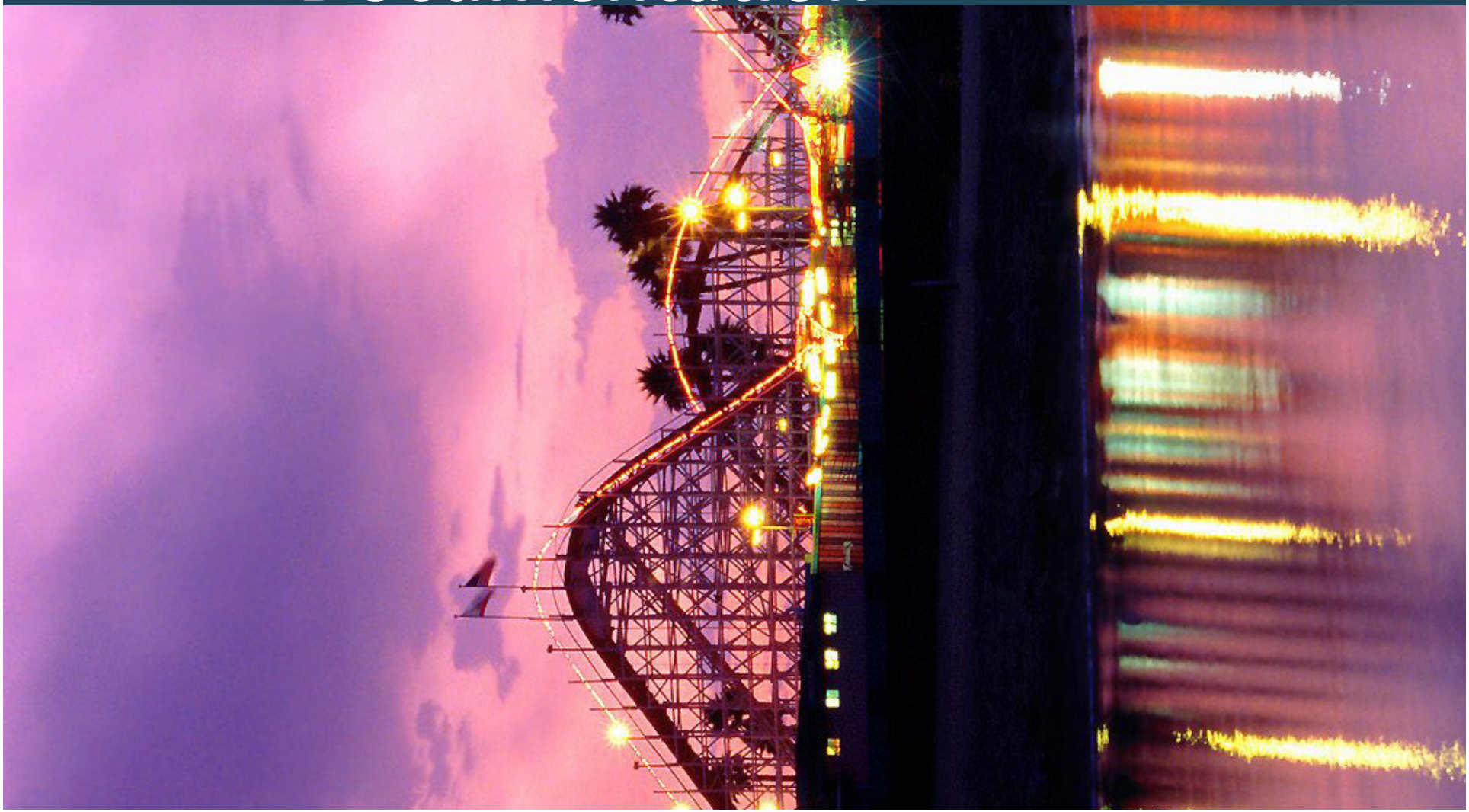
F Regional Travel Demand Model and Land Use Model Documentation



Introduction

The Association of Monterey Bay Area Governments (AMBAG) is the federally designated Metropolitan Planning Organization (MPO) for the tri-county Monterey Bay Area. To carry out Metropolitan Transportation Planning activities, AMBAG works closely with the Santa Cruz County Regional Transportation Commission (SCCRTC), the Transportation Agency for Monterey County (TAMC), the Council of San Benito County Governments (SBtCOG), the Monterey Bay Unified Air Pollution Control District (MBUAPCD), Monterey-Salinas Transit (MST), the Santa Cruz Metropolitan Transit District (METRO), Caltrans, Federal Highway Administration (FHWA), Federal Transit Administration (FTA) and all local jurisdictions (18 cities and 3 counties) within the tri-county Monterey Bay Area.

The Monterey Bay Area constitutes California's North Central Coast Air Basin. Situated between the San Francisco Bay Area to the north and San Luis Obispo County to the south, it spans a total of 6,000 square miles. However, urbanized areas constitute less than 150 square miles.

