3.30 Transportation Modeling/Projecting Future Demand

Modeling is one method of forecasting future demands on the transportation system, and is an important source of information supporting the conclusions contained in the RTP. Typically the larger MPOs have the staff expertise and funding to conduct their own modeling. Smaller MPOs and RTPAs typically use subcontractors or rely on a review of existing documents. Current FHWA and FTA planning regulations require only that the MPO have an analytical process in place for evaluating projects.

Travel demand models are statistical and algorithmic attempts to model human travel behavior. They endeavor to forecast potential outcomes of various transportation scenarios. The models provide essential information about the regions transportation system operations, conditions and performance and they are used to predict future transportation needs. Typical factors that are included in the models are a region's demographic profile, general plan designations, distribution of trips and existing travel patterns including morning and evening peak hour travel demand, trip generation, and modal split among automobile, transit, carpool, bicycle, and pedestrian trips.

The models are used to evaluate alternative travel patterns and their implications before a regional transportation plan is adopted. California Government Code Section 65080(b)(1) gives MPO's with a population of over 200,000 the option to quantify various indicators of their regional transportation needs. The models are also used to conduct special studies, such as corridor studies that would assess the potential impacts of a new freeway or transit line.

Periodically the federal government reviews the policies and practices of the regional agencies, including an assessment of the travel demand models used in the development of the regional transportation plans.

Assumptions play a key role in the assessment of all statistical modeling efforts. Three key assumptions are typical of transportation demand models:

(1) Key characteristics of the system can be described in terms of quantifiable variables (e.g., number of automobiles per household, household size, etc.);

(2) A relationship between the variables described and behavior exists (e.g., the more automobiles per household, the greater the number of automobile trips per household); and,

(3) This relationship can be expressed in mathematical terms. This relationship is the same for all individuals and is constant over time. Challenges to the validity of transportation models often focus on one of these three assumptions.

Model results are only as good as the data that go into the model. MPOs must use the most current household travel survey, demographics, socio-economic and census data available, especially if the region is growing rapidly. The most current household travel survey will provide key inputs on travel behavior such as the trip characteristics and trip rates to the four-step model. MPOs should make every effort to explain the information and assumptions that went into creating the model in plain, understandable terms.

Described below is the traditional four-step process for modeling transportation demand. For the past 40 years, transportation professionals have used a four-step approach in modeling transportation demand. Most modeling approaches use some form of these steps today. Once some understanding has been established as to what the land use, population, and employment levels are in a study area, the four modeling steps are:

Trip generation: Estimates the number of trips generated in a zone or at a particular location, and attracted to a zone or a particular location, based on the assumed relationship among socio-economic factors, land use characteristics, and the number of trips. Trip generation then leads to:

Trip distribution Estimates the number of trips that originate in every zone in the study area, with destinations to every other zone. The result is a trip table that is used in:

Mode split: Estimates, for the number of trips predicted between each origin and destination, the number of trips made via each type of mode that is available for that trip. Thus, "x" percent are likely to drive alone, "y" percent are likely to take transit, "z" percent are likely to ride-share, etc. Mode split leads to:

Network assignment: Estimates the number of trips via a particular mode that will take specific paths through a road or transit network. The result, when all trips are assigned to a network, is an estimate of the total number of trips that will use each link in the network. When compared to the capacity of this link, planners can forecast the level of congestion that will occur at that location. This becomes the basis for assessing the performance of the transportation system.

Four-step models are commonly used to predict the demand for transportation services. Transportation planners and engineers also use other types of models to analyze and evaluate the performance of transportation systems and resulting impacts. Impact models determine the likely effects that constructing and operating transportation facilities will have on the surrounding environment and community. For example, planners often use air quality models, noise models, and community impact models in analyzing transportation alternatives. Cost models estimate the likely costs of transportation facilities and services. For example, cost models estimate the unit cost per component of a facility (e.g., dollars per linear foot of rail line), and multiply this by the estimated number of units needed. Most recent cost-modeling approaches incorporate a life cycle costing perspective that requires the planner to estimate expected costs, both capital and operating, for a possible project over the expected life of that project.

