APPENDIX D

Equity Analysis Background

MEMORANDUM

To: Alameda County Transportation Commission

From: Nelson\Nygaard Team

Date: November 3, 2015

Subject: 2016 CTP Equity Analysis Final Approach

After reviewing guidance, predecessors, and academic literature, the Countywide Plan project and consultant teams have aligned on an approach to analyzing equity for the 2016 Countywide Transportation Plan. This memo outlines the agreed-upon approach.

OVERVIEW

This analysis will allow the Alameda CTC to understand for which historically disadvantaged demographic groups there are statistically significant disparities in transportation outcomes or spending. The findings will enable the Alameda CTC to invest in programs and projects that are assumed to have an impact on these disparities.

The analysis will use spatial analysis methods to understand for which groups disparities exist, but the findings will not be expressed in geographic terms (i.e. the analysis will not say there are performance shortfalls for a specific set of Census tracts). Instead, **it will identify historically disadvantaged demographic groups for which average *countywide* system performance or investment levels are worse than those of groups without historical disadvantages.** Based on the findings, the project team can decide to increase investment levels in programs that tend to benefit these groups, or focus capital spending in areas with high concentrations of these groups.

The final approach to identifying demographic groups that deal with performance or investment levels that are worse in a statistically significant way is rooted in a review of literature on equity analysis and best practices from peer agencies (the literature review is documented in Appendix 2). Based on this review, the team discussed a range of methodological options over several months. The final approach outlined here was selected because it is a robust methodological approach that is possible within the constraints of existing data and analytical tools currently available to the Alameda CTC.

Note that this equity analysis will not include an analysis of projected future performance. The modeling tools available cannot accurately predict travel behavior at the tract level 25 years in the future, and it would be unwise to make assumptions about how the spatial distribution of sensitive demographic groups will change in the intervening years. In a separate effort that is part of the overall Countywide Plan project, the team will recommend ways in which equity performance measures can be incorporated in Alameda CTC's direct local distribution (DLD) funding process. Doing so will allow for ongoing analysis of how equitably the agency's funding is invested at the local level and how system performance changes over time for historically disadvantaged groups.

An overview of what is included in this memo:

- **Goals**: The purpose and goals of this equity analysis

- **Demographic groups**: The groups to be included in the equity analysis and a rationale for their inclusion
- **Performance metrics**: Final agreed upon performance metrics, and an explanation of how they connect to the overall CTP goals and to data sources
- **Methodology**: A detailed overview of the proposed equity analysis methodology, which will include the following components:
  - A **funding allocation (use-based) analysis** looking at how equitably funds are spent in the county, including consideration of both capital and programmatic funding, and how spending patterns affect sensitive and underserved demographic groups
  - A **geographic analysis** that examines how the geographic distribution of sensitive and underserved demographic groups relates to the spatial patterns in transportation system performance
- **Use of equity analysis in CTP investment plan**: An overview of how the team might use the findings from equity analysis to inform investment decisions for the CTP.

GOALS

For their 2016 CTP, the Alameda CTC is required by the Metropolitan Transportation Commission (MTC) to conduct an equity analysis as part of their plan update. As stated in the Alameda CTC's RFP, the purpose of taking a closer look at equity is to:

"*Understand how [the CTP's] projects and programs affect minority, low-income and other underserved communities; and to build on the initial set of Community Based Transportation Plans (CBTPs) developed in Alameda County to develop a more comprehensive equity strategy that will guide CTP policies and the development, selection and prioritization of CTP projects and programs. The overarching objective of the combined equity analysis and strategy is to create a CTP that directly addresses the needs of minority, low-income and other underserved communities and actively works to improve access, mobility and overall health for these communities.*"

In accordance with these overarching goals for the CTP, the 2016 CTP equity analysis aims to accomplish the following:

- Understand how equitably transportation system "inputs," i.e. how transportation dollars are spent, and "outcomes," i.e. the performance and accessibility of the transportation system in Alameda County, are distributed today.
- Estimate how equitable of the transportation system in Alameda County will be in the future, based on planned investments and what we know about their potential impacts.

To clarify terminology, an "equitable" transportation system is one in which transportation spending and system performance are comparable for the general population and underserved and sensitive demographic groups in Alameda County, further discussed in the following section.

The findings of this equity analysis will be a key consideration in shaping the investment approach for the 2016 CTP.

DEMOGRAPHIC GROUPS

This analysis will focus on the historically underserved demographic groups shown in Figure 1. Groups were included based on the Federal Transit Administration's Title VI guidance, U.S. Census Bureau categories and thresholds, and/or inclusion in Plan Bay Area. The analysis deems females a sensitive demographic group given voluminous research showing disparities in economic outcomes between women and men.

As fully explained in the methodology section below, the initial base analysis will assess where the greatest disparities exist. At that juncture the team may decide that it is appropriate to remove some groups from further analysis if there are no significant disparities identified between certain historically disadvantaged groups and the rest of the population.