Developing the 2045 Metropolitan Transportation Plan (MTP) and Sustainable Communities Strategy (SCS)

The Metropolitan Transportation Plan (MTP) has a horizon year of 2045 and is scheduled for adoption by the AMBAG Board of Directors in June 2022. One of the first steps in the development of the 2045 MTP/SCS was to evaluate and update the stated goals and objectives from the 2040 MTP/SCS. The AMBAG Board of Directors approved updated goals and policies as well as accepted updated performance measures at its February 2020 meeting. The performance measures were used to evaluate alternative transportation/land use scenarios and relate to each of the goal areas which are as follows:

- Access and Mobility – Provide convenient, accessible, and reliable travel options while maximizing productivity for all people and goods in the region.
- Economic Vitality – Raise the region's standard of living by enhancing the performance of the transportation system.
- Environment – Promote environmental sustainability and protect the natural environment.
- Healthy Communities – Protect the health of our residents; foster efficient development patterns that optimize travel, housing and employment choices and encourage active transportation.
- Social Equity – Provide an equitable level of transportation services to all segments of the population.
- System Preservation and Safety – Preserve and ensure a sustainable and safe regional transportation system.

AMBAG, in coordination with the Regional Transportation Planning Agencies (RTPAs), developed revenue projections and project costs.

The MTP is supplemented by the three county level Regional Transportation Plans (RTPs) prepared by SBtCOG, SCCRTC and TAMC. Therefore, the updates to all four plans, including goals and objectives, transportation project evaluation criteria, revenue projections, etc. were prepared to be consistent with each other.

The Sustainable Communities Strategy (SCS) is an element of the MTP, as required by Senate Bill 375 and shows how regional greenhouse gas (GHG) targets will be achieved through efficient development patterns, infrastructure investments, transportation measures, and policies that are determined to be feasible. The regional GHG targets are measured from a 2005 baseline and for the AMBAG region are a three percent per capita increase by 2020 and a five percent per capita reduction by 2035. If the SCS had not met regional GHG targets, an Alternative Planning Strategy (APS) could have been developed to demonstrate what alternative scenario and additional measures would be needed in order for the region to meet its GHG target.

Development of the Draft 2045 MTP/SCS

In order to evaluate various combinations of transportation and land use strategies that could lead to achieving the GHG targets adopted by the California Air Resources Board (CARB) for the tri-county region, AMBAG worked with the three county RTPAs, local governments, transit agencies and the public to develop and evaluate various strategies, using its upgraded transportation and land use modeling capabilities. The AMBAG Board of Directors selected a preferred scenario that formed the basis for the Draft 2045 MTP/SCS. Please see Chapter 4 and Appendix E for more information on the SCS.

Public Participation Plan and Interagency Coordination

Another requirement of SB 375 is that each MPO adopt a public participation plan for development of the SCS and Alternative Planning Strategy (APS), if one is required. Some of the key requirements of SB 375 related to public participation are:

- Outreach efforts to encourage the active participation of a broad range of stakeholder groups in the planning process, consistent with the agency's adopted Federal Public Participation Plan, including, but not limited to, affordable housing advocates, transportation advocates, neighborhood and community groups, environmental advocates, home builder representatives, broad based business organizations, landowners, commercial property interests and homeowner associations.
- Consultation with congestion management agencies, transportation agencies and transportation commissions as applicable.
- Workshops throughout the region to provide the public with the information and tools necessary to provide a clear understanding of the issues and policy choices. Each workshop, to the extent practicable, shall include urban simulation computer modeling to create visual representations of the SCS and the APS, if one is prepared.
- Preparation and circulation of a draft SCS and APS, if one is prepared, not less than 55 days before adoption of the final MTP.
- At least three public hearings on the draft SCS. To the maximum extent feasible, the hearings shall be in different parts of the region to maximize the opportunity for participation by members of the public throughout the region.
- A process for enabling members of the public to provide a single request to receive notices, information and updates.

For more information on public participation and outreach refer to Appendix D.

Coordination of Modeling Activities with Partner Agencies

AMBAG, as a federally designated MPO, is required to develop and maintain a tri-county Regional Travel Demand Model (RTDM) to meet federal and state requirements. The GHG target set by CARB applies to the tri-county Monterey Bay region. In this context AMBAG and the RTPA staff have established two levels of working committees that regularly met and worked together to develop the region's MTP and RTPs as well as to conduct modeling analysis. While the RTPAs do not maintain or run the RTDM, they were engaged in the consideration of the results of scenario model runs and in the process of refining the alternative scenarios. As the MTP was being developed, AMBAG worked with all of its partners (RTPAs, transit operators and local jurisdictions) as well as the appropriate federal and state agencies to ensure its MTP conforms to all applicable state and federal regulations.