The goal of applying transportation models and analytical techniques, as part of the RTP process, is to enhance the quality of information and analysis presented to educate public decision makers and the public at large regarding the implications of various policy options, while recognizing that the final decisions on policy choices are their responsibility.

1. For preparation of the RTP required under Sections 65080 et seq. of the Government Code, by July 1, 2008, each MPO or RTPA over 200,000 in population is urged to establish transportation modeling and analytical techniques that facilitate its evaluation of one or more alternative planning scenarios under the provisions of Section 65080.3.

2. As part of the four-year RTP process each MPO or RTPA should strive to enhance, to the extent that data and resources permit, its modeling and analytical techniques in order to improve its assessment of the likely implications of key policy options. Such improvements should educate decision-makers and the public regarding how such options would potentially affect trip making, choice of travel modes, VMT, major land use development decisions, and quality of life issues.

3. To evaluate the effectiveness of policies to reduce GHG, the California Air Resources Board (ARB) and others need to compare modeling outputs across all regions in the State. To be able to compare travel projections across regions in California, some basic recommended modeling protocols should be adopted. These should be specific to groups of regions, according to policy problems encountered. Modeling practices should be consistent between California Department of Transportation (Caltrans) District Offices, MPOs, RTPAs, cities, counties, and Congestion Management Agencies (CMA).

Modeling Performance Measures

Recommendations:

- For meeting the goals of SB 375, modeling performance measures should cover one or more of the following: VMT, VHT, greenhouse gas emissions, and fuel usage.

Requirements (Shalls)
Federal: Title 23 CFR 450.322(f)(1) requires the RTP to contain "the projected transportation demand of persons and goods in the metropolitan planning area over the period of the transportation plan."
State: None

Recommendations (Shoulds)
Federal: None
State: California Government Code Section 65080(b)(1) gives MPO's with a population of over 200,000 the option to quantify various indicators of their regional transportation needs.

Best Practices:
http://calblueprint.dot.ca.gov
http://www.sjvalleyblueprint.com

3.30.1 RTP Modeling Requirements and Recommendations

MPOs, RTPAs and CMAs may be grouped according to modeling needs. For each group, we define: Model features and data, possible applications of the model, and policy analysis capabilities. **These recommendations are cumulative, with each set of model guidelines including the earlier ones on the list.**

A. Counties with very slow growth in population and jobs, little or no congestion, and no significant new road or transit construction plans (i.e., Modoc, Inyo, Siskiyou, which have 1990-2000 population growth rates below 3%)

These counties do not need to run a network travel model. Road congestion is not increasing rapidly. Emission changes from higher-MPG vehicles can be factored or derived from the ARB inventory.

Requirements (Shall)
Federal: None
State: None

Recommendations (Should)
Federal: None
State: None

B. Regions with attainment Air Quality (AQ), slow growth, or virtually no transit, plus the rural, isolated non-attainment areas.

Recommendations:

- The use of 3-step models can continue for the next few years. The models should be run to equilibrium. The models should implement post-processing of model output to account for the effects of land use characteristics on travel, in the short term. The models should address changes in regional demographic patterns.

- Geographic Information Systems (GIS) capabilities should be developed in these counties, leading to simple land use models in a few years. All natural resources data should be entered into the GIS. Parcel data should be developed within a few years and an existing land use data layer created.

- Agencies can define and evaluate trend forecast, combined general plans, preferred RTP, and low-VMT scenarios. The low-VMT scenario should achieve the regional VMT and GHG targets, if they are adopted by the ARB. Otherwise, the low-VMT scenario can simply reduce VMT substantially and increasingly over time, compared to the proposed RTP.