Figure 1 Groups for Analysis

Grouping	Sensitive Groups	Source
Racial/Ethnic	American Indian and Alaska Native Asian[1] Black or African American Hispanic or Latino Native Hawaiian or Other Pacific Islander[2]	FTA Title VI Guidance (Circular 4702.1B)
Income/Affordability	Up to 200% of federal poverty line ($50,000/household as estimate)[3]	U.S. Census Bureau Poverty Thresholds
Age	Mobile Youth (10-19 years)[4] Senior (>75 years)[5]	Youth: U.S Census and California DMV Senior: Plan Bay Area equity category
Gender	Female	
Language Skills	Limited English Proficiency[6]	Plan Bay Area criterion
Mobility	Zero-Car Households	Plan Bay Area criterion

[1] Includes, per FTA Circular 4702.1B: "People having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent, including, for example, Cambodia, China, India, Japan, Korea, Malaysa, Pakistan, the Philippine Islands, Thailand, and Vietnam."

[2] Includes, per FTA Circular 4702.1B: "People having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands."

[3] Approximately 200% of poverty for a family of four. The poverty line for a family of two adults and two related children was $24,008, according to the most recent thresholds released in 2014. . The 200% federal poverty line metric was chosen to maintain consistency with federal funding guidelines using this threshold to identify low-income people. This income threshold equates to 54% of the Alameda County Area Median Income for family households in 2014. (http://www.census.gov/hhes/www/poverty/data/threshld/thresh14.xls and http://factfinder.census.gov/bkmk/table/1.0/en/ACS/13_5YR/S1901/0500000US06001)

[4] The selected census age groups represent the age range at which minors are generally independently mobile but lack an automobile. The team used DMV license data to confirm that this bracket should include people in their late teens – this cohort gets drivers licenses at much lower rates than other age brackets.

[5] Per Plan Bay Area, 75 represents advanced enough age that mobility might start to be limited for a significant portion of this cohort.

[6] Per FTA Circular 4702.1B: "Includes people who reported to the U.S. census that they speak English less than very well, not well, or not at all."

PERFORMANCE METRICS

These metrics were selected to capture distribution of *inputs* into the transportation system, i.e. how monies are allocated, and *outcomes* of transportation spending, i.e. the resulting accessibility, quality, and usability of the transportation system.

Inputs: The team will also analyze the equity of funding distributions by estimating the share of capital and programmatic funding sensitive demographic groups benefit from, estimated through program survey data or city demographic breakdowns.

Outcomes: The analysis will measure equity of outcomes using a subset of the CTP performance measures that are relevant and methodologically feasible, shown in Figure 2. These metrics were developed to capture the full range of impacts most important to underserved and sensitive populations. The full list of potential CTP measures is included as Figure 4 for reference with an explanation of which were selected for the equity analysis and why, and conversely which were not selected and why.

Figure 2 Equity Performance Metrics

Topic Area	Metric	Rationale
Inputs		
Capital and Programmatic Investment Level by User Demographic Breakdown	Funding allocated to Demographic Groups based on Existing User Base (current Alameda CTC allocations only; not including MTC regional projects)	Connected to CTP performance metric for equity
Outcomes		
Overall System Performance	Transit/Auto Accessibility Ratio	Rooted in literature (Golub and Martens); connects to a variety of plan goals[7] and performance metrics[8]
Bike Facility Proximity	Share of Households Proximate to Low-Stress/High Quality Bike Facilities and Routes	CTP performance metric
Safety	Pedestrian and Bike-Involved Collisions	Connects to plan goal of healthy/vibrant community
Bike/Ped Comfort	Average Level of Traffic Stress (City Level)	CTP performance metric
Air Quality (Potential)	Ozone concentration over state standard	Connects to plan goal of healthy/vibrant community
Air Quality (Potential)	Annual Mean PM2.5 Concentration	Connects to plan goal of healthy/vibrant community

[7] From RFP, page 23 (27 of PDF); includes: reducing congestion and GHG emissions, increasing multimodal connectivity, expanding transportation choices, and supporting economic growth/access

[8] Includes: Auto/transit travel time between OD pairs, auto/transit compatibility with land-use decisions;

Topic Area	Metric	Rationale
Air Quality (Potential)	Diesel particulate matter (PM)	Connects to plan goal of healthy/vibrant community
Air Quality (Potential)	Baseline traffic density within 150 meters of tract boundary	Connects to plan goal of healthy/vibrant community
Air Quality (Potential)	Asthma ER Visit Rate	Connects to plan goal of healthy/vibrant community
Pavement Condition	Average PCI (City)	CTP Performance Metric

Appendix 3 (sent to Alameda CTC and Fehr & Peers as a memo, "Equity Analysis – Data Request," October 29, 2015) details data sources and the members of the team responsible for sending data to Nelson\Nygaard. The memo also identifies the specific NAICS job categories to be considered for the accessibility metrics.

Note that Nelson\Nygaard added several potential air quality metrics, based on the availability of the data at the tract level from the State of California (CalEnviroScreen 2.0). All of the potential air quality metrics have some relationship with transportation-related emissions. The team will assess the how meaningful each metric is relative to this analysis and will likely narrow to one or two.

Combining *input* and *outcome* measures will allow the team to identify a wide range of potential gaps in the Alameda Countywide Transportation Plan. However, the equity analysis will be an iterative process, and additional performance measures may be added if considered necessary.

METHODOLOGY

Overview

The equity analysis will proceed in stages.

