SPECIAL REPORT 288

METROPOLITAN TRAVEL FORECASTING

Current Practice and Future Direction

Committee for Determination of the State of the Practice
in Metropolitan Area Travel Forecasting

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Summary Findings and Recommendations

Under federal law, metropolitan planning organizations (MPOs) are charged with developing transportation plans and programs to accommodate mobility needs for persons and goods within their regions. To this end, the MPOs estimate future travel demand and analyze the impacts of alternative transportation investment scenarios using computerized travel demand forecasting models. These models are used to estimate how urban growth and proposed facilities and the associated operational investments and transportation policies will affect mobility and the operation of the transportation system. Forecasts derived from these models enable policy makers to make informed decisions on investments and policies relating to the transportation system. In addition, MPOs in federally designated air quality nonattainment or maintenance areas have been given a central role in determining whether their regional transportation plans and programs conform to State Implementation Plans for meeting national air quality standards. Travel forecasting models play a principal role in this process as well.

STUDY CHARGE

The committee was tasked with assessing the state of the practice in travel demand forecasting and identifying shortcomings in travel forecasting models, obstacles to better practice, and actions needed to ensure the use of appropriate technical approaches. This report provides the requested assessment and recommendations for improvement and is designed for officials and policy makers who rely on the results of travel forecasting. A separate report com-

missioned by the committee is intended for readers with an interest in the technical details of current practice.

FINDINGS

The findings summarized below are based on surveys of MPO and state agency practice, a literature review, and the knowledge and judgment of the committee members.

Current State of Practice

The basic modeling approach at most MPOs remains a sequential four-step process by which the number of daily trips is estimated, distributed among origin and destination zones, divided according to mode of travel, and finally assigned to highway and transit networks. In smaller metropolitan areas, there may be little or no public transit, and the mode-of-travel step may be omitted, resulting in a three-step process. This basic approach has been in use since the 1950s and was originally intended to aid in decisions on the scaling and location of major highway and transit capital investments. Through the years, refinements and incremental improvements to this process have been made, but its basic structure has remained unchanged. A few metropolitan areas have adopted or are experimenting with the use of more advanced travel models based on tours of travel or the representation of human activity, unlike the four-step approach, which is based on single trips. These more advanced models can provide a better representation of actual travel behavior and are more appropriate for modeling policy alternatives and traffic operations. Other fundamental advances being used in a few places include joint transportation–land use models and the combining of travel demand forecasting with detailed traffic simulation models.

Although the four-step process is nearly ubiquitous, there are considerable variations in the completeness and complexity of the models and data employed. Smaller metropolitan areas with stable growth may use a simple version of the current models without a transit component or land use model, addressing travel only on the network of larger highways. Areas with more complex needs are likely to use more sophisticated four-step models, including combined transportation–land use models, or to adopt advanced techniques, such as activity-based models. Metropolitan areas such as San Francisco, New

York, and Columbus, Ohio, have implemented more advanced approaches. ***The committee finds that there is no single approach to travel forecasting or set of procedures that is "correct" for all applications or all MPOs. Travel forecasting tools developed and used by an MPO should be appropriate for the nature of the questions being posed by its constituent jurisdictions and the types of analysis being conducted.***

Shortcomings of Current Models and Modeling Practice

The demands on forecasting models have grown significantly in recent years as a result of new policy concerns. Existing models are inadequate to address many of these new concerns. MPOs are required by federal law to consider in their planning process how projects and strategies will affect a wide variety of policy concerns. Requirements specific to modeling include estimating motor vehicle emissions (which depends on estimating speeds and traffic volumes by time of day), estimating new travel generated by adding new capacity, evaluating alternative land use policies, and estimating freight movement and nonmotorized trips. In general, the conventional four-step models in use by most MPOs perform reasonably well in representing and forecasting aggregate system- and corridor-level travel demand. As the problems being studied become more disaggregate and more linked to individual behavior, however, the four-step process yields less satisfactory results.