- These models can be used to evaluate increased density and mix, urban growth limits, and improved neighborhood walkability and bikeability.

Requirements (Shall)
Federal: None
State: None

Recommendations (Should)
Federal: TBD
State: TBD

C. Regions with rapid growth, nonattainment AQ, <u>or</u> the potential for significant transit use.

<u>Recommendations:</u>

- These regions should develop 4-step travel models as soon as is possible. In the near-term, post-processing should be used. The travel model set should be run to full equilibration across all model steps.

- Simple land use models should be used, such as GIS rule-based ones, in the short term. Economic, market-based land use models should be developed within a few years. Parcel data and an existing urban layer should be developed as soon as is possible. A digital general plan layer should be developed in the short-term.

- A simple freight model should be used.

- Several employment types should be used, along with several trip purposes.

- The models should have sufficient temporal resolution to adequately model peak and off-peak periods.

- All road capacities and speeds should be validated with surveys.

- The urban development footprint in GIS should be used to calculate environmental impacts on terrestrial and aquatic ecosystems.

- More policy scenarios can be run. The same policies as in *B* could be run, plus one or more transit improvement proposals, as well as demand management and pricing strategies.

- In addition to the policies and performance measures in *B*, these agencies can evaluate policies for their effects on lower-income households, as required by Federal and State law. This can be done by evaluating traveler welfare measures based on the mode choice log sums for each household income class, or based on travel costs for them. In addition, these agencies can evaluate simple road pricing, parking charges, and higher fuel taxes or carbon taxes in the plan, or in the Government Code Section 65080.3 alternative.

Requirements (Shall)
Federal: None
State: None

Recommendations (Should)
Federal: TBD
State: TBD

D. Regions with serious or worse ozone or CO non-attainment.

Recommendations:

- These regions should achieve the requirements of the Federal AQ Conformity Rule, meaning 4-step models with full feedback across travel model steps and some sort of land use modeling. In addition to the conformity requirements, they should also add an auto ownership step and make this step and the mode choice equations for transit and walk and bike and the trip generation step sensitive to land use variables and transit accessibility. Walk and bike modes should be explicitly represented. Small Traffic Analysis Zones (TAZ) should be used, to increase sensitivity to densification near to rail stations and in Bus Rapid Transit (BRT) corridors. Parking quantity and cost should be represented in the travel model. Parking quantity and cost should be represented in the travel model. The carpool mode should be included, along with access-to-transit sub modes. Speed post-processing should be used and take into account the effects of corridor capacity operational issues and bottlenecks on congested speeds and emissions.

- The regions should implement simple land use models for the next RTP and develop formal, economic land use models in the next few years.

- Freight models should be implemented in the short term and commodity flows models within a few years.

- Simple Environmental Justice analyses should be done using travel costs or mode choice log sums, as in *C.*

- Agencies should develop and test joint mode-destination choice models. .

- These regions should monitor the large RTPAs and MPOs, in *E* below, as they develop tour/activity-based travel models.

- The next household travel survey should include activities and tours. Floor space rent data should be collected.

- A full range in performance and impact measures could be developed, for economic, environmental, and equity effects, as required by SAFETEA-LU, National Environmental Policy Act, CEQA, and other laws. Traveler welfare could be measured and, if possible, locator welfare. Various measures of economic development could also be created, such as wages, jobs, production, and exports.

Requirements (Shall)
Federal: None
State: None

Recommendations (Should)
Federal: TBD
State: TBD

***E. The largest four MPOs and RTPAs with rapid growth and established transit systems*.**

Recommendations:

- If not already developed and validated for use for the current RTP cycle, MPOs are encouraged to transition to activity-based travel demand models for the following RTP cycle. This can be a phased approach by first developing tour-based travel demand models and then moving to more advanced activity-based travel demand models or moving directly to an activity-based model without a phased approach.