- First a "base" case will be analyzed that reflects the current performance of the transportation system. This first stage will identify:
  - Inputs: Inequities in how funding is currently distributed (the inputs analysis will only include the base, not the baseline).
  - Outcomes: Existing or projected disparities in transportation system performance, i.e. whether the system is less accessible and/or performs more poorly in areas where there are higher concentrations of sensitive and underserved demographic groups
- The second stage of the analysis will recommend ways of allocating funding to address identified disparities (described in the final section of this memo).

Inputs: Funding Allocation (Use-Based) Analysis

To understand equity of inputs, the team will estimate to what extent different demographic groups benefit from funding allocations today, based on funding allocations and the demographic profiles of programs' user bases. The basic process:

1) Identify total funding available to each program in the base and baseline future scenarios.

2) Identify the demographic breakdown of users of each program based on available data. For some programs and investments (i.e. transit), this will be based on survey data. For programs and investments for which there is no accurate or comprehensive survey data, the analysis will look at the distribution of funding to cities and the cities' respective demographic breakdowns, per census data.

3) Multiply each program's funding level by the share of users from each demographic group of interest. This step essentially estimates the share of investment in a given program from which a particular demographic group benefits.

4) Sum funding levels for each demographic group of interest, figure out the share of funds allocated to that group, and compare to the countywide share of the population that group represents.

5) Use a Chi-Squared test for each set of demographic variables to note where there are statistically significant differences between the distribution of funding among demographic groups and the distribution of those demographic groups among the population of the whole county (see Figure 8 for an example of how this might be set up). **Flag demographic groups of interest for which there is a statistically significant difference and the group's share of funding is lower than its share of the overall population.**

Outcomes: Geographic Analysis

The team will use a multi-stage process to identify inequitable conditions on each of the performance outcome metrics:

1) Difference of Means Test

    a. Calculate location quotients for each demographic group of interest for each tract (the tract's share of the countywide population of the demographic group divided by the tract's overall population share of the total countywide population).

    b. Establish a location-quotient threshold for each demographic group of interest that allows the analysis to identify a set of tracts that capture more than half (or another share, to be determined) of the countywide population of the demographic group. Location quotient thresholds could be different for each set of demographic categories (i.e. race versus gender versus income level).

    c. Use a difference of means test to compare the average performance of tracts identified in step B to the average performance of all other tracts on each outcome metric. **Flag metric/demographic group combinations that yield statistically significant differences in performance.**

2) Chi-Squared or ANOVA Test

    a. Use the results of steps a and b above to identify tracts of interest for each demographic group.

    b. Divide tract-level performance on each metric into quintiles.

    c. Compare the expected distribution of performance to the observed distribution for each demographic group of interest (see Figure 8 and Figure 9 for an example of how this might be set up). **Flag metric/demographic group**

combinations for which the observed distribution is more heavily weighted toward the quintiles associated with worse performance.

3) Regression

   a. Regress concentrations of demographic groups identified in Figure 1 against outcomes identified in Figure 2.

   b. Identify correlations based on the direction and statistical significance of coefficients. Consider r^2 values of models but do not throw out models with low r^2 values, as this analysis is most concerned with identifying correlations between outcomes and a limited set of independent variables and understanding their direction (positive or negative), not explaining as much of the variation in outcomes as possible.

   c. Flag metric/demographic group combinations for which statistically significant coefficients indicate that increased shares of the demographic group in a given tract are correlated with increased levels of poor performance for that tract.

4) Compare results on the three tests and note insights. The analysis will likely flag issues raised by any of the statistical tests.

Reporting Memo Structure

The team will report the results of these analyses in a memo with the following basic structure:

1. Introduction: High-level review of regulatory context, academic literature, and goals of the equity analysis
2. Methodology: Review final demographic groups, performance metrics, and analysis approach (*shorter summary of the methodology section of this memo*)
3. Existing Distribution: Demographic Groups
   a. Report share of countywide population for each demographic group
   b. Heat maps (and brief description of key clusters) for each demographic group
   c. Tracts of interest based on location quotients
4. Existing Year Base Analysis
   a. Summary data for base
      i. Funding by program
      ii. Outcome measures – summary statistics
      iii. Demographic groups – summary statistics
   b. Inputs: Financial Allocation Analysis using most recent fiscal year
      i. Total/share allocated by demographic group
      ii. Chi-Squared Test comparing to population shares
   c. Outcomes:
      i. Difference of Means Test Results
      ii. Chi-Squared Test Results
      iii. Regression Test Results
      iv. Discussion of Insights

5. No-Project Future Baseline Analysis
    a. Summary data for baseline
        i. Funding by program (adjusting formula spending to Measure B levels and projecting forward current spending levels, adjusting for inflation, for programs not included in Measure B)
        ii. Outcome measures – summary statistics
        iii. Demographic groups – summary statistics
    b. Inputs: Financial Allocation Analysis
        i. Total/share allocated by demographic group
        ii. Chi-Squared Test comparing to population shares
    c. Outcomes
        i. Difference of Means Test Results
        ii. Chi-Squared Test Results
        iii. Regression Test Results
        iv. Discussion of Insights
6. Conclusions: Summary of equity issues identified and potential policy levers to address issues

USE OF EQUITY ANALYSIS IN CTP INVESTMENT PLAN

Alameda CTC will use findings from the base and baseline equity analysis to identify groups for which additional investments might be warranted to make up for lower levels of programmatic allocations or transportation performance today. Figure 3 shows the capital and programmatic funding levers that can address equity issues.