Current models have inherent weaknesses. Most fundamentally, the processes that represent travel demand in the four-step model are not behavioral in nature; that is, they are not based on a coherent theory of travel behavior and are not well suited to representing travelers' responses to the complex range of policies typically of interest to today's planners and politicians. They also are unable to represent dynamic conditions for the transportation system. The conventional travel models make use of networks, both highway and transit, in which congestion is represented by averages over an extended period. These models cannot represent the conditions that would be expected or found by an individual traveler choosing how, when, and where to travel. ***As a consequence of these weaknesses, the following cannot be adequately represented:***

- **Time chosen for travel:** The conventional model structure is inherently incapable of accurate treatment of the choices travelers make in response to congestion and other indicators of system performance. Applications that depend on the ability of models to characterize and forecast travel by time of

day include vehicle emissions, variable pricing toll strategies, variable work hours, convertible traffic lanes, and time shifting of travel in response to congested networks or road pricing.

• **Travel behavior:** Traveler behavior is currently represented in a highly aggregate manner. Factors influencing travel behavior—such as value of time and value of reliability—for different sectors of the traveling public are impossible to model with the four-step process. This makes it difficult to represent travelers' responses to changes in public policies, such as road pricing, telecommuting programs, transit vouchers, and land use controls.

• **Nonmotorized travel:** Many walking or bicycle trips take place or are affected by features wholly within a travel analysis zone and thus cannot be captured by the current models. One solution to this limitation is to code a much finer-grained zone system; however, doing so imposes a major burden of labor and computer processing. As a result, many MPOs do not model walking or bicycle travel. This makes it difficult to evaluate the impact of such initiatives as smart growth and transit-oriented development.

• **Time-specific traffic volumes and speeds:** The four-step process does not produce accurate, disaggregate estimates of time-specific volumes or speeds on specific routes. These estimates are needed to evaluate improvements in traffic operations, modes of access to transit stations, time shifting of travel in congested networks, and freight movement policies, as well as to calculate air quality emissions.

• **Freight and commercial vehicle movements:** The lack of robust, validated models with which to forecast freight movement and commercial truck activity is of great concern, especially since these vehicles have a disproportionate effect on emissions, traffic, and pavement wear. The reasons for this deficiency include a lack of data (since much freight movement begins or ends outside the metropolitan area) and a lack of information on the business demands that drive freight movements.

Shortcomings of conventional forecasts are also related to poor technical practice in the use of models. The committee notes that this problem is not particular to conventional models and will need to be addressed for advanced models as well. Examples of this problem include the following:

• **Inadequate data:** The survey conducted for this study found that many MPOs have inadequate data to support their modeling process. This is particularly true of hourly directional traffic counts to support model validation, current household travel data rich enough to support market segmentation

or other disaggregate needs, and any useful origin–destination data on freight movement for use in specifying models of goods movement.

• **Optimism bias:** A number of studies have shown that forecasts for toll road and new transit projects are typically substantially higher than actual start-up patronage. This is true for projects undertaken 20 years ago as well as for more recent start-ups, although forecasts supporting requests for federal capital assistance for transit (Transit New Starts) have improved. These problems have drawn the attention of the Federal Transit Administration (FTA) and bond rating agencies.

• **Quality control:** Organizing a metropolitan travel forecasting process is a complex undertaking requiring detailed network coding, use of extensive traffic and passenger volume data, and proper integration of various models and submodels. Many opportunities to introduce errors arise. The best practice is to have a rigorous, formally defined quality control process, with independent assurance during each step. While some MPOs have such a process in place, many do not.

• **Validation errors:** Validating the ability of a model to predict future behavior requires comparing its predictions with information other than that used in estimating the model. Perceived problems with model validation include insufficient emphasis and effort focused on the validation phase, the unavailability of accurate and current data for validation purposes, and the lack of necessary documentation. The survey of MPOs conducted for this study found that validation is hampered by a dearth of independent data sources.

The committee believes that FTA is to be commended for taking steps to ensure quality in the travel forecasting methods used for major project planning. In particular, FTA initiatives to ensure the quality of New Start ridership, revenue, and cost information have been useful in uncovering weaknesses in model practice and form.

Obstacles to the Development and Application of Improved Models

Despite some obvious shortcomings of current travel forecasting models, change has been slow to come in comparison with, for example, the period 1950–1960, during which much of the current four-step urban transportation modeling system was developed. Advanced models exist that are more responsive than conventional approaches to a wider array of current issues, but there

are also barriers to their widespread implementation. Obstacles to advances in modeling practice include preoccupation with the immediate demands of production, fear of legal challenges, and significant budget and staff limitations.