- They should also build formal microeconomic land use models, as soon as is practical, so that they can be used to evaluate economic welfare (utility) and economic development (wages, jobs, exports).

- Travel demand processes should incorporate freight movement. Information from the statewide freight model, when available, local trip-based truck demand models, or more advanced commodity flows models could be used. Commercial movements with truck and van tours should be accommodated in a commodity flow model. Freight data collection programs should be emphasized with coordination with statewide efforts.

- Household travel surveys should be activity-based and include a tour table. GPS sampling is encouraged or extra emphasis should be placed on accurate geocoding of households, workplace locations, and stops. Stated preference surveys of households and firms should be performed, as necessary, for use in location choice models. Microsimulation of households and firms should be investigated and developed, if feasible.

- Economic measures from the land use model could be implemented. These measures are more complete than those from the travel model and include locator welfare, wages, and exports. Equity analysis could include change in welfare by household income class. Water quality, housing affordability, and fire hazard analysis are examples of the measures that such model sets can also produce. These microsimulation land use models can evaluate the energy use and GHGs produced by households and workers in building space. Economic development impacts may be comprehensively evaluated with this model set. Time-of-day road tolls can be evaluated.

Requirements (Shall)

Federal: None
State: None

Recommendations (Should)

Federal: TBD
State: TBD

The following additional guidance applies to all MPO's except those that fall under Category A as defined above.

Requirements:

- Each MPO shall model a range of alternative scenarios in the regional transportation plan based on the policy goals of the MPO and input from the public.

- MPO models shall be capable of estimating future transportation demand at least 20 years into the future.

- For federal conformity purposes, each MPO shall model criteria pollutants from on road vehicles as applicable. Emission projections should be performed using ARB's EMFAC modeling software.

- Each MPO shall determine the greenhouse gas emissions impacts associated with their SB 375 Sustainable Communities Strategy, or Alternative Planning Strategy if applicable, with a methodology deemed acceptable by ARB.

- The MPO, the State(s), and the public transportation operator(s) shall validate data utilized in preparing other existing modal plans for providing input to the transportation plan. In updating the transportation plan, the MPO shall base the update on the latest available estimates and assumptions for population, land use, travel, employment, congestion, and economic activity. The MPO shall approve transportation plan contents and supporting analyses produced by a transportation plan update.

- The metropolitan transportation plan shall include the projected transportation demand of persons and goods in the metropolitan planning area over the period of the transportation plan.

Recommendations:

o For the current RTP cycle (post last adoption), MPOs should use their current travel demand model for federal conformity purposes, and a suite of analytical tools, including but not limited to, travel demand models (as described in Categories B through E above), small area modeling tools, and other generally accepted analytical methods for determining the emissions, VMT, and other performance factor impacts of sustainable communities strategies being considered pursuant to SB375.

o Measures of means of travel should include percentage share of all trips (work and non-work) made by all single occupant vehicle, multiple occupant vehicle, or carpool, transit, walking, and bicycling.

o To the extent practical, travel demand models should be calibrated using the most recent observed data including household travel diaries, traffic

counts, gas receipts, Highway Performance Monitoring System (HPMS), transit surveys, and passenger counts.

- o It is recommended that transportation agencies have an on-going model improvement program to focus on increasing model accuracy and policy sensitivity. This includes on-going data development and acquisition programs to support model calibration and validation activities.

Requirements (Shall)

Federal: 23 CFR 450.212 Transportation planning studies and project development. 23 CFR 450.322 Development and content of the metropolitan transportation plan. 40 CFR 1502.14 Environmental Impact Statement.
State: California Code Section 14522.2

Recommendations (Should)

Federal: TBD
State: TBD

Sketch Modeling of Scenarios

Modeling groups B, C, D and E may wish to develop fast turnaround sketch modeling tools for testing scenarios in public workshops. These sketch models allow the rapid input of land uses and produce rough estimates of changes for the area being analyzed. After a range of scenarios capable of reducing GHG to various degrees is identified from these exercises, the final set of scenarios is evaluated with the official travel model and land use model, to get accurate and detailed performance measures. The best scenarios may then be included in the RTP, SCS, and APS processes.