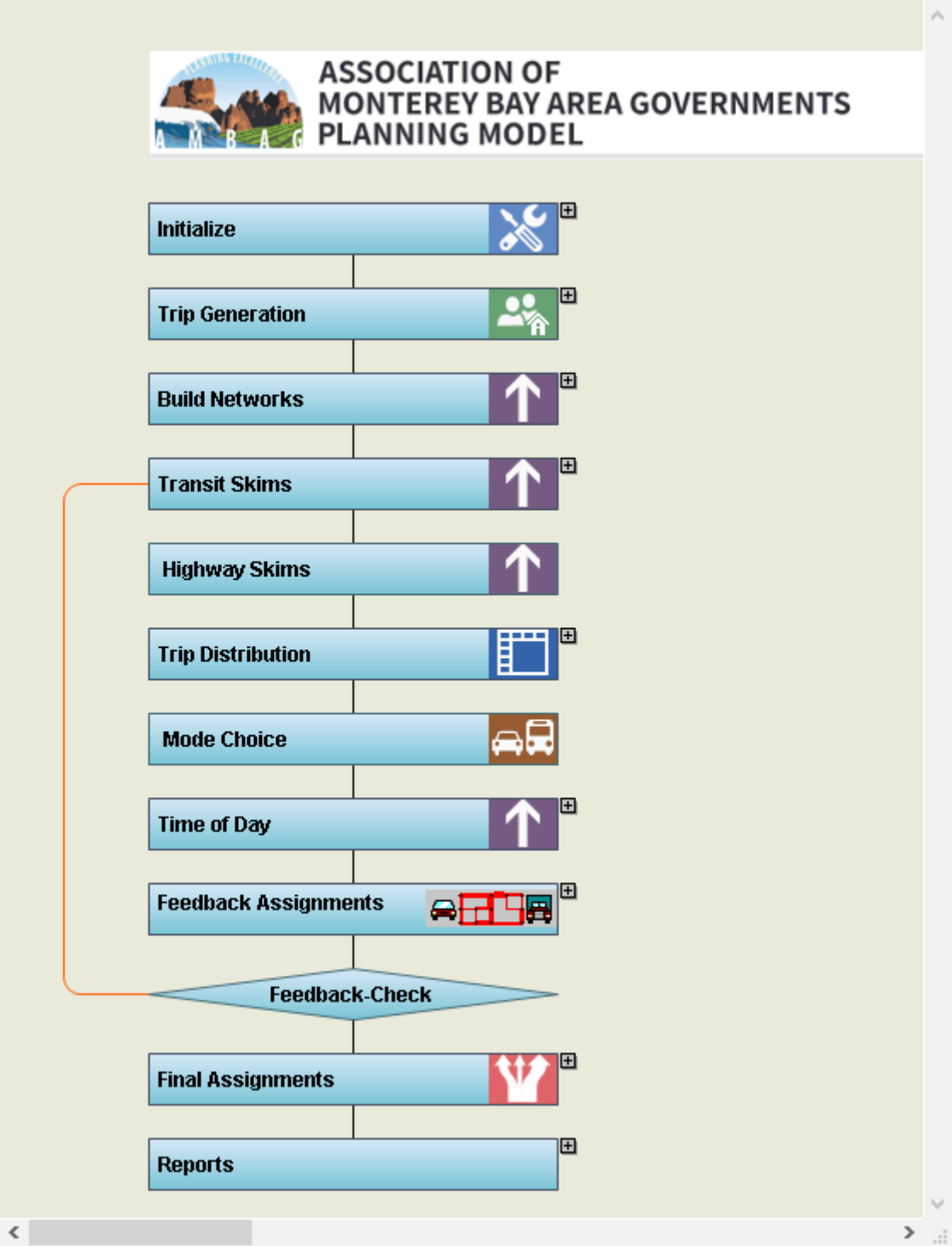
2022 Regional Growth Forecast

In 2019, AMBAG began the process of developing a new forecast with a horizon year of 2045. The regional forecast is based on an analysis of forecasted state and national industry growth compared to the region's historical share of each industry.

The disaggregation of the forecast at jurisdiction level uses shift-share methods for population and employment. These methods essentially calculate future years population and employment based on previous trends. The forecast disaggregation also takes into consideration local land use policies and was developed using a collaborative approach whereby AMBAG incorporated the input of local planners, elected officials and the public. The final forecast is scheduled for adoption in June 2022 along with the 2045 MTP/SCS. The SCS scenarios were developed using this population and employment forecast as a control total in consultation and collaboration with region's local and regional agencies. The technical documentation for the Regional Growth Forecast is included in Appendix A.