Insufficient evidence exists that advanced models can be implemented for a reasonable cost and will provide significant improvements over current practice. Although a number of agencies have begun to use tour- and activity-based models, many believe that these models are not fully ready for implementation. There are valid concerns about the costs associated with the new models and the amount of data needed to specify, calibrate, and validate them. Yet agencies that are using these advanced models are providing a growing body of evidence that they can successfully replace the current models used to perform basic MPO forecasting activities and address more complex policy and operational issues as well.

Intergovernmental relations have changed over time. Direct federal involvement in and funding for the development of models and associated training have gradually decreased. Responsibilities for model development have devolved to the states and MPOs, with private-sector support. At the same time, federal planning and related environmental requirements for states and MPOs have grown. Even as the federal government has greatly reduced its financial support for efforts at model enhancement, federal regulations have imposed additional requirements on the modeling process. Aside from recent significant federal investment in a complex microsimulation modeling package (TRANSIMS), MPOs and states have been on their own in developing models that can respond appropriately to these requirements.

Federal funding for MPO model development efforts has not grown commensurately with travel modeling and forecasting requirements and is severely deficient. The Travel Model Improvement Program (TMIP) has the potential to greatly facilitate the adoption of advanced modeling practices and the improvement of current practices. For the past several years, TMIP has been funded at $500,000 per year for all activities other than development of TRANSIMS. This is an inadequate amount to assist MPOs with meeting the federal requirements.

Although TRANSIMS was not evaluated for this study, the committee notes that it has provided an important bridge from the current practice of static, trip-based modeling to improved future practice. TRANSIMS receives about $2 million annually through the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) to support the development of new applications and to assist agencies with its deploy-

ment. This funding is not adequate for these purposes. By comparison, in the late 1970s and early 1980s, federal highway and transit agencies spent about $5 million a year on travel modeling, an amount that equates to about $15 million in current dollars.

To put this funding issue in context, SAFETEA-LU authorizes about $40 billion annually in federal support for highway and transit improvements, many of which are subject to metropolitan and statewide planning rules or other programmatic requirements, such as Transit New Starts. One would expect appropriate corresponding support for models used to provide critical information on how this large investment should be planned and implemented.

Recent Advances in Modeling Practice

Through the TRANSIMS initiative and other efforts by university researchers and consultants, advanced travel models are being developed that are based on a more comprehensive understanding of the activities of households and a more complete representation of network performance that accounts for the details of congested operations throughout the day. Such models have been implemented in a few places, where they appear to perform well.

Summary

The findings summarized above reveal that most agencies continue to use a trip-based three- or four-step modeling process that, while improved during the past 40 years, has remained fundamentally unchanged. These models have basic, documented deficiencies in meeting current modeling needs. There are also deficiencies in current practice—particularly data gaps—that will not be resolved by switching to more advanced models. The institutional environment for travel modeling has devolved much of the responsibility for the development of travel models to the states and MPOs, although the federal government retains a strong interest in the area. Advanced models that better meet the needs of MPOs have been developed and satisfactorily implemented by some metropolitan areas. There are, however, considerable barriers to fundamental change, including resource limitations, practitioners' uncertainty as to whether new practices will be better than those they replace, a lack of coordination among stakeholders, and inadequate investment in the

development and transfer of new techniques. Accordingly, the pace of fundamental change in the field of travel forecasting has been very slow.

RECOMMENDATIONS

It is imperative that policy makers have the ability to make informed decisions about future investments and public policies for the transportation system. On the basis of the findings presented in this report, the committee concludes that current models and modeling practice are not adequate for many of the tasks to which they are being applied. **The committee therefore recommends development and implementation of new modeling approaches to demand forecasting that are better suited to providing reliable information for such applications as multimodal investment analyses, operational analyses, environmental assessments, evaluations of a wide range of policy alternatives, toll-facility revenue forecasts, and freight forecasts, and to meeting federal and state regulatory requirements.** The committee acknowledges evidence that current practice is also deficient in many respects and that introducing advanced models will not in itself improve that practice. **Therefore, steps must be taken to improve both current and future practice in metropolitan travel forecasting.**

The committee believes that the key to change and growth in these areas rests with the government agencies whose programs would benefit from accurate, reliable travel forecasts—MPOs, states, and the federal government. Each level of government has unique responsibilities and opportunities to assist in the needed transition to more advanced models and practice. Therefore, the policy recommendations that follow are organized by the level of government responsible for their implementation. Advanced models are not needed for all applications and may take some time to adopt where they are most needed. It is also imperative, therefore, to improve existing models and their use. The following suggestions and recommendations are based on the committee's judgment about how the fundamental recommendation made above can be accomplished.