Interregional Travel and Modeling

Interregional travel is defined as the sum of the following:

1. Trips beginning outside a given MPO's boundary and ending within it (X-I trip)
2. Trips beginning inside a given MPO's boundary and ending outside it (I-X trip)
3. Trips beginning outside a given MPO's boundary, traveling across some portion of the region and ending outside the boundary (X-X trip)

The Statewide Travel Demand Model will provide interregional trip data to be used in MPO regional models. In those instances where adjacent MPO models produce dissimilar interregional volumes, the Statewide Travel Demand Model will act as the controlling source of data which the MPO regional models should reasonably match. The Department of Transportation will act as arbiter in these situations to help reach consensus.

3.30.2 Regional Economic and Land Use Model Recommendations

Based on the guiding federal and state statutes regarding RTP development, the California Transportation Commission has developed the following transportation modeling guidelines to support these policy objectives.

Requirements:

- Socioeconomic models shall include capabilities to measure the impacts of transportation investments on low income and minority communities as required under federal and state law.

Recommendations:

- o Regional land use and demographic projections should be consistent with existing local general plans and/or local policies. If a forecast horizon is beyond the horizon of local general plans, the MPO should work with local officials to define a best guess scenario for development beyond the general plan horizon.

- o Microeconomic land use models should be developed for use with activity-based travel demand models. Microeconomic land use models could be used to evaluate economic welfare (utility) and economic development (wages, jobs, exports). Geocoded employment data with occupational code should be purchased for two or more past years. Floor space quantity and rent data should be gathered.

- o Regional models should consider population growth based on birth and mortality and international and domestic migration.

- o Socioeconomic models should provide projections on future employment indicators including jobs by sector and income.

- o Land use models should be sensitive to transportation scenarios such that the effects of land use and transportation policies can interact with feedback in an integrated transportation and land use model.

Requirements (Shall)
Federal: 23 U.S.C. §109(h). Executive Order No. 12898 (1994). U.S. DOT Order 5610.2. U.S. DOT Order 6640.23.
State: None

Recommendations (Should)
Federal: TBD
State: TBD

3.30.3 RTP Modeling Quality Control and Consistency

The following recommendations for quality control through model consistency and peer review are essential in creating confidence in modeling results. These process recommendations should be implemented by all agencies as soon as is possible.

Consistency of RTP Modeling

Recommendations:

- For modeling groups *C*, *D*, and *E*, the No Action alternative and the Proposed Plan alternative in an RTP should be modeled consistently. This means both should be done using the same land use model and the same travel model. The inputs for the models, including alternative land use policies; will be different, of course. This practice will reduce the arbitrariness of zonal projections for households and employment in travel models.

- The same land use model used in the RTP modeling should be used in the impact assessment for the No Action alternative, the Proposed Plan alternative, and the Environmentally Preferable Alternative. Only in this way, will all of the outputs in the RTP and EIR be comparable. An alternative-planning scenario under Government Code Section 65080.3 should also be evaluated with the same models.

Model Peer Review, Testing and Documentation

Recommendations:

- All substantial model changes should be subjected to peer review and documented. The four largest MPOs should use the Travel Model Improvement Program (TMIP) national peer review process, but include two California modelers from another MPO, for their understanding of California laws. Other agencies should set up reviews using California modelers. The California Inter-Agency (CIA) Forum or other body of California modelers may develop validation guidelines.

<<OR THIS PROPOSED LANGUAGE (following bullet only)>>

- Each MPO should participate in a peer review program every ten years or after a major model enhancement such as transitioning from a four step to activity based travel demand model. The four largest MPOs (SCAG, MTC, SANDAG, and SACOG) should use the Federal Highway Administration's Travel Model Improvement Program (TMIP) peer review process, but include a modeler from another California MPO of similar size for their understanding of California laws. Other agencies should set up reviews using California modelers. Peer reviews should be made publicly available with the model documentation.