Other Key 2045 MTP/SCS Tasks

Other key major tasks include updates to the plan performance measures, environmental justice analysis, new revenue projections, revised cost estimates for projects, programs and services and integration of system and demand management measures into the scenarios. In addition, the 2045 MTP/SCS incorporates recommendations from recently completed or underway studies such as the Central Coast Highway 1 Climate Resiliency Study, 2021 Title VI Plan, 2018 Coordinated Plan, Monterey County Regional Conservation Investment Strategy (RCIS), Santa Cruz County RCIS, Monterey County Active Transportation Plan, various Safe Routes to School Plans, Monterey Bay Area Rail Network Integration Study, Monterey Bay Area Feasibility Study of Bus on Shoulder Operations on State Route 1 and the Monterey Branch Line, Unified Corridor Investment Study, Transit Corridor Alternatives Analysis & Rail Network Integration Study: Watsonville to Santa Cruz, Highway 9/ San Lorenzo Valley Complete Streets Corridor Plan, and Highway 25 Public Transit Study. Other studies that are relevant to the development of the new AMBAG model include the Monterey Bay Origin and Destination Study, the Santa Cruz METRO On-Board Survey, the California Household Travel Survey (CHTS), and the 2017 National Household Travel Survey (NHTS).


ASSOCIATION OF
MONTEREY BAY AREA GOVERNMENTS
PLANNING MODEL
Initialize
Trip Generation
Build Networks
Transit Skims
Highway Skims
Trip Distribution
Mode Choice
Time of Day
Feedback Assignments
Feedback-Check
Final Assignments
Reports

Modeling Methodology

Development of the Regional Travel Demand Model

This section provides a comprehensive description of the 2020 AMBAG RTDM update. The 2020 AMBAG RTDM is an updated travel demand model estimated and calibrated to 2015 conditions. The model was updated to run on TransCAD Version 9.0, which is the latest released version of TransCAD. This insures that the model uses the most advanced and model version of TransCAD available and can take advantage of all updated TransCAD software and performance features. The model interface was updated to TransCAD's modern flowchart interface. The flowchart interface improves model, file, parameter and scenario management. The flowchart interface for the AMBAG model is shown below.

Travel Survey Datasets, and Model Estimation

The 2022 model update was estimated and calibrated using survey data from the 2010 CHTS and 2017 NHTS, Census, employment, and traffic data from that same year. The model utilizes innovative techniques to capture travel behavior at a more individual-based level and incorporates disaggregate level data into some of the modeling stages. The primary reasons for introducing more disaggregate level data into the model was to assist in addressing elements of SB 375, and to pave the way for a possible transition to a tour-based modeling approach in the future. This updated model is a traditional four-step trip-based approach, and as such includes models for Trip Generation, Trip Distribution, Mode Choice, and Trip Assignment. Specific differences compared with traditional approaches is described in more detail later in this document, include a population synthesis to drive the trip generation socioeconomic variables, calculation of the 4D variables (Density, Diversity, Design, and Destinations) using GIS techniques to support inputs to various model stages, the use of person-based trip rates, destination choice model for the trip distribution, and a mode choice component designed and estimated entirely from the survey. The model also employs a highly convergent traffic assignment algorithm.

The model is comprised of four primary time periods, an A.M. Peak Period defined as 6:00 A.M. to 9:00 A.M., a P.M. Peak Period from 4:00 P.M. to 7:00 P.M., a Mid-day Period from 9:00AM- 4:00 P.M. and an Evening Period from 7:00 P.M. to 6:00 A.M. The model is calibrated to Annual Average Daily Traffic (AADT) count data wherever available. The AADT calibration is based on summing the assigned flows for the four periods and comparing them against the AADTs from Caltrans and local jurisdictional count sources. The Percent Root Mean Square Error (%RMSE) is 29.82% system-wide, 15.91% on the freeways, and 23.68% on major arterials. As per the modeling guidance established by FHWA and various peer MPOs, the level of calibration of the current AMBAG RTDM is within the acceptable range and care has been taken to not over fit the base year model to observed conditions. Overall, the AMBAG RTDM maintains appropriate levels of sensitivity and forecasting ability.

Travel behavior in the AMBAG region is especially difficult to simulate for a variety of reasons. First, the region has a high variability in residential density and has a large rural component, particularly in the eastern and southern sections of the area. The region also has high income variability, which further complicates the process of linking the residential and employment zones so necessary to explaining travel behavior in the region. Heavy commuter travel and interregional travel to the San Francisco Bay area and a high number of people telecommuting complicate matters further. In addition, the region has a rich collection of tourist activities and special events occurring on weekends and during different seasons. There are also significant agriculture activities from farm workers making seasonal transient (field-to-field) trips and goods movements by freight modes such as trucks. The region experiences a wide variation in rural and urban characteristics with significantly longer trip lengths in rural areas resulting in higher VMT and peak spreading and a more rapidly aging population in and around coastal communities. The AMBAG RTDM has addressed these aspects well through the deployment of a disaggregated person-based trip generation model and a destination choice model

for many of the home-based trip purposes.

