heydar, Y. Liu, and M.E.H. Petering, Transport Chicago, Chicago, Illinois, June 2011.
5. "Parallel versus perpendicular yard layouts for seaport container transshipment terminals: an extensive simulation analysis," M.E.H. Petering, International Trade and Freight Transportation Conference, Ayia Napa, Cyprus, September 2008.
6. "Simulation analysis of yard crane routing systems at a marine container transshipment terminal," M.E.H. Petering, Y. Wu, W. Li, M. Goh, K.G. Murty, and R. de Souza, International Congress on Logistics and Supply Chain Management Systems, Kaohsiung, Taiwan, May 2006.
7. "Simulation analysis of algorithms for container storage and yard crane scheduling at a container terminal," M.E.H. Petering and K.G. Murty, Second International Intelligent Logistics Systems Conference, Brisbane, Australia, February 2006.
8. "Performance analysis of a multiple vehicle tandem system with inter-vehicle buffers and blocking," M.E.H. Petering, J. Seo, and C. Lee, Fifth International Conference on "Analysis of Manufacturing Systems - Production Management," Zakynthos Island, Greece, May 2005.

## CONFERENCE PRESENTATIONS

1. "Distrix and FastMap: Addressing America's gerrymandering problem with a puzzle book, strategy game, and computer algorithm," M.E.H. Petering, INFORMS Annual Conference, Phoenix, Arizona, October 2023.
2. "University course scheduling during a pandemic," M.E.H. Petering and M. Khamechian, CORS/INFORMS International Conference, Vancouver, Canada, June 2022.
3. "Reevaluating order fulfillment plans in real time in an online retail environment," A. Kalantari and M.E.H. Petering, INFORMS Annual Conference, Seattle, Washington, October 2019.
4. "Inventory control with flexible demand: Cyclic case with multiple batch supply and demand processes," M.E.H. Petering, X. Chen, and W. Hsieh, INFORMS Annual Conference, Phoenix, Arizona, November 2018.
5. "Evaluating exact vs. rule-based algorithms for the unending real-time traveling repairperson problem under true simulated operating conditions," M.E.H. Petering, Odysseus 2018 Seventh International Workshop on Freight Transportation and Logistics, Cagliari, Sardinia, Italy, June 2018 (peer-reviewed abstract - $60 \%$ acceptance rate).
6. "Using simulation and optimization to evaluate algorithms for revising online order fulfillment plans in real time," A. Kalantari and M.E.H. Petering, POMS Annual Conference, Houston, Texas, May 2018.
7. "Simulation and optimization for reevaluating order fulfillment decisions in an online retail environment," A. Kalantari and M.E.H. Petering, INFORMS Annual Conference, Houston, Texas, October 2017.
8. "Simulation and optimization for reevaluating order fulfillment plans in an online retail environment," A. Kalantari and M.E.H. Petering, POMS Annual Conference, Seattle, Washington, May 2017.
9. "Railway capacity analysis and cyclic, combined train timetabling and platforming for a single track, bidirectional railway line," M. Heydar and M.E.H. Petering, INFORMS Annual Conference, Nashville, Tennessee, November 2016.
10. "Comparison of algorithms for the unending real-time traveling repairperson problem by fully embedding them within a discrete event simulation model," M.E.H. Petering, Odysseus 2015 Sixth International Workshop on Freight Transportation and Logistics, Ajaccio, Corsica, France, June 2015 (peer-reviewed abstract - $60 \%$ acceptance rate).
11. "Discrete event simulation analysis of a reservation-based, one-way car sharing system," M.E.H. Petering, The Sixth POMS-HK International Conference, Guangzhou, China, January 2015.
12. "Triple bottom line analysis of alternative reimbursement policies and configurations for a hospital intensive care unit with early patient discharges and readmissions," M.E.H. Petering, O.T. Aydas, K. Kuzu, and A. Ross, Sustainability Summit, Milwaukee, Wisconsin, March 2014.
13. "Integer programming for cyclic railway timetabling and routing on a single track unidirectional line," M.E.H. Petering, M. Heydar, and D. Bergmann, INFORMS Annual Conference, Minneapolis, Minnesota, October 2013.
14. "Discrete event simulation analysis of a reservation-based car sharing system offering one-way journeys," L. Li and M.E.H. Petering, INFORMS Annual Conference, Minneapolis, Minnesota, October 2013.
15. "Real-time container storage location assignment at a seaport container transshipment terminal: dispersion levels and math programming strategies," M.E.H. Petering, K.G. Murty, Y. Wu, W. Li, M. Goh, and R. de Souza, 2nd INFORMS TSL Society Workshop, Pacific Grove, CA, June 2013 (peer-reviewed abstract).