- The travel demand model, and regional economic and land use model if applicable, should be documented, including all statistical goodness-of-fit measures derived from sub-model specification. The documentation should be placed on the MPOs website and included in the RTP / SCS / APS review submittal sent to ARB under SB 375.

- The model documentation should include a comprehensive list of output metrics the model is capable of producing. To the extent practical, the documentation should include potential uses for each metric.

Model Validation and Sensitivity

Recommendations:

- Models should be validated and tested for sensitivity to changes in inputs, parameter values, and policies. Elasticities for several variables should be calculated and compared to theory and other models. Validation over time with forecasts or backcasts should be performed whenever possible. Validation and sensitivity tests should be documented, and made publicly available with the model documentation.

- As part of the validation/calibration process, all models should be sensitive to the following items:
    a. Price sensitivity, such as in tolling or congestion-pricing applications
    b. Evaluation of outcomes in designated transit-oriented development
    c. Evaluation of effects of different regional development densities (e.g., single family housing versus multi-family, etc.)
    d. Evaluation of development in known industrial areas
    e. Evaluation of development of specific "Greenfield" areas, to see how well the model can predict the expansion of the urban area
    f. Evaluation of outcomes in redevelopment and infill areas
    g. Equity and environmental justice sensitivities, such as effects of transportation and development scenarios on low-income or transit-dependent households
    h. Sensitivity to different types of transportation options, including transit, walking and bicycles

Requirements (Shall)

Federal: None
State: None

Recommendations (Should)

Federal: TBD
State: TBD

3.30.3 RTP Modeling as a Policy Tool

The RTP analyses should provide to decision-makers and the public:

1. A clear explanation of the modeling and analytical techniques applied in assessing the implications of the "likely" land use scenario, and any land use and other alternatives studied;
2. Reasonable transparency to that modeling and analytical process;
3. An understanding of the sensitivity of the forecast results to various policy assumptions; for example, where feasible offering estimates of the elasticities and cross elasticities of demand for various modes of travel with respect to critical variables such as access time, travel time, reliability, safety, privacy, and cost;
4. The degree to which analytical results can be expected to:

a. Be more indicative of a general expected trend or order of magnitude change rather than a quantifiably valid forecast;

b. Provide the degree of certainty needed for the quantifiable forecasts; and

5. Any insights gained through market-based research into the variables that most influence consumer choices with respect to housing in transit oriented and mixed-use developments, the use of transit services, and decision to use single occupant vehicles.

Requirements (Shall)

Federal: 23 U.S.C. §109(h). Executive Order No. 12898 (1994). U.S. DOT Order 5610.2. U.S. DOT Order 6640.23.
State: None

Recommendations (Should)

Federal: TBD
State: TBD

3.30.4 Modeling References

"Predicting Air Quality Effects of Traffic-Flow Improvements," NCHRP Report 535

"Assessment of Integrated Transportation/ Land Use Models", Robert Johnston and Mike McCoy, UC Davis for Caltrans, May 2006.
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"Assessment of Local Models and Tools for Analyzing Smart-Growth Strategies," DKS Associates, with UC Irvine and UC Santa Barbara, for Caltrans, July 2007.
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"Traveler Response to Transportation System Changes, Interim Handbook," TCRP Web Document 12 (Project B-12), March 2000.

"Metropolitan Travel Forecasting: Current Practice and Future Direction" Transportation Research Board, Special Report 288.

Robert A. Johnston, "Review of U.S. and European Regional Modeling Studies of Policies Intended to Reduce Transportation Greenhouse Gas Emissions" July 30, 2007. On the VTPI web site and available from the author at UC Davis.