Data, Surveys, and Studies Used in Model Development

Data from the recent American community Survey (ACS), Public Use Microdata Sample (PUMS) and Public Use Microdata Area (PUMA) from the US Census Bureau was used in the updated 2022 model. The AMBAG 2022 RGF, the 2011-12 CHTS, 2017 NHTS, Employment data procured from multiple sources (EDD, InfoUSA and Dun and Bradstreet), vehicle registration data from DMV, the 2012 External Origin-Destination (OD) Study conducted by Fehr & Peers and Air Sage, the SCCRTC Onboard Transit Survey for the Santa Cruz METRO transit system, the City of Watsonville Transit Study, County and Caltrans traffic count data were used for the development, calibration, and validation of the model. In addition, reliable and validated output data from the neighboring MPOs (interregional commute components) and data from the agriculture vanpool program were utilized for the model development.

Following is a summary of the key modeling components and brief description of the methodology/approach applied in the 2022 AMBAG RTDM update.

Update to the Highway, Transit and Bicycle Networks for the 2015 Base Year, 2020, 2035 and 2045 Future Years

AMBAG Staff with the consultant assistant completed a comprehensive review and update to the highway, transit, and bicycle networks for the 2020 model update. AMBAG also employed a web based tool to engage local jurisdictions to review and ground truth key transportation network attributes such as speed, number of lane, and traffic counts. The latest data sets have exceptional geographic accuracy. The updated files include bicycle facilities and other geographic considerations pertinent to transit accessibility. For the 2015, 2020, 2035 and 2045 networks, the consultant worked with AMBAG, the RTPAs and Caltrans staff to determine which infrastructure improvements to include in each scenario.

Update to the Traffic Analysis Zone (TAZ) Data Layers

Utilizing current estimates and projections for future year socioeconomic characteristics pertinent to the model at various geographic scopes, AMBAG staff and the consultant generated attributes using GIS tools for the 2015 model base year and 2020, 2035 and 2045 future year TAZ data layers. The TAZ geography used in the updated model is an aggregation of 2010 Census Block boundaries. The geography is very similar to that submitted to the Census by AMBAG as part of the TAZ delineation process. The zone structure is comprised of 1,710 TAZs including 37 external zones that serve as the primary gateways to the study area. This consistency ensures a reliable calculation and transfer of important demographic data from the Census data files. Although the TAZ boundaries will remain the same for the horizon years (2035 and 2045) of the model, the socioeconomic characteristics may change significantly by jurisdictions within the region. AMBAG staff in consultation with the 21 local jurisdictions updated land use information for the base and future year TAZ data layers.

Population Synthesis

Anchoring the socioeconomic component of the model is a sophisticated nested population synthesis routine. This routine utilizes data at three levels to derive a synthetic population consistent with attributes found at the Census Block and Block Group levels. The routine utilizes the 5% PUMS from the Census and consistent with the PUMA boundaries. CHTS data points were also utilized to augment the PUMS data, requiring household weights to be re-calculated for the input PUMS data set. The population synthesis utilizes input data at the TAZ level and matches those household and population characteristics where ever possible. Household distributions by size of

household, number of vehicles, and income group are matched. In addition, population by workers and non-works are matched.

The following attributes are output at the person and household levels and matched against the TAZ marginal estimates and are later used as inputs into the trip generation model:

For Households:

- Household Size
- Vehicles in Household
- Income Category
- Tenure (own or rent)
- Number of Children under 18 in Household
- Number of persons above 65 years of age in household

For Persons:

- Age
- Employment Status
- Sex
- Enrolled in School
- Education Level Attained
- Race
- Worker Status

Trip Generation Model

In developing the trip generation model, AMBAG, with the consultant's assistance, evaluated increasing the number of explanatory variables. In addition to auto availability, age, and household size, other geographic variables such as lifestyle considerations, presence of young children in the household, and the availability of recreational opportunities were explored for inclusion in the model. A final list of variables included is shown below.

The AMBAG region is a large and diverse area. To better handle such diversity, the AMBAG model estimates a person based trip rate model instead of a household based model. This includes the creation of a synthetic population for the AMBAG region detailing a discrete record of persons and their characteristics to which the trip generation model is applied. Applying person based trip generation models has several advantages. It increases the sample size of data used to estimate the models and better explains the variations in travel

behavior. It also provides a better platform on which to quantify the 4D factors (Density, Diversity, Design, and Destinations) and prepares the foundation for a possible transition to an activity based model (ABM).

The above listed population synthesis output attributes are at the person and household levels and matched against the appropriate census aggregation (block or block group) and are used as inputs into the trip generation model.

The trip generation model forecasts trip productions and trip attractions at the zonal level for seven primary trip purposes: Home based Work (HBW), Home based Shopping (HBShop), Home based School (HBSchool), Home based University (HBUniv), Home based Other (HBOther), Non home based-work (NHBW), and Non home based other (NHBO), and Visitors (to shopping and tourism sites). NHBW refers to trips that are non-home-based but have one trip end at a work location. NHBO trips are similar except that neither end of the trip is a work location. The visitor model is split into two market segments: Visitors to Shopping sites (Visitor_Shop) and Visitor to Tourism sites (Visitor_Tourist). The visitor purposes are the only models not fully supported by the travel survey. They are based on previous AMBAG modeling efforts with some modification.

