HISTORY OF TRAVEL DEMAND FORECASTING IN CALIFORNIA

The travel demand forecasting and analysis function in California initially was developed in response to the demonstrated need for additional and improved transportation facilities during the Interstate Highway construction era of the 1950's. Response to this need first required more extensive planning for the safe and efficient movement of people and goods. Over several decades travel forecasting evolved from non-existent to extremely sophisticated as it stands today.

Transportation planning and travel forecasting expanded to meet the information needs of decision-makers in each of several distinct transportation periods. Prior to the 1920's, interregional and intercity travel was primarily by rail or wagon. Highways were generally a local concern only, and local coordination and standards for transportation were established. During this period, there was no reason for travel demand estimation, as the explosive growth of California had not yet commenced.

From the 1920's through the 1940's, travel demand was estimated by “Rule of Thumb” for each facility being considered. This was the road network period when the Federal Aid Primary system was initiated and when facility design and other criteria developed. Simply put, newly constructed highway facilities virtually always exceeded demand when a project was completed. In most cases, many years may have past before the facility became inadequate. Sometimes even decades past before demand exceeded capacity and expansion or a new facility was required to meet the needs of the traveling public.

The first real demand for system analysis came in the mid-1940's, as small towns began to be bypassed, and has continued to the present. In that decade, both population and automobile ownership increased at such a rapid rate that the demand for intercity and urban area mobility could no longer be ignored. The Federal-aid Act of 1944 first provided Federal funds for the construction of urban area highways and advocated urban transportation planning. Almost 20 years later, the Federal-aid Act of 1962 required transportation planning for all urban areas of more than 50,000 population and formalized the Urban Transportation Planning Process which includes the 3-C Process for planning, e.g., cooperative, comprehensive, and continuing.

This new process provided the framework within which all levels of government (local, regional, State, and Federal) began conducting transportation planning. That framework included inventories, data and model analysis, forecasts, transportation system analysis, plan development, plan evaluation, plan selection, and plan implementation, followed by continuing reevaluation. This new process was a significant departure from the simplistic rule-of-thumb methods that provided for an estimate of the future based upon past experience (trend line, for example). Rule-of-thumb methods were limited to the point at which the estimate was made on the existing or proposed network only. Urban travel demand forecasting provided for an analysis of the entire system based upon alternative networks and service (supply side) and alternative estimates of socioeconomic data such as housing, population, income, employment, etc. (demand side). This process gave answers to the following questions for each of the alternatives:
What is the magnitude of the system?
Where are the activities located?
How many trips will be generated?
Where will the trips go?
By which mode?
By which route?

As the need for system analysis and travel demand forecasting matured through the 1960's, the next decade of the 1970's became the “environmental” era when the demand for environmental impact assessment was brought to the forefront and travel demand forecasting became fully entrenched in the transportation planning process. Caltrans’ Office of Travel Forecasting & Analysis (OTF&A), as it exists in the Caltrans organization today, has undergone an organizational and functional metamorphosis over the years. Backing up to the 1950's and 1960's, the Transportation Analysis Branch within the California Division of Highways, provided modeling and forecasting services on a statewide basis to all regions in the State. The unit ran models on mainframe data processing machines to provide travel forecasts to the Caltrans district offices and their associated regional planning agencies. In the early 1970's, however, when Caltrans was created as a multi-modal department, the Division of Transportation Planning was legislatively mandated and OTF&A was created.

While OTF&A continued to provide considerable travel forecasting services to the districts and regions, the “locals” began their quest for independence and expressed desires to do their own modeling and travel forecasting. Currently, most all RTPAs and MPOs do their own technical travel demand analysis. This capability developed with the introduction of the desktop PC and workstations to replace mainframe UNIX-based EDP equipment that only the largest organizations previously could afford. The Office of Travel Forecasting & Analysis focuses on regional support, research, and vehicular emissions forecasting for air quality analysis. Through its regional support function, OTF&A provides technical services, updated software, and training (when requested) to modeling staff in the Caltrans districts, the RTPAs, and to some smaller local jurisdictions that do their own modeling, yet need technical assistance to become self-sufficient.

In its research function, OTF&A investigates and develops new techniques in modeling activities, particularly those related to operational improvements to facilities. Examples of Caltrans’ ongoing research activities include investigation into intelligent transportation systems, driving cycle protocol development associated with air quality analysis, and data collection techniques using instrumented vehicles and relatively new state-of-the-practice research activities include investigation into intelligent transportation systems, driving cycle protocol development associated with air quality analysis, and data collection techniques using instrumented vehicles and relatively new state-of-the-practice equipment such as GPS.