Figure 3 Project and Programmatic Levers to Address Equity Issues

Metric	Capital Levers (Geographic)	Programmatic Levers (not geographic)
Inputs		
Programmatic Funding Distribution	• N/A	• Increased Formula Funding to Cities with High Concentrations of Sensitive Groups • Increased Funding for Transit Operations • Increased Funding for Student Transit Pass Program • Increased Funding for Other Programs with High Levels of Usage by Vulnerable Groups
Outcomes		

Metric	Capital Levers (Geographic)	Programmatic Levers (not geographic)
Transit/Auto Accessibility Ratio	• Transit Infrastructure/Right of Way • Transit Speed and Reliability • Transit Service • Traffic Calming/Road Diets	• Paratransit funding • Student Transit Pass Program funding • Streets and Roads: Complete Streets
Transit Accessibility	• Transit Infrastructure/Right of Way	• Paratransit funding
Bike and Pedestrian Safety	• Traffic Calming/Road Diets • Bike Infrastructure/Right of Way • Pedestrian Safety Infrastructure	• Bike Planning • Pedestrian Planning • Safe Routes to Schools • Student Transit Pass Program • Streets and Roads: Complete Streets
Bike and Pedestrian Comfort	• Traffic Calming/Road Diets • Bike Infrastructure/Right of Way • Pedestrian Safety Infrastructure	• Bike Planning • Pedestrian Planning • Safe Routes to Schools • Student Transit Pass Program • Streets and Roads: Complete Streets
Air Quality	• Transit Infrastructure • Transit Service • Traffic Calming/Road Diets • Freight-Priority Infrastructure	• Safe Routes to Schools (minor impact)
Pavement Quality	• Traffic Calming/Road Diets	• Streets and Roads

For capital levers, the team can create heat maps for demographic groups for which the base analysis showed an equity issue. The heat map can help identify clusters of tracts with high concentrations of people in the group and direct additional capital investments toward those clusters. The exact methodology for identifying clusters, including threshold values the team might use, will be determined after the base analysis is complete.

Programmatic funding for programs that can address identified equity issues might also be increased to address equity issues. This is how the CTP will address members of demographic groups of concern who live in areas with concentrations below the thresholds noted above.

As noted above, while the model *could* produce estimates of how equitable system outcomes are under different investment scenarios, the estimates are unlikely to be accurate at the tract level because of modeling tools' inherent limitations. As such, the team recommends that equity analysis of the investment plans be focused on how resources will be distributed, and that assessments of system performance take place regularly through DLD funding and reporting processes.

Future Steps

As this is the first time Alameda CTC has conducted such an extensive equity analysis, the process is somewhat limited in understanding impacts of investment strategies. As this data is tracked over time, Alameda CTC can gain a better understanding of how effective different investment strategies are at addressing inequities in the system. Alameda CTC can evolve its funding strategies to be more and more responsive to equity concerns.

The final plan will include an equity strategy that will recommend a series of next steps that will help the agency and the transportation system in Alameda County to be more responsive to the needs of minority, low-income, and other underserved and sensitive communities. It may also include recommendations for additional studies or pilot programs designed to test innovative approaches to addressing transportation needs and gaps with the goal of improving access, mobility, and overall health for these communities.

APPENDIX 1 – COMPARISON OF CTP PERFORMANCE MEASURES AND EQUITY METRICS

Figure 4 CTP Performance Measures and Assessment for Equity Analysis

Performance Measure	Tract-Level Data	Equity Metric Coverage	Commentary
Measures to understand travel time and congestion			
Percent lane miles of congestion	No	Transit/Auto Accessibility Ratio	Accessibility metric better suited for equity analysis
Travel time by mode (auto and transit)	No	Transit/Auto Accessibility Ratio	Accessibility metric better suited for equity analysis
Travel time, ratio of peak hour to off-peak hour	No		Off-Peak transit travel time does not account for wait time
V/C ratio on critical screenlines	No	Transit/Auto Accessibility Ratio	Accessibility metric better suited for equity analysis
Person hours of travel per capita	Yes		Not used in equity analysis because it is unclear whether less travel is positive or negative for sensitive groups, as it may indicate less economic activity
Person hours of delay on critical corridors	Yes		Not used in equity analysis, as it is related to person hours of travel – unclear whether less travel is good
Measures to understand usage of different transportation modes			
Mode share	Yes		Accessibility metric better suited for equity analysis
Daily transit ridership	Yes		Accessibility metric better suited for equity analysis
Transit passengers per bus revenue hour of service	No		Measure of system efficiency, not service provision
VMT per capita (which can also be used to estimate GHG and other emissions)	Yes	VMT Generated in Tract	More concerned about the local effects of trips from all origins than the sum of VMT from tract residents
Measures to understand the accessibility of the transportation system			