Interregional Trip Estimates and the Assumptions

AMBAG recently conducted an Origin Destination (OD) study using two different methodologies as well as weeklong classified traffic counts. The OD survey results using license plate video survey were used to account for External-External (X-X), External-Internal (X-I), and Internal-External (I-X) and was validated with traffic counts. AMBAG also consulted with Metropolitan Transportation Commission, Santa Clara Valley Transportation Authority, San Luis Obispo Council of Governments and Merced County Association of Governments modeling staff for the verification and validation of the future year traffic forecast for respective external gateway locations and incorporation into the 2022 AMBAG RTDM.

Trip Distribution (Destination Choice Model)

The AMBAG RTDM deployed two primary trip distribution models, a destination choice model and a gravity model for this model component. Traditionally, distribution models have primarily utilized a formulation of a gravity model. Unfortunately, the gravity model's aggregate nature limits its ability to capture the range of individual destination choice behaviors manifested by the population. A destination choice modeling approach has the potential to introduce more behavioral realism and hence generate trip tables that are closer to reality and more sensitive to smart growth land use policies.

A destination choice model also can include variables not typically present in a traditional gravity model. For instance, the home-based-work trip purpose gravity model can be replaced with a work location choice model for workers that predict their work zone. Another clear advantage of the destination choice model is that accessibility measures can be directly input as variables to the choice models. Finally, destination choice models will eliminate the need for ad-hoc adjustments such as the use of K-factors in the gravity model.

Gravity Model

The mode choice model was evaluated to explore avenues for enhancing its structure, utility specifications, and coefficients. Model parameters were compared against Federal Transit Administration (FTA) guidelines to document any instances of values that fall outside of the ranges suggested by the guidelines. Nevertheless, it should be noted that the most appropriate model parameters for the AMBAG region were obtained by re-estimating the model from the latest CHTS and Census data. The non-uniform travel characteristics, demographics, and population densities of the region meant that additional improvements for optimizing the mode choice component of the travel demand model had to be incorporated. These include:

- Shortest paths were computed from zone to zone based on travel time and estimated congested travel times were skimmed from the least cost paths utilized in the traffic assignment stage. Intra-zonal travel times were computed based on the average time to the nearest 3 zones.
- The balanced productions and attractions were obtained from the trip generation stage.
- Friction Factor Computation

To compute the friction factors, the origin and the destination zone for each trip in the survey data was obtained using the analysis tools in TransCAD. The trip length for each trip was determined based on the shortest path matrix. Using the survey weights, the trip length frequencies were determined on a minute by minute basis for each of the trip purposes. The trip frequencies were plotted versus trip travel time intervals, and gamma function curves were fitted to match the observations. It was generally observed that the best fit was obtained by using two sets of gamma curves for each trip purpose. One curve was used to model the initial and the peak region of the observations (generally around 1 – 15 minutes) and the other curve was employed to model the tail region of the observations (> 15 minutes). The trip interval used to aggregate trip frequencies was 1 minute for all trip purposes. Friction factors were estimated for both Urban and Rural zone sets due to significant differences in observed trip lengths and travel behavior in the CHTS.

Mode Choice Model

The updated mode choice model for the AMBAG RTDM utilizes a nested logit-based model structure. The model is fully estimated using the combined 2010 CHTS and 2017 NHTS survey records and as such only includes variables found to be significant. For the model update, one of the objectives was to estimate mode choice models that include 4Ds explanatory variables, the idea being that the model should be responsive to these parameters.

The estimated models are a series of logit models (multinomial or nested) that vary by trip purpose and by peak/off-peak periods. For most purposes, the following travel modes are estimated:

- Auto drive alone
- Auto shared ride (carpool)
- Walk
- Bike

School Bus and Other modes were added as needed to capture purpose-specific situations. The mode choice model was evaluated to explore avenues for enhancing its structure, utility specifications, and coefficients. Model parameters were compared against Federal Transit Administration (FTA) guidelines to document any instances of values that fall outside of the ranges suggested by the guidelines. Nevertheless, it should be noted that the most appropriate model parameters for the AMBAG region were obtained by re-estimating the model from the latest CHTS, NHTS and Census data. The non-uniform travel characteristics, demographics, and population densities of the region meant that additional improvements for optimizing the mode choice component of the travel demand model had to be incorporated. These include:

- Re-estimating the existing models with the latest surveys and model skims.
- Moving from the current daily skims to a time-of-day approach that might better match peak and off peak skims to those perceived and experienced by surveyed travelers.

- Implementing additional nesting structures to better fit the new data.
- Utilizing regional heterogeneity so that the mode choice model nested structure varies by trip purpose.