16. "Mixed integer programming for capacity analysis of a single track railway part III," M.E.H. Petering and M. Heydar, IIE Annual Conference, San Juan, Puerto Rico, May 2013.
17. "Mixed integer programming for minimizing the period of a cyclic railway timetable for a single track line with two train types," M.E.H. Petering, M. Heydar, and D. Bergmann, INFORMS Annual Conference, Phoenix, Arizona, October 2012.
18. "Real-time container storage location assignment at a seaport container transshipment terminal part III," M.E.H. Petering, LOGMS 2012 Conference, Bremen, Germany, August 2012.
19. "Genetic algorithm-based simulation optimization of stacking algorithms for yard cranes to reduce fuel consumption at seaport container transshipment terminals," M. Hussein and M.E.H. Petering, 2012 IEEE Congress on Evolutionary Computation, Brisbane, Australia, June 2012 ("A" rated computer science conference).
20. "Real-time container storage location assignment at a seaport container transshipment terminal part II," M.E.H. Petering, Odysseus 2012 Fifth International Workshop on Freight Transportation and Logistics, Mykonos Island, Greece, May 2012 (peer-reviewed abstract- $61 \%$ acceptance rate).
21. "Real-time container storage location assignment at a seaport container transshipment terminal part II," M.E.H. Petering, INFORMS Annual Conference, Charlotte, North Carolina, Nov. 2011.
22. "A new mixed integer program and comparison of algorithms for the block relocation problem," M.E.H. Petering and M. Hussein, INFORMS Annual Conference, Austin, Texas, Nov. 2010.
23. "Real-time container storage location assignment at a seaport container transshipment terminal," M.E.H. Petering and K.G. Murty, LOGMS 2010 Conference, Busan, South Korea, September 2010.
24. "Real-time container storage location assignment at a seaport container transshipment terminal," M.E.H. Petering and K.G. Murty, IIE Annual Conference, Cancun, Mexico, June 2010.
25. "Design and real-time control of a seaport container transshipment terminal," M.E.H. Petering, INFORMS Annual Conference, San Diego, California, Oct. 2009.
26. "Parallel versus perpendicular yard layouts for seaport container transshipment terminals: an extensive simulation analysis," M.E.H. Petering, CORS-INFORMS Meeting, Toronto, June 2009.
27. "Real-time container storage location assignment at a seaport container transshipment terminal," M.E.H. Petering and K.G. Murty, Odysseus 2009 Fourth International Workshop on Freight Transportation and Logistics, Cesme, Turkey, May 2009 (peer-reviewed abstract).
28. "Development and simulation analysis of real-time yard crane control systems for seaport container transshipment terminals," M.E.H. Petering, Y. Wu, W. Li, M. Goh, and R. de Souza, INFORMS Annual Conference, Washington DC, Oct. 2008.
29. "Parallel versus perpendicular yard layouts for seaport container transshipment terminals: an extensive simulation analysis," M.E.H. Petering, International Trade and Freight Transportation Conference, Ayia Napa, Cyprus, September 2008.
30. "Development and simulation analysis of real-time, dual-load yard truck dispatching systems for seaport container transshipment terminals," M.E.H. Petering, $3^{\text {rd }}$ German-Korean Workshop on IT-Based Planning and Control of Seaport Container Terminals, Bremen, Germany, Aug. 2008.
31. "Design of seaport container transshipment terminals: yard layout, fleet composition, and scalability issues," M.E.H. Petering, IIE Annual Conference, Vancouver, Canada, May 2008.
32. "Real-time container storage location assignment at a seaport container transshipment terminal," M.E.H. Petering and K.G. Murty, INFORMS Annual Conference, Seattle, Washington, Nov. 2007.
33. "Simulation analysis of yard crane routing systems at a marine container transshipment terminal," M.E.H. Petering, Y. Wu, W. Li, M. Goh, K.G. Murty, and R. de Souza, International Congress on Logistics and Supply Chain Management Systems, Kaohsiung, Taiwan, May 2006.
34. "Simulation analysis of algorithms for container storage and yard crane scheduling at a container terminal," M.E.H. Petering and K.G. Murty, Second International Intelligent Logistics Systems Conference, Brisbane, Australia, February 2006.
35. "Performance analysis of a multiple vehicle tandem system with inter-vehicle buffers and blocking," M.E.H. Petering, J. Seo, and C. Lee, Fifth International Conference on "Analysis of Manufacturing Systems - Production Management," Zakynthos Island, Greece, May 2005.