Metropolitan Planning Organizations

The committee believes that MPOs would benefit from establishing a national metropolitan cooperative research program. Because models

must suit local needs and contexts, it is important for MPOs to take a leadership role in their development, testing, verification, and application. Large costs are involved in both improving current and developing more advanced models. Rather than having these costs duplicated at each MPO, it would be beneficial to pool resources for such activities as enhancement of existing models, development of new models, implementation procedures, and staff training programs. Pooling of roughly $4 million to $5 million annually would allow MPOs to organize and conduct such a program. This fund could be created through the state transportation agencies that receive federal funds for MPOs or directly by the federal government. Another approach would be for MPOs with common needs to join in research and development studies of mutual interest. Regardless of the specific operating mechanism, pooling of research and development funds would be an efficient means of meeting MPO needs for model enhancement, development, and implementation. Under such an arrangement, the MPOs would be in direct charge of a substantial, ongoing fund that could be used for their own model research and development needs or for other research purposes as determined by the MPOs themselves.

MPOs should conduct formal peer reviews of their modeling practice. Independent peer review of modeling practice is essential given the complexity of the modeling enterprise and the need to assure stakeholders of the quality of travel forecasts. Such reviews have been an ongoing activity for many MPOs on an ad hoc basis, funded by TMIP.

Individual MPOs and universities could form partnerships to foster research on travel modeling and the implementation of advanced modeling practice. Universities and MPOs in California, Florida, and Texas have demonstrated the benefits of such partnerships for advancing the state of practice of metropolitan travel forecasting.

MPOs and other planning agencies should conduct reasonableness checks of demand and cost forecasts for major projects. This can be accomplished by comparing forecasts with similar operational projects. Another possible reasonableness test is the use of differing model inputs and assumptions to determine whether the changes in modeled results are realistic. The FTA Summit tool can also be employed for model checking.

MPOs experimenting with or fully implementing advanced modeling practices should document their experiences, including costs, advantages, drawbacks, and any transferable data or model components. Given the pressure on MPOs for timely completion of their work programs, this

recommendation is most likely to be fulfilled if supported by the MPO research program or federal assistance.

State Transportation Agencies

States play a particularly important role in supporting smaller MPOs but should also be collaborating with larger MPOs within their borders. This collaboration could be accomplished through the following means:

• **Support for the development of the national MPO cooperative research program described above and other research related to MPO needs.** States could be partners in and beneficiaries of such a program. They could be active partners in garnering a small takedown of federal MPO funds and could provide supplemental support, perhaps through the National Cooperative Highway Research Program of the state departments of transportation.

• **Support for model user groups.** Such groups could provide a means for training, discussion of common issues, and purchase of modeling software for statewide use.

• **Evaluation, in cooperation with MPOs, of socioeconomic forecasts used for MPO modeling and forecasting.** A large amount of potential transportation forecasting error is associated with socioeconomic forecasts, including those for households, employment, and population.

• **Coordination with MPOs on statewide and metropolitan models and data needs.**

Federal Government

There is a historic precedent for a strong federal role in providing leadership and resources for the development and implementation of travel models and associated training. The need for this role is underscored by the considerable federal requirements that guide MPO planning activities. It is also in the federal interest to ensure that federal funds are being used to support the highest-priority needs for maintenance and improvement of the national transportation system. **The committee recommends that the U.S. Department of Transportation (USDOT), the Federal Highway**

Administration (FHWA), and FTA take the steps outlined below to assist in the needed improvements in practice.

Support and provide funding for incremental improvements to existing four-step (or three-step) trip-based models in settings appropriate for their use. This support would ensure that these models are adequate for the planning applications of many MPOs, that they can continue to be used as new planning needs arise, and that staff have the training necessary to use them.

Support and provide funding for the continued development, demonstration, and implementation of advanced modeling approaches, including activity-based models. MPOs with more challenging planning applications need resources and encouragement to implement advanced models. MPOs also require assistance in using case studies to document their experiences with new modeling approaches.