Weighted nested and multinomial logit model estimations were conducted using the Nested Logit Estimation procedure in TransCAD 9.0. One objective was to estimate separate mode choice models for the peak and off-peak periods. However, no significant difference was observed for any of the purposes. A combined model was therefore estimated for each of the purposes.

The estimated models are a series of logit models (multinomial or nested) that vary by trip purpose and by peak/off-peak periods. For most purposes, the following travel modes are estimated (for further technical details on the mode choice model by each trip purpose please refer to the AMBAG RTDM Technical Documentation Report):

- Auto drive alone
- Auto shared ride (carpool)
- Walk
- Bike
- Transit

Truck Model

A simplified truck model was inserted into the model stream to estimate Internal-to-Internal truck trips. IX-XI truck trips and XX truck trips are already factored into the model since the IX –XI and XX trips are based on external station traffic counts that include truck trips. The truck model is based on The Southern California Association of Government's (SCAG) 2003 truck model, which estimates truck trip rates based upon employment variables. The employment categories were re-categorized into the AMBAG employment categories, and the trip rates were then re-estimated based upon the AMBAG employment categories. Truck trip generation, distribution, and time-of-day models were added to the model stream. The truck distribution model utilized a Gravity Model with separate friction factor curve definitions for light, medium, and heavy trucks. The friction factors are calculated using a generalized cost formulation that considers operating cost per hour (dollars), fuel efficiency (miles per gallon), operating cost per distance (dollars), and fuel price (dollars per gallon).

Time of Day Analysis

A major upgrade to the model is the deployment of time period and trip purpose specific parameters. This includes the utilization of separate peak and off peak period skims, and model parameters. This approach provides a superior explanation of peak and off peak travel patterns throughout the region

AMBAG worked closely with Caltrans, and other relevant regional and local agencies to determine the most appropriate day and time periods for modeling. The model uses the following time periods:

- A.M. peak hour and period (6:00-9:00 A.M.)
- P.M. peak hour and period (4:00-7:00 P.M.)

- Mid-day (9:00 A.M.-4:00 P.M.)
- Night (7:00 P.M.-6:00 A.M.)

Using the available count data, the AMBAG RTDM was calibrated for each of the time periods shown above.

Highway and Transit Assignment

For highway assignment the AMBAG RTDM utilized a state of the practice and highly convergent traffic assignment methodology known as Origin-Based User Equilibrium. This method improves significantly on previous highway assignment methods by providing a more stable solution to the highway assignment problem. This provided AMBAG RTDM with the ability to more accurately quantify project benefits and explain the highway assignment results in a clearer context.

In the highway assignment step, trips from the origin destination matrix are assigned to the highway network to determine flows on links and route choices between any origin and destination. In the AMBAG model, four assignments are performed: A.M. peak period trips (6:00-9:00 A.M.), P.M. Peak period trips (4:00-7:00 P.M.), Mid-day (9:00 A.M.-4:00 P.M.), and Evening/Night (7:00 P.M.- 6:00 A.M.).

Transit assignment was performed using TransCAD's Pathfinder methodology. This methodology is a generalization and significant improvement of the highly-regarded Optimal Strategies approach and far superior to typical Urban Transportation Planning System (UTPS) methodologies. The transit assignment includes walk and bike access, along with park and ride functionality for both access (A.M.) and egress (P.M.). The Pathfinder methodology has been deployed successfully across the United States, and has gained wide acceptance from the FTA. For the transit assignments peak and off-peak transit trips are assigned separately and then aggregated for time of the day assignments into a total transit flow table.

Feedback

After the end of the highway assignment step, the congested travel times are used to update the input travel times into the both the highway and transit networks. Both the highway and transit skimming routines then use these congested times to produce congested highway and transit skim matrices. The logic of feedback is that the congested times are a more accurate measure of travel time than the initial free flow times, and can have a profound effect on the trip distribution and mode choice stages steps. During the feedback process, all models following the skimming stage are run again until an updated set of congested times is found following the highway assignment. This loop continues until a set number of feedback iterations are completed. The Multiple Successive Averages (MSA) method is used to calculate the congested time resulting from each feedback iteration. A total of 5 feedback loops are performed in the AMBAG RTDM. Five loops were found to be sufficient to ensure stability in the final solution. Due to the peak period definitions and the high variance in flow at the start of the peak and the remaining hours, skims for the peak period utilized AM skims derived from the hours 7:00-9:00 A.M. The assignment results are reported for all three hours of this period, however. Mid-day skims are used for the off-peak periods, utilizing a four-hour capacity.

Sensitivity Testing Results

AMBAG, Caliper and Fehr and Peers jointly conducted a model sensitivity test for modified land use changes (density and diversity), added highway capacity, transit fare, and additional bus rapid transit (BRT)/light rail transit (LRT) transit services using the update 2045 No Build RTDM.