## INVITED PRESENTATIONS AND SEMINAR TALKS

36. "An algorithmic approach to redistricting in Michigan," presentation to the Michigan Independent Citizens Redistricting Commission (MICRC), https://www.youtube.com/watch?v=NJnn7Xj3Gb8\&t=4371s.
37. "Unraveling gerrymandering: Wisconsin's journey to fair redistricting," Milwaukee Public Library online program, May 24, 2021, https://www.youtube.com/watch?v=vuisaqZ9K08.
38. "Fair maps or gerrymandered maps?" Virtual town hall meeting with Wisconsin State Senator Chris Larson, April 26, 2021, https://www.youtube.com/watch?v=yQ80hscLzlw.
39. "Transforming connected systems into smart connected systems: research insights and future opportunities," Sheldon Lubar School of Business, UW-Milwaukee, April 2018.
40. "Illustration of three operations research modeling techniques," Department of Systems Engineering and Engineering Management, Chinese University of Hong Kong, Hong Kong, February 2016.
41. "Math and computer modeling of logistics and transportation systems," UW-Milwaukee Applied and Computational Mathematics research group seminar, April 2, 2015.
42. "Real-time container storage location assignment at a seaport container transshipment terminal," Department of Systems Engineering and Engineering Management, Chinese University of Hong Kong, Hong Kong, January 2015.
43. "Computer-driven decision support for the design and operations management of logistics and transportation systems," UW-Milwaukee Computer Science Dept., October 25, 2013.
44. "Operations research in action in today's world," meeting of the UW-Milwaukee INFORMS student chapter, UW-Milwaukee Institute of Industrial Innovation, December 9, 2011.
45. "Design, analysis, and real-time control of seaport container transshipment terminals," The Kühne Logistics University, Hamburg, Germany, April 6, 2011.
46. "Real-time container storage location assignment at a seaport container transshipment terminal," Institute for Maritime Logistics and Fraunhofer Center for Maritime Logistics, Technical University of Hamburg-Harburg, Hamburg, January 17, 2011.
47. "A new mixed integer program and comparison of algorithms for the block relocation problem," Institute of Information Systems, University of Hamburg, December 9, 2010.
48. "Design, analysis, and real-time control of seaport container transshipment terminals," Faculty of Applied Sciences, Simon Fraser University, Vancouver, July 26, 2010.
49. "Introduction to container shipping," Center for International Education, UW-Milwaukee, March 24, 2009.
50. "Real-time container storage location assignment at a seaport container transshipment terminal," Division of Systems \& Engineering Management, Nanyang Technological University, Singapore, Jan 10, 2008.
51. "Simulation analysis of real-time yard control systems for marine container transshipment terminals," Dept. of Ocean and Resources Engineering, University of Hawaii, Oct 18, 2006.
52. "Simulation analysis of real-time yard control systems at a marine container transshipment terminal," Department of Industrial and Operations Engineering, University of Michigan, September 27, 2006.
53. "Operations management at a marine container terminal," The Logistics Institute-Asia Pacific, National University of Singapore, February 16, 2006.

## RESEARCH FUNDING

## EXTERNAL FUNDING

1. Title: "Southeast Wisconsin Wind Energy Educational Collaborative."

Source: U.S. Department of Energy
Dates: September 1, 2009 - August 31, 2011
Amount: \$330,184
Role: Co-PI (PI is Professor David Yu)
2. Title: "CFIRE Partner Grant Years 1-2: Freight Transshipment, Cost, \& O-D Table Disaggregation."
Source: National Center for Freight \& Infrastructure Research \& Education at UW-Madison Dates: October 1, 2007 - September 30, 2009
Amount: \$200,000
Role: Co-PI (PI is Professor Alan Horowitz)

## INTERNAL FUNDING

3. Title: "Reducing the cost of operating the UW-Milwaukee shuttle bus services."

Source: UWM Dept. of Facilities Planning \& Management (Dept. of Parking \& Transit)
Dates: January 21, 2014 - June 20, 2014
Amount: \$47,000
Role: Sole PI

## COORDINATION OF PROGRAMS, DEPARTMENTS, OR CENTERS

1. Faculty leader of two, three-week-long UWM College of Engineering and Applied Science (CEAS) study abroad programs at Chung Yuan Christian University and Feng Chai University in Taiwan (July 2012, 2013, 2014, 2015, 2016, 2017).