MODELING SOFTWARE AND SYSTEMS USED IN CALIFORNIA

A variety of travel demand forecasting processes and software have been used in California since the 1960's. The old “Division of Highways” developed its own proprietary software of analytical modeling programs, known as the TRN and FWY systems. The TRN system handled all the data reduction of
origin-destination data collected through massive home interview survey efforts conducted throughout
the State. The FWY system was a mainframe system that addressed all phases of modeling including
trip generation, distribution, assignment, and mode-split.

Over time, as work stations and personal computers became more and more powerful, other travel
demand modeling systems were developed and evolved externally such as TRANPLAN, MINUTP,
EMME2, and TP+/VPER, just to name a few. The Caltrans modelers have utilized these more user-
friendly systems and have adopted many of them as viable replacements to our TRN and FWY systems
and the Federal UTPS mainframe system. Thus, the Caltrans systems and other mainframe systems have
gone by the wayside as too expensive to maintain, particularly when most of the regions are doing their
own modeling (using simpler systems and more powerful PCs). Many advantages are found in federal
government systems or vendor systems that better meet the regional agencies’ specific needs and data
processing equipment.

While this paper primarily addresses systems used by the California Department of Transportation,
several of our regional partners are very sophisticated in their development, use, and adaptation of
various models. A prime example is the efforts that have been developed at the Metropolitan
Transportation Commission in the San Francisco Bay Area. MTC completed work in 1997 on a new
model system, known as BAYCAST, through the aggregate validation of all trip distribution models.

BAYCAST was designed as an advanced state-of-the-practice trip-based travel forecasting system that
derived from the typical ‘four-step’ model. This modeling system includes the standard four steps of
generation, distribution, mode choice, and assignment, as well as three extra main models: workers in
household, auto ownership choice, and time-of-day choice models. BAYCAST, as a model system, is
intended for application with different network planning packages including, but not limited to
MINUTP, TRANPLAN, and EMME/2. To date, this model system has been used for updating both the
Regional Transportation Plan and for updating county congestion agency model systems.

CALIFORNIA STATEWIDE TRAVEL MODEL

In addition to the modeling systems used by Caltrans and the regions for regional travel forecasting,
several years ago OTF&A developed a Statewide Travel Model that specifically focuses on long,
interregional/intrastate travel. The Statewide Travel Model is primarily intended to provide a baseline
for statewide aggregated data rather than detailed regional forecasts. The Statewide Travel Model
operates similarly to a standard regional travel demand model using the same variables but on a
statewide basis. Trip generation, distribution, and assignment is run on a 1400 zone network, although
this zone system and network was recently expanded to some 2500 zones in order to increase the
accuracy of the model outputs.

MOTOR VEHICLE STOCK, TRAVEL AND FUEL FORECAST MODEL

Also, Caltrans has developed the Motor Vehicle Stock, Travel and Fuel Forecast (MVSTAFF) model
that uses a macroeconomic approach to modeling statewide motor vehicle holdings, VMT, and total fuel
consumption. Econometric equations are used to forecast total vehicle stock, total diesel fuel
consumption, and total VMT based on variables such as population, income, vehicle ownership, and the fuel cost per mile. Total on-road fuel consumption is estimated by dividing total VMT by an estimate of on-road fleet fuel economy. Total gasoline consumption is obtained as the difference between total fuel consumption and diesel fuel consumption.

The MVSTAFF forecasts are used for both short- and long-range statewide transportation planning, travel forecasting, and projections of revenues from excise taxes on fuel. This model is used to forecast travel on a total statewide basis rather than aggregate the regional modeling efforts into a statewide composite. Some interesting facts about California and its travel history and future resulting from MVSTAFF outputs follow:

- The decade of the 1950's experienced a 71% increase in VMT which was driven primarily by a 49% increase in population and helped along with moderate increases in per capita total personal income and vehicle ownership.
- The 1960's saw a 64% increase in VMT although population grew at about half the rate that it did in the 1950's. The driving force in this decade would appear to be the growth in per capita income and vehicle ownership, the highest in 40 years.
- The 1970's produced the smallest percentage increase in VMT (38%) in the previous 40 years as a result of the lowest percentage increase in population, a slower growing economy, and sharply rising fuel prices in the last half of the decade.
- In the 1980's, VMT grew by 62% while per capita income and vehicle ownership grew by only 12% and 7%, respectively. Most of the growth in VMT in the 1980's can, therefore, be attributed to strong population gains (26%) and the precipitous drop in the real fuel cost per mile of travel (57%), resulting from a 45% drop in the real price of fuel and a 39% increase in the on-road fleet fuel economy.
- In the 1990's, VMT has grown, but at a greatly reduced rate of 22% as population growth slows down to 16% and personal income shows small growth (9%).
- In the 2000's and 2010's, VMT is forecasted to grow moderately (27% and 22%, respectively) as population growth rates increase only slightly (18% and 16%) over the 1990's and personal income increases moderately (15% and 12%). Fuel cost per mile will have a small increase of only 2% in the 20-year period from 2000-2020.

Three years ago the Institute of Transportation Studies at University of California at Davis completed an in-depth analysis of Caltrans’ MVSTAFF Model to evaluate the estimates generated by the model and to provide Caltrans with suggestions for enhancements to the methodology used, if necessary. The assessment clearly demonstrated that MVSTAFF is a viable tool in meeting its programmatic objectives and is consistent with models, used by other organizations, that are based on widely different methodologies and purposes. While some specific modeling and process improvement recommendations were made, the overall conclusion was that this model has analytical integrity and
GUIDELINES FOR MODELING IN CALIFORNIA

In the early 1990's, in association with consultants and the FHWA, OTF&A developed a set of Travel Forecasting Guidelines, documented in a publication provided to the travel forecasting community upon request. This publication presents what reasonable and consistent methods should be used in preparation of regional travel forecasts developed to yield mobile source emission inventories. The Guidelines document addresses this purpose in three major areas: 1) An overview of state-of-the-practice in transportation modeling (as of 1992); 2) A description of the linkage with mobile source emission inventories, including methods for addressing transportation control measures in the modeling process; and 3) A discussion of future research and model improvement needs, some of which have already occurred or at least have been addressed by the modeling community. Other reasons for development of these modeling guidelines follow.

Several years ago, it was proposed that travel demand forecasting models be used for estimating emissions, traffic operational analyses, and congestion management planning. This proposal came as a result of passage of the California Clean air Act of 1988, the Federal Clean Air Act Amendments of 1990, and the Congestion Management Program of 1990. Each of these uses had different requirements for the accuracy and usefulness of the model outputs and the validity of the input assumptions and data. These new uses for existing travel demand forecasting models prompted Caltrans to initiate a set of travel demand forecasting guidelines.

The State and Federal legislative requirements for modeling, particularly California’s Congestion Management Program, resulted in a proliferation of regional or countywide models. While regional modeling used to be practiced by only a few metropolitan planning organizations in the State, the CMP legislation led to the development of a countywide model by virtually every county in the State that contained an urban area. Many of the regional or countywide models in the state were reasonably sophisticated and constituted good modeling practice, but some MPOs or CMP agencies were using procedures that had not been updated since the 1960's or 1970's.

Alternatively, some agencies were using default values provided with the analytical software packages that were being utilized. As a result, there was considerable variation in the level of sophistication and the level of accuracy of regional models within the State. The effort to develop statewide guidelines was designed to raise the overall level of the quality of modeling within the State and to provide some consistency in the way that modeling is practiced in California.

The primary purpose for regional modeling of travel when it began in the late 1950's was to determine the need or requirements for major highway investments. This determination was most often made on the basis of projected volumes on particular roadway links. From that estimate, the number of lanes of additional capacity needed or the need for new roadway facilities was determined. When used for this purpose, rough approximations of forecast volumes (particularly in rural areas) were sufficient to
determine when existing facility improvements or development of new facilities were needed. In and around urban areas, the detailed outputs of sophisticated zonal forecast and freeway system models were necessary and usage of these early models increased.

With an emerging regulatory and legislative environment some ten years ago, however, significantly greater accuracy and sensitivity became necessary. An emphasis on meeting air quality standards within the State became a primary focus in developing guidelines to improve the forecasting of travel activity data as an input to emissions estimation as part of an overall conformity analysis for regional transportation plans and transportation improvement programs.

A secondary concern to be addressed in the Guidelines emerged regarding the accuracy of models in conjunction with how they would be used: 1) To produce inputs for level of service calculations as required by the Congestion Management Program; 2) To evaluate transportation control measures as required by the Federal and State Clean Air Acts; and 3) To evaluate alternative modes such as transit or other high occupancy vehicle modes, including carpooling and vanpooling. Within each of these areas, there was concern about inconsistencies and inaccuracies in the model systems and how they represented travel behavior.