Performance Measure	Tract-Level Data	Equity Metric Coverage	Commentary
Households and jobs proximate to transit or to high-quality bicycle facilities	Yes	Estimated Share of Households Proximate to Transit or High Quality Bicycle Facilities	Equity analysis is focused on residential locations
Households within 20-minute drive or 30-minute transit ride of activity centers	Yes	Transit/Auto Accessibility Ratio	Modified to compare same travel time across modes, measure accessibility to jobs
Measures to understand the quality and safety of the transportation system and user experience			
Network connectivity by mode	No		Not able to accurately attribute effects of network gaps to tracts in a comprehensive fashion
Bicycle comfort index (Level of Traffic Stress)	No	Average LTS (City Level)	Using same metric, attributed to geographic sub-units
Pavement Condition Index	Yes	Average PCI	Using same metric, attributed to geographic sub-units
Level of ITS investment on critical corridors	No	Transit/Auto Accessibility Ratio	Secondary effects captured in accessibility measure
Annual projected injury and fatality crashes	Yes	Bicycle/Pedestrian-Involved Collisions	Using same metric, attributed to geographic sub-units
Measures to understand the cost effectiveness and geographic equity of investments in the transportation system			
Geographic distribution of investment	No	Estimated Demographic Distribution of Investment	Geographic distribution covered in geographic equity analysis
Return on Investment (Change in any of the above metrics expressed per $ spent)	No		N/A

APPENDIX 2 – BACKGROUND, GUIDANCE, AND LITERATURE REVIEW

This equity analysis will represent the first time the Alameda CTC has executed an equity analysis as part of its countywide plan. Only a limited number of congestion management agencies (CMAs) and metropolitan transportation organizations (MPOs) have done similar analyses on long-term planning documents, but a few of these prior efforts have received attention from academia in recent years, and the critiques and observations in the academic literature form an important foundation for Alameda CTC's equity analysis.

This appendix details federal guidance on equity, the approach other Bay Area jurisdictions have taken in analyzing equity, and various critiques and suggestions from the academic literature.

Official Guidance on Equity Analysis

Guidance from the Federal government and from MTC establishes the need to analyze equity in long-range plans. Not all of this guidance applies directly to the Alameda CTC Countywide Plan, and it generally lacks specific detail or instruction on how such an analysis should be executed. However, the guidance can be helpful in informing the types of environmental justice communities ACTC's analysis should focus on and offering a general approach to executing the equity analysis.

MTC's guidance is quite broad. In its "Guidelines for Countywide Transportation Plans," the commission leaves CMAs significant latitude to determine how they will actually execute an equity analysis: "MTC recommends that counties conduct an equity analysis with input from the public, tailored to the specific character of the county, and with a focus on minority, low-income, and other underserved communities."

Title VI of the Civil Rights Act requires that any transportation plans or projects that will receive Federal funding include an equity analysis. While a Title VI analysis is not required for the Countywide Plan, guidance related to the law and others can help shape this analysis.[9] Circular 4702.1B from the Federal Transit Administration provides the most up-to-date Title VI direction for transit service providers and regional transit agencies.[10] Such agencies must do three things in Title VI analyses of transportation plans:

1) Describe the "procedures by which the mobility needs of minority populations are identified and considered within the planning process."

2) Create demographic maps that overlay minority and non-minority populations for a selected geographic unit of analysis (i.e. census tracts)

[9] Per informal counsel from a USDOT staff member, the Countywide Plan likely does not need to include a formal Title VI analysis. The passage from the FTA Circular 4702.1B on who must provide Title VI assurances and when: "In accordance with 49 CFR Section 21.7(a), every application for financial assistance from FTA must be accompanied by an assurance that the applicant will carry out the program in compliance with DOT's Title VI regulations. This requirement shall be fulfilled when the applicant/recipient submits its annual certifications and assurances to FTA. Primary recipients shall collect Title VI assurances from subrecipients prior to passing through FTA funds. The text of FTA's annual certifications and assurances is available on FTA's website."

[10] Federal Transit Administration of the United States (FTA) (2012a). Circular 4702.1B, Title VI Requirements and Guidelines for Federal Transit Administration Recipients. FTA, Washington, D.C.

3) Determine if there are disparate impacts and whether there is "substantial legitimate justification for the policy" that results in a disparate impact, or identify a suitable mitigation.

FTA Circular 4703.1 gives further guidance on how agencies should consider environmental justice in transportation planning, based on policy direction from a 1994 executive order.[11] The document emphasizes the need to solicit input from environmental justice populations, which include those from minority backgrounds (defined as American Indian or Alaska Native, Asian, Black/African American, Hispanic or Latino, and Native Hawaiian or other Pacific Islander) and those with low incomes (defined as households with incomes below the Federal poverty line).

It also calls for a spatial analysis that compares the reach of a given policy or project to the location of minority and low-income communities. It advises agencies that use thresholds, or levels of concentration of a particular demographic variable, to define which geographic areas should be considered environmental justice communities to do so with caution. The guidance notes: "While the minority or low-income population in an area may be small, this does not eliminate the possibility of a disproportionately high and adverse effect of a proposed action."

Other Plans

MTC's Plan Bay Area Equity Analysis provides the most comprehensive local model for an equity analysis.[12] MTC completed three rounds of equity analysis during its Plan Bay Area planning process, examining the equity implications of the initial vision, alternative investment scenarios, and the final draft plan. The efforts were informed by regular input from an Equity Working Group, which included stakeholders from environmental justice communities, local jurisdictions, public health departments, community-based organizations, and advocacy groups.