The conclusions of these tests demonstrate the model's sensitivity to land use and transportation changes. For changes where the model is not sensitive, potential enhancements or post-processing methods is

recommended. For additional technical details please refer to the 2022 AMBAG RTDM Technical Documentation Report.

Added Roadway Capacity

he model is appropriately sensitive during traffic assignment for roadway widening projects in terms of route selection. The influence of roadway capacity on trip generation, distribution, mode choice, and GHG emission were not evaluated.

Modified Land Use

The changes in land use and the formulation of the mode choice model were not significant enough to cause a change in mode. As a result, the implication of the land use change on VMT is determined by the location and magnitude of the land use rather than the density, diversity and other D factors. Post-processing for active transportation, Transportation Demand Management (TDM), and density were recommended to apply where necessary for 2045 MTP/SCS.

Added Transit Service and Fare Change

The model is not sensitive to changes in transit services and fare change (free transit or double the existing fare). The mode choice model estimation based on survey data resulted in a fairly static mode split model. As such, the change to transit shifted trips from local bus to BRT or LRT, but overall mode shares remained constant. Although these tests were conducted in isolation to determine model sensitivity, it is recommended that scenarios be developed to maximize the sensitivity by incorporating multiple strategies cohesively. For example, additional infill or density should be accompanied with enhances transit service along the route, and stops should be placed within walking distance.

Off-Model Adjustments

Where the impacts of certain policy scenarios cannot be measured in the 2022 RTDM, AMBAG relied on "off-model" techniques based on academic literature reviews, collaboration with other MPOs and consultation with CARB's Policies and Practices Guidelines.

Off-model adjustments were made for three programs or bundles of projects that are included in the 2045 MTP/SCS: The increasing prevalence of telecommuting (Work From Home), TDM and other travel demand reduction programs such as vanpools for agriculture workers, car sharing and MBARD and 3CE incentives to promote zero emission vehicle (ZEV) and Electric Vehicle Infrastructure for the AMBAG region. The need for these adjustments was recognized in the Regional Targets Advisory Committee Final Report to CARB.

Several references were used for estimating the potential GHG off-model adjustments for WFH, TDM and incentives to promote ZEV and supportive infrastructure. :

- The CAPCOA "Quantifying Greenhouse Gas Mitigation Measures."
- SACOG Model Technical Report, APPENDIX C-4: Final Environmental Impact Report For The Metropolitan Transportation Plan/ Sustainable Communities Strategy For 2035, SACOG, February 2012.
- Plan Bay Area 2050, Long-range strategic plan, Metropolitan Transportation Commission (MTC) and Association of Bay Area Governments (ABAG), July 2020-21.

These references were used for several reasons. Each reference synthesized current research and program effectiveness results from many other sources, with high standards for data quality applied to the synthesis. Each reference focused analysis of transportation-generated GHG. Table 4.8-4 in the 2045 MTP/SCS Environmental Impact Report summarizes the total reductions of the GHG emission for the tri-county AMBAG region with implementation of the 2045 MTP/SCS.

EMFAC Model

AMBAG used the 2014 EMission FACtors model (EMFAC2014) to calculate GHG (CO2) emissions for the SCS as required by California Government Code 65080. For the 2045 MTP/SCS EIR purposes, AMBAG used the most current 2017 EMission FACtors model (EMFAC2017) to calculate air quality impact analysis. EMFAC is a California specific air quality emission computer model developed by CARB that calculates daily emissions of air pollutants from all on-road motor vehicles including passenger cars, trucks and buses for calendar years 1970 to 2050. In the EMFAC model, the emission rates from each of the motor vehicle types are multiplied by the vehicle activity data to calculate vehicle emissions. The GHG emissions analysis for passenger vehicles, (LDA, LDT1, LDT2 and MDV vehicle types), uses the automobile VMT by speed class from the AMBAG RTDM model run for each scenario.

Land Use Modeling

AMBAG previously used UPlan to translate changes in land use to inputs for the RTDM for the 2040 MTP/SCS. The use of UPlan was evaluated for use in the development of the 2045 MTP/SCS and was decided a different tool was warranted. The 2045 MTP/SCS plans used a new GIS based online tool, Urban Footprint. AMBAG has continued use of a place based typology system to conceptualize changes in land use across the region. They typologies act as a crosswalk between the 21 jurisdiction general plans and provide a common language for specifying land use changes, they include specifications for density and intensity of land use. These typologies will be categorized in Urban Footprint and leveraging Urban Footprint base case data, will translate the floor to area ratios into employment. Dwelling units per acre is already included within the typology system and can be aggregated to the traffic analysis zone geography using GIS software, ArcMap. The outputs include population, housing and employment which were fed into model at the traffic analysis zone level. For the 2045 MTP/SCS, population, households and employment will be updated as traffic analysis zone level for the development of multiple land use scenarios for 2020, 2035, and 2045 modeling years.