Greater accuracy in modeling was desired as a means of more efficiently planning for transportation facilities or facility management programs. Also, greater consistency was desired to facilitate comparisons of forecasts between regions or between agencies within the same region in a process of prioritizing state project funds. For these purposes, there was the desire to establish more consistent methodologies for travel forecasting and for more consistent use of assumptions within the models. The guidelines as they were developed and published were an attempt to specify a minimum acceptable standard. Caltrans encouraged that this standard would apply to all agencies throughout the State. It also was suggested that a more advanced level of acceptable practice would be expected from the four larger, more sophisticated agencies in the State that do their own transportation modeling (Los Angeles-SCAG, Bay Area-MTC, Sacramento-SACOG, and San Diego-SanDAG).

The Caltrans Travel Forecasting Guidelines consists of two chapters that provide guidance on travel demand modeling (Input Data & Assumptions and Travel Demand Models), one chapter on the requirements that emission inventories places on travel demand modeling (Emission Inventory Needs), and one chapter on further research that will promote improved travel demand modeling for air quality analysis (Research & Recommendations). Copies of this document are available from the Office of Travel Forecasting & Analysis in the Transportation System Information Program at Caltrans.

DATA COLLECTION IN CALIFORNIA

Another area that Caltrans has undertaken very aggressively over the years is data collection through travel surveys, conducted in a variety of ways. Using temporary local staff hired by Caltrans, the Department conducted massive home interview origin-destination surveys in the 1960's and 1970's. From 1963 to 1972, Caltrans conducted 12 separate home interview surveys up and down the State. With a 20% sampling rate, some 3,100 households were interviewed in Eureka and over 33,00 households were interviewed in Los Angeles (a 1% sampling rate). Over 140,000 household were interviewed in that ten-year period, an accomplishment that today is not only fiscally unfeasible but also
logistically impossible.

From 1976 to 1980, Caltrans covered the State again with another, yet much smaller, Statewide Travel Survey update. The last Statewide Travel Survey was conducted in 1991, by a consultant, and data were collected from some 15,000 households throughout the State, with a minimum of 500 samples in any one region. With such small samples (compared to 20-30 years ago), the survey was primarily used to update trip generation rates. As the new millennium approaches, efforts are underway to acquire funding for a Year 2000 Statewide Travel Survey to once again update the statewide database.

Current activities are underway in California for a data collection effort that includes a Truck Travel Survey. It is anticipated that trucks will be surveyed for origin-destination information at major border crossings, weigh stations, and at major interregional screenlines. This survey that will establish a new database for interregional truck travel in California and will be the basis for development of a truck travel model which is sorely needed in the State.

THE FUTURE OF MODELING IN CALIFORNIA

Now that virtually all of the regional transportation planning agencies in California are doing their own travel forecasts and not relying on Caltrans to do the modeling for them, the focus of the Department has changed. Caltrans has always been research-oriented in reference to modeling systems. The Department is now specifically focusing on models related to operational improvements and intelligent transportation systems as well as an integration of GIS into travel demand modeling systems.

A few years ago a travel demand and simulation modeling contract was executed by Caltrans to improve methods for forecasting mode shift, route diversion, and mobile source emissions that result from the implementation of high occupancy vehicle (HOV) lanes and other freeway operations strategies. The primary goal of that project was to develop an analytical tool that would improve upon the sensitivity and accuracy of then currently available transportation modeling software used for predicting impacts of HOV facilities. These impacts included changes in operational characteristics such as speed and congestion, emissions, and fuel consumption. The analytical tool that was developed was a model framework that integrated a regional planning model with a freeway simulation model (FREQ) and an emissions model (the Direct Travel Impact Model, DTIM). The resultant CALINK software produced a direct linkage between freeway simulation software and transportation planning software packages. The current emphasis on traffic simulation modeling systems is directed toward such models as CORSIM, FRESIM, NETSIM, INTEGRATION, FREQ11, FREQ12 (in development), and PARAMICS. A training project was just recently completed with the University of California at Berkeley where 28 Caltrans staff members were provided with in-depth technical training in the use of these analytical tools. Additional training courses are being developed for attendance by more Caltrans modelers and traffic engineers as well as for regional agency staff. Expanding to this type of modeling is an attempt by Caltrans to keep up both with the state-of-the-practice and the state-of-the-art in the technical areas related to travel demand modeling and travel forecasting.