MTC mainly analyzed equity through the lens of "Communities of Concern." These areas, comprised of groups of census tracts, were defined based on the percentage of the tract's population that fell into nine different demographic criteria, shown in Figure 5. Census tracts with populations exceeding thresholds on four of the nine criteria or on both the minority and low-income population thresholds were deemed Communities of Concern. The designation applied to 305 of the region's 1,405 census tracts (323 of MTC's 1,454 transportation analysis zones (TAZ)). Figure 5 shows that for most of the criteria, the Communities of Concern captured less than 40% the region's total population meeting the criteria. To comply with Title VI guidance, a portion of the MTC analysis focused exclusively on tracts with minority populations exceeding the regional average of 58% instead of the Communities of Concern.

Figure 5 MTC Community of Concern Criteria and Thresholds

Criterion	Additional Definition Detail	Threshold	% Captured by Communities of Concern
Minority Population	American Indian or Alaska Native Asian Black or African American	70%	30%

[11] Federal Transit Administration of the United States (FTA) (2012b). Circular 4703.1, Environmental Justice Policy Guidance for Federal Transit Administration Recipients. FTA, Washington, D.C.

[12] Metropolitan Transportation Commission. "Plan Bay Area: Draft Equity Analysis Report." March 2013.

Criterion	Additional Definition Detail	Threshold	% Captured by Communities of Concern
	Hispanic or Latino Native Hawaiian or Pacific Islander		
Low Income Population	<200% of Poverty	30%	40%
Limited-English Proficient Population	Speak English "not well" or "not well at all	20%	44%
Zero-Vehicle Households		10%	40%
Seniors	Age 75 or older	10%	18%
Population with a Disability		25%	29%
Single-Parent Families		20%	31%
Rent-Burdened Households	Renters paying more than 50% of income in rent	15%	35%

Source: Plan Bay Area

The MTC analysis looked at equity in three ways:

- Population/Use: The project team calculated a region-wide measure of how funding was distributed between minority and non-minority populations and between low-income and non-low-income populations by multiplying funding dedicated to a specific mode by the rates at which different populations use that mode. The analysis compared the distribution of funding overall to the regional population distribution. In a similar analysis to comply with Title VI, the project team also measured the per capita benefit of estimated state and federal transit funding for minority and non-minority populations and transit riders.
- Project Mapping: The team completed a qualitative assessment of whether plan projects were distributed in such a way that there was no pattern of excluding disadvantaged communities from plan investments. This assessment used both Communities of Concern and tracts with minority shares larger than the regional average.
- Performance Measures: Looked at how Communities of Concern performed relative to the rest of the region on five performance measures, including housing and transportation affordability, risk of displacement, vehicle miles traveled (VMT) density, average commute time, and average non-commute travel time.

In reviewing the final plan using the three methodologies above, the analysis found that the Plan Bay Area investment plan was generally equitable on all measures. On a limited number of measures, the analysis found slightly lower performance for minority or Community of Concern geographies, but none were deemed statistically significant. The final equity report included several proposed mitigations in the cases where the analysis found these slight differences.

Few Bay Area CMAs have completed full equity analyses as part of their countywide planning efforts. The San Francisco County Transportation Authority completed such an analysis as part of

its 2040 countywide plan.[13] The effort compared average results on a variety of safety, coverage, and performance metrics for Communities of Concern to those of non-Communities of Concern. The SFCTA used the MTC's Community of Concern definitions and analyzed current and future baseline conditions. The analysis did not look at the investment plan.

Based on a brief review of the seven other Bay Area counties' long-range transportation plans, none completed a full equity analysis as part of their most recent efforts. Napa and Contra Costa counties' plans mention Communities of Concern and review aspects of MTC's equity analysis but do not seem to use equity as an explicit consideration in analyzing existing transportation conditions or plan investments. With funding help from Caltrans, the San Mateo's City/County Association of Governments completed a Transportation Plan for Low-Income Communities that aimed to "influence project and program development and funding decisions that will increase transportation options for low-income residents."[14] However, the analysis does not appear to have been connected to a long-range transportation or investment plan.

Critiques of Equity Analyses

Plan Bay Area and the San Francisco Transportation Plan equity analyses each follow a typical framework, summarized by Karner, *et al.*:[15]

1) Define target populations or geographic areas based on threshold percentages for selected demographic groups
2) Define measures of system benefits or impacts that will function as equity metrics
3) Examine whether base or forecast conditions are similar for the "target geography" as for the rest of the jurisdiction

However, as the earlier review of guidance and regulations showed, there is no single prescribed way to execute an equity analysis, and this has meant "the completion of *any* analysis is considered sufficient for compliance." Without clear guidance rooted in rigorous analytical principles, subtle biases can enter these analyses based on the selection of geographic units of analysis, the definition of inclusion criteria, and determinations of what constitutes an inequitable result on a given metric. Those analyzing equity generally have not completed sensitivity analyses to understand how these key methodological choices affect the results.

Identifying target geographies based on a mix of demographic variables can also be problematic, particularly when attempting to understand system performance (i.e. average travel times) rather than the impacts of the transportation system on a given area (i.e. air pollution). Citing other research, the authors note that assuming "group performance" can be "inferred from performance for groups of areal units" is an "ecological flaw," as these geographic areas' performance actually reflects that of an unknown mix of component populations and other residents in the area. This approach "will tend to obscure the differences between individuals and their spatial locations," according to Karner, *et al.* They also point to a related problem researchers have identified with

[13] SFCTA. "San Francisco Transportation Plan 2040: Appendix F, Transportation Equity Analysis." October 2013.