## INVOLVEMENT IN STUDENT ACTIVITIES

1. Faculty Advisor, UWM student chapter of the Institute of Industrial and Systems Engineers (IISE) (2012-2022).

## AWARDS AND HONORS FOR SERVICE

1. Received the "Advisor of the Year" award (one recipient per year across the entire university) for work done as the faculty advisor of the UW-Milwaukee student chapter of the Institute of Industrial and Systems Engineers (IISE) during the 2012-2013 academic year.

## MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS

1. Institute for Operations Research and the Management Sciences (INFORMS)—member since 2002.
2. Institute of Industrial and Systems Engineers (IISE)—member since 2006.

## UNIVERSITY-RELATED COMMITTEE AND TASK FORCE WORK

## UW-Milwaukee University-Wide Committee Work

1. Member of university-wide Global Studies Advisory Committee (2008-09, 2011-14, 2016-17).
2. Member of university-wide Undergraduate Overseas Research Awards Review Committee (2008-10, 2011-14, 2016-17).
3. Member of university-wide Physical Environment Committee (2016-18).
4. Member of university-wide Task Force on Internationalization (2009 calendar year).

UW-Milwaukee College of Engineering and Applied Science (CEAS) Committee Work
5. Member of CEAS Transportation Engineering Search and Screen Committees (2022-2023).
6. Chair of CEAS Academic Planning Committee (2021)
7. Member of CEAS Scholastic Appeals Committee (2020)
8. Member of CEAS Academic Planning Committee (2017-2018, 2020)
9. Member of CEAS Curriculum Committee (2016-2017)
10. Member of CEAS Best Place to Work Committee (2013-2014).
11. Member of CEAS/Lubar Supply Chain Management Search and Screen Committee (2011-2012).
12. Member of CEAS Green Manufacturing Search and Screen Committee (2008-2009).
13. Member of CEAS Graduate Program Subcommittee (2007-2009).

UW-Milwaukee Dept. of Industrial and Manufacturing Engineering (IME) Committee Work
14. Department ABET Accreditation Coordinator (2016-2024)
15. Chair of IME Dept. Curriculum Committee (2009-2010, 2011-2014).
16. Member of team that prepared IME Dept. Five-Year Strategic Plan, 2013.
17. Chair of IME Dept. Operations Research Track Qualifying Examination Committee (2011-2013).
18. Member of IME Dept. Search and Screen Committee ( 21 faculty candidates hosted and interviewed, 2007-2010).

## The Kühne Logistics University

19. Academic advisor for M.Sc. Program in Global Logistics during 2010-2011 academic year.
20. Chair of the admissions committee for M.Sc. programs during 2010-2011 academic year.
21. Deputy chair of the examinations committee during 2010-2011 academic year.

## NOTEWORTHY INDUSTRIAL EXPERIENCE

## Seaport container terminals (worldwide)

Visited, and spoke with managers at, 30 seaport container terminals around the world

## Manufacturing facilities in greater Milwaukee

Organized six field trips to local manufacturing companies during each of the Fall 2011, 2012, 2013, 2014, 2015, 2016, 2017, and 2018 semesters as part of the course "IND ENG 350: Manufacturing Processes" which have enhanced student comprehension of modern manufacturing practice.

## SPECIAL ASSIGNMENTS FOR PROFESSIONAL ORGANIZATIONS

1. Reviewer for the journal "INFORMS Journal on Applied Analytics"
2. Reviewer for the journal "Computers and Operations Research"
3. Reviewer for the journal "Computers and Industrial Engineering"
4. Reviewer for the journal "Decision Support Systems"
5. Reviewer for the journal "Transportation Science"
6. Reviewer for the journal "Transportation Research B"
7. Reviewer for the journal "Transportation Research E"
8. Reviewer for the journal "Naval Research Logistics"
9. Reviewer for the journal "Journal of Simulation"
10. Reviewer for the journal "European Journal of Operational Research"
11. Reviewer for the journal "Production and Operations Management"
12. Reviewer for the journal "Annals of Operations Research"
13. Reviewer for the journal "OR Spectrum"
14. Reviewer for the journal "Flexible Services and Manufacturing"
15. Reviewer for the journal "IEEE Transactions on Automation Science and Engineering"
16. Reviewer for the journal "IISE Transactions"
17. Reviewer for the journal "INFOR"

## EXTERNAL CONSULTING

Consultant, Voces De La Frontera - drafted multiple proposals to incorporate a third Hispanic influence district into the City of Milwaukee aldermanic districts, 2021.

Consultant, Tax Airfreight, Inc. - developed model-based solutions for improving the productivity of an overnight LTL transportation and logistics company, 2017.