Continue to rely on TMIP as an appropriate mechanism for advancing the above recommendations, with funding necessary to support the program. To date, TMIP has supported a number of highly useful national activities to advance the state of practice in travel modeling. New funds would be used to help build MPO institutional capacity; develop and improve analytical methods derived from federal requirements; and support mechanisms designed to ensure the quality of technical analyses used to inform decision making and meet local, state, and federal program requirements. TMIP could also support MPO peer reviews, outreach activities, a handbook of practice (see below), training and capacity building, and state model users groups.

Continue support for the implementation of activity-based modeling and other advanced practices; considerably expand this support through deployment efforts in multiple urban areas. TMIP's TRANSIMS initiative has focused attention on the potential for activity-based modeling and travel simulation, and in particular has provided an essential component of these methods—the population synthesizer.

Increase funding to appropriate levels to support the federal government's role as a partner with MPOs and state transportation agencies. An annual investment in model development of 0.05 percent of the highway and transit capital program would amount to $20 million, comparable, in constant dollars, with the amounts spent 30 years ago. The committee recognizes that congressional authorization and additional funding would be required to support this level of assistance and encourages USDOT to seek such authorization and Congress to provide it.

Continue the federal MPO certification process, with a model checklist to provide MPOs with useful information on minimum expectations for their models. In addition, examination of the conduct and results of peer reviews (see the MPO recommendation on conducting such reviews) should be incorporated into the certification process. The resulting information could be the basis for an ongoing national compendium of the state of practice, thus continuing the work of the present study.

The committee recommends that in their planning guidance and planning regulations, USDOT, FHWA, FTA, and the U.S. Environmental Protection Agency allow MPOs substantial flexibility in their travel demand modeling practices, recognizing that one size does not fit all, and that unnecessary technical planning requirements could inhibit innovation and advanced practice.

Intergovernmental Cooperation

A large degree of intergovernmental cooperation is inherent in the metropolitan planning and travel forecasting process. The recommendations presented above recognize overlapping responsibilities of MPOs and the state and federal governments in such areas as research, implementation of improved travel models, staff training, data collection, and funding.

MPOs, state transportation agencies, and federal agencies should work cooperatively to establish appropriate goals, responsibilities, and means of improving travel forecasting practice. This cooperation could be accomplished through a steering committee of principal representatives from each of these levels of government that would meet regularly to set goals and an agenda for joint activities aimed at improving travel models and modeling practice.

A national travel forecasting handbook should be developed and kept current to provide salient information to those practicing travel demand forecasting. The current institutional environment for metropolitan travel forecasting is highly decentralized. Although the federal government establishes requirements for what must be accomplished through the metropolitan planning process, there is little guidance on the technical processes necessary to meet these requirements. No single source of information describes current or evolving practices for travel modeling and forecasting. The proposed handbook would fill this void by describing alternative best prac-

tices for addressing different travel markets and metropolitan needs, recognizing that differing approaches are needed according to the metropolitan context. It should also include extensive information on various ways to conduct quality control and model validation. Such a handbook would be an informational and evolving document, without prescriptive or regulatory implications.

Implementation of the handbook might be achieved through a national organization that brings together practitioners and researchers from agencies, consulting firms, and academia; the primary stakeholders would be those responsible for conducting metropolitan travel forecasting. Resources to support this effort might be derived from the proposed metropolitan cooperative research program, the National Cooperative Highway Research Program, the Transit Cooperative Research Program, and the federal government.

Studies should be performed to compare the performance of conventional and advanced models. Questions persist about the efficacy of advanced modeling practices and about whether they can provide improvements sufficient to warrant the time and expense associated with their development. This issue should be resolved through comparative studies using such techniques as time series, backcasting, and sensitivity analyses to evaluate the capability of conventional and advanced models to analyze simple and complex scenarios and to forecast future travel. The ability of advanced models to handle complex planning issues beyond the scope of current models should be evaluated as well.

MPOs, together with the federal government and the states, should examine in detail data requirements for validating current travel forecasting models, meeting regulatory requirements, and developing freight models and advanced travel models. This may include updating travel surveys, collecting information on freight flows, expanding traffic counts, and measuring traffic speeds. On the basis of these requirements, data collection needs should be documented, and strategies and sources of funding for the collection of such data should be identified.