[14] San Mateo City/County Council of Governments. "San Mateo County Transportation Plan for Low-Income Populations." February 2012.

[15] Karner, Alex and Deb Niemeier. "Civil rights guidance and equity analysis methods for regional transportation plans: a critical review of literature and practice." Journal of Transport Geography, 33 (2013).

trying to identify the location of populations using thresholds: "To the extent that groups do not congregate spatially, performance indicators will be less accurate."

The authors suggest that those executing equity analyses complete sensitivity analyses and explicitly acknowledge the effects of threshold and boundary choices. They also suggest that planners use data sources that are rich in demographic data (i.e. travel surveys), which can obviate the need to identify populations based on where they spatially congregate, reducing potential associated biases. Many modeling tools fail to build race/ethnicity and other demographic variables into their assumptions, but activity-based models (like MTC's Travel One or SFCTA's SF-CHAMP) open up the potential to do so, enabling future-year comparisons of performance for different demographic groups.

Equity analyses should also explicitly consider base-year disparities and judge the effectiveness of a plan based on the extent to which investments are likely to narrow these disparities, according to the authors. In other words, a 10% increase on a given metric for each of region or county's Communities of Concern and other areas should not be considered an equitable result, as it simply reinforces existing disparities.

Golub *et al.*, argue that it is critical for long-range transportation plans to compensate for existing inequality, given the racially inequitable nature of many 20th Century planning efforts and the ways in which even seemingly race-, class-, and ability-neutral planning can reinforce the pernicious effects of historical investment and building patterns. Looking at the East Bay specifically, they lay out how transportation planning decisions and related investments divided or destroyed working class or poor African American neighborhoods to serve long-distance travel from emerging white and middle class suburbs.[16] Based on this history, they argue that "until the legacy of the past is acknowledged and redressed, not through laws and words, but in the physicality of its urban space, race-neutral processes will likely continue to be superimposed on an inherited racialized geography and thus to yield discriminatory outcomes."

Methodological Suggestions

Beyond those broad suggestions, several researchers have tested more rigorous ways of understanding how equitably a transportation system and proposed investments perform.

Karner, *et al.*, point to an approach using Gini coefficients, proposed and tested on a single transportation project by Levinson.[17] Gini coefficients look at how equitably resources are distributed across a given population. If resources or benefits are evenly distributed across a group of individuals or a set of population sub-groups, the result would be a coefficient of 0. If all resources or benefits accrue to a single group or person, the result would be a coefficient of 1. The concept has generally been applied to understand the distribution of economic resources, but Levinson used it to understand how equitably the benefits of freeway ramp metering on several segments of Minneapolis-area freeways distributed across different origin-destination travel markets. The analysis showed that while ramp metering increased average speeds and reduced travel times and delay overall, the benefits accrued to different O-D pairs unevenly, resulting in higher overall Gini coefficients.

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[16] Golub, Aaron, Richard Marcantonio, and Thomas Sanchez. "Race, Space, and Struggles for Mobility: Transportation Impacts on African Americans in Oakland and the East Bay." *Urban Geography*, 2013.

[17] Levinson, David. "Identifying Winners and Losers in Transportation." TRR 1812, paper number 02-2014.

Golob and Martens propose another approach to comparing transportation system outcomes for different groups.[18] They argue that because accessibility, or the number of attractions one can reach in a given amount of time, is the fundamental purpose of a transportation system, comparing levels of accessibility across groups should give a basic idea of how effective the transportation system is in achieving its goals. Accessibility is mainly a function of both mobility (how quickly one can travel) and proximity (how close a given destination or set of destinations is to one's origin).[19] Cumulative accessibility would be the number of attractions or jobs one can reach from a given place in a given amount of time.

The authors suggest that the ratio of cumulative accessibility by transit to cumulative accessibility by car is a good and easy measure of equity. Because car ownership is associated with higher levels of income, one can assume that a system with a ratio closer to one (which would represent equal accessibility by transit and car) is more equitable. One advantage of the approach is that the data requirements are relatively minor, including demographic data and calculated cumulative accessibility (typically calculable by transportation models) for each tract or TAZ. The authors tested the idea using MTC's 2005 Regional Transportation Plan and found improvements in access ratios for the region overall and for Communities of Concern specifically.

[18] Golub and Martens. "Using principles of justice to assess the modal equity of regional transportation plans." Journal of Transport Geography, 41 (2014).

[19] Levine, Jonathan, Joe Grengs, Qingyun Shen, and Qing Shen. "Does Accessibility Require Density or Speed?" Journal of the American Planning Association, 78:2, pp 157-172.

APPENDIX 3 – ACCESSIBILITY JOB CATEGORIES

This analysis uses the MTC Prosperity Plan Jobs Housing Report's categorization of NAICS codes by wage level. The following table shows the employment category, NAICS code, LODES variable number, and average annual wage, from the Prosperity Plan.[20] The analysis will compare results from looking at all jobs together, looking at each sub-category separately, and grouping low- and mid-range job categories together.

Figure 6 Job Categories

Category	NAICS	LODES Variable (CNS)	Average Annual Wage
High Wage			
Information	51	09	$147,000
Finance and Insurance	52	10	$131,000
Professional and Technical Services	54	12	$104,000
Management of Companies and Enterprises	55	13	$141,000
Low Wage			
Retail Trade	44-45	07	$32,200
Administrative, Support, Waste Management, Remediation	56	14	$39,800
Arts, Entertainment, Recreation	71	17	$42,400
Accommodation and Food Services	72	18	$19,800
Other Services (not Public Administration)	81	19	$34,200
Mid-Range			
Construction	23	04	$56,600
Manufacturing	31-33	05	$84,300
Wholesale Trade	42	06	$73,000
Transportation and Warehousing	48-49	08	$50,000
Real Estate, Rental, Leasing	53	11	$62,600
Educational Services	61	15	$46,300

[20] http://planbayarea.org/pdf/prosperity/research/Jobs-Housing_Report.pdf, page 10; wage information originally from the BLS Quarterly Census of Employment Wages, First Quarter, 2014, California averages.

Category	NAICS	LODES Variable (CNS)	Average Annual Wage
Health Care/Social Assistance	62	16	$45,600
Public Administration	92	20	Unknown
Other			
Agriculture, etc.	11	01	$25,740
Mining, Quarrying, Oil, and Gas	21	02	$147,000
Utilities	22	03	$146,000

APPENDIX 4 – EXPLANATIONS OF STATISTICAL TESTS

Difference of Means Tests

A difference of means test allows one to estimate whether the average outcomes found for two populations are different, based on the average outcomes for two samples and the distribution of outcomes (variance) across the two samples. If the difference between sample means is large enough and/or the standard error (calculated based on the distribution of individual observations in each sample) is small enough, there will be a small probability that the population means are the same.

This analysis will compare the mean and distribution of outcomes for tracts above a location-quotient threshold for a historically disadvantaged demographic group to the mean and distribution of outcomes for tracts below that location quotient threshold. If the difference in observed average performance between these two sets of tracts is large enough and/or if the calculated standard error is small enough, the team will deem the outcomes notably different.

Note that difference of means tests do not allow one to see *why* there are different outcomes. It only allows one to establish that there are notably different outcomes. A measured difference could indicate that there are different outcomes across the two populations despite having the same inputs, or, that it is in fact different (possibly inequitable) inputs that cause the resulting differences in outcomes. The analysis that accompanies the statistical tests will have to make connections between results for different disadvantaged demographic groups.

Chi-Squared Tests

This statistical test measures whether differences between an observed distribution of outcomes among discrete groups and the expected distribution of outcomes among the discrete groups are statistically significant.

For inputs (Figure 8), the Chi Squared test will allow the analysis to understand whether the distribution of funding across demographic groups is significantly different from the countywide population distribution. This starts with the premise that each demographic group should benefit from a share of funding that equals that demographic group's share of the county's overall population. While the equity analysis may lead the Alameda CTC to recommend skewing funding levels toward programs that are of particular help to certain disadvantaged demographic groups, to make up for existing performance inequalities, the base analysis will assume that funding should be proportional.

For outcomes (Figure 9), the test will compare how tracts in which a particular disadvantaged demographic is above a certain concentration perform relative to tracts below that concentration.

Figure 7 Inputs Chi-Squared Test Setup

Racial/Ethnic Group	Share
African American	Observed (share of funding): X% Expected (share of population): Y%
Asian	Observed (share of funding): X% Expected (share of population): Y%

Racial/Ethnic Group	Share
American Indian/Alaska Native	Observed (share of funding): X% Expected (share of population): Y%
Hawaiian/Pacific Islander	Observed (share of funding): X% Expected (share of population): Y%
Caucasian	Observed (share of funding): X% Expected (share of population): Y%

Figure 8 Outcomes Chi-Squared Test Setup

Group	First	Second	Third	Fourth	Fifth
Overrepresented for Demographic Group by 10% or More	Observed: X% Expected: Y%	Observed: X% Expected: Y%	Observed: X% Expected: Y%	Observed: X% Expected: Y%	Observed: X% Expected: Y%
Less than 10% Overrepresented	Observed: X% Expected: Y%	Observed: X% Expected: Y%	Observed: X% Expected: Y%	Observed: X% Expected: Y%	Observed: X% Expected: Y%

Regression

Univariate and multivariate regression look at the relationships between variables. Regression tests whether a dependent variable changes consistently (in any direction) based on changes in one or more independent variables.

Regression produces an overall r-squared value that expresses the share of variability in the dependent variable that can be explained by the collection of independent variables in a given model. Social science applications of regression typically result in low r-squared values, as it is often impossible to measure and gather data on all of the factors that influence a dependent variable. As such, this analysis will ignore r-squared.

The analysis will focus on the coefficients regression produces for each independent variable. The coefficients express the amount by which the dependent variable is estimated to change with a change in the independent variable (i.e. if the independent variable goes up by one unit, the dependent variable is expected to rise or fall by the value of the coefficient). Each coefficient is given a probability value that expresses how likely it is that the coefficient value is actually zero (in other words, changes in the independent variable do not consistently affect the dependent variable).

For this analysis, regression will help the team estimate whether there is a statistically significant likelihood that there is a consistent relationship between the share of a tract's population represented by a given demographic group and transportation system performance on a given metric. The sign on statistically significant coefficients will help the team identify where higher concentrations of a given demographic group equate to worse performance on a given metric.