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Moving Travel Models to the Next Level

Gregory D. Erhardt, *Parsons Brinckerhoff*
Rolf Moeckel, *Parsons Brinckerhoff*
Jon Williams, *Transportation Research Board*

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Gregory D. Erhardt
Parsons Brinckerhoff
San Francisco, CA
Phone (415) 307 6974
erhardt@pbworld.com

Rolf Moeckel
Parsons Brinckerhoff
New York, NY
Phone (212) 465 5630
moeckel@pbworld.com

Jon Williams
Transportation Research Board
Washington, DC
Phone (202) 334 3245
jwilliams@nas.edu

1. Introduction

At the beginning of the 21st century, a growing number of agencies across the U.S. are abandoning established traditional modeling techniques to explore advanced practices in travel forecasting. This paper summarizes (1) The benefits reported by agencies implementing advanced models, (2) Implementation and institutional issues that may become a barrier to change, and (3) Lessons learned from those agencies that did explore advanced modeling practices. The work builds on research conducted for a National Cooperative Highway Research Program (NCHRP) Synthesis of Practice.

Findings are mainly based on interviews with agencies that work with advanced travel models. A total of 23 agencies were interviewed for this study (Figure 1). Though a questionnaire was provided, the interviews were narrative in format to account for the various stages from early consideration to full implementation of advanced models in different agencies. Literature reviews and practical experience of one decade of advanced travel forecasting completed the research.

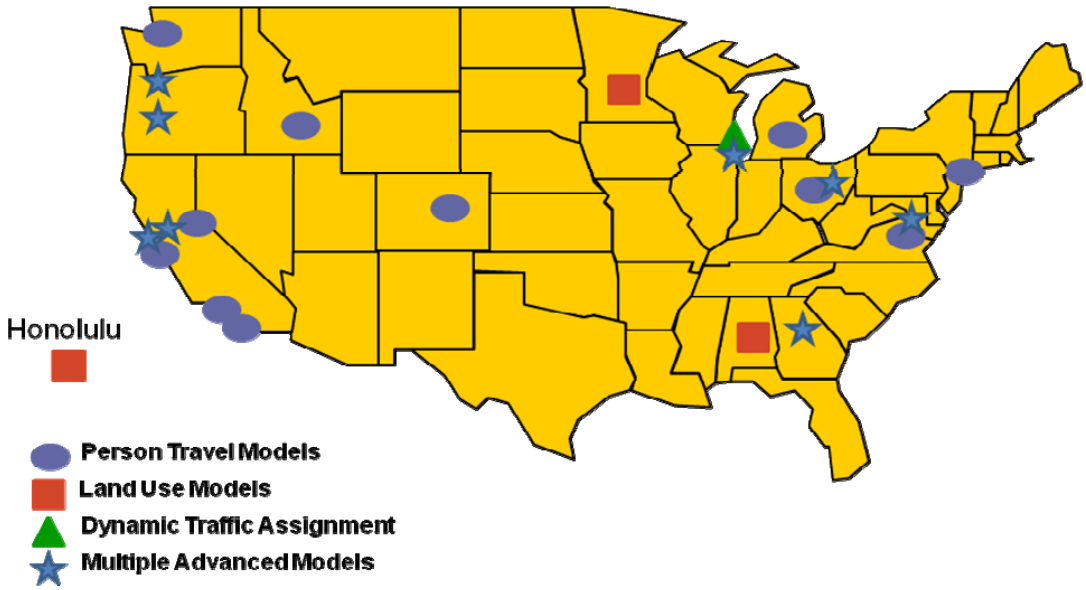

Figure 1: Location of agencies that were interviewed for this study

This paper defines advanced transportation modeling as practices that go beyond the traditional four-step travel demand modeling approach. Specifically, this includes five areas of modeling: tour- and activity-based models, land use models, freight and commercial movement models, statewide models, and dynamic network models. Today, with the possible exception of dynamic network models, all types of advanced modeling have been deployed successfully to analyze policy questions that could not have been properly analyzed with traditional four-step models.

2. Benefits of advanced practices in travel modeling

Once advanced models are applied and implementation obstacles have been circumnavigated, most agencies reported significant benefits in application from having moved towards advanced modeling practices. A frequently mentioned example is the elimination of non-home-based trips in tour- and activity-based models. Agencies found value in the ability to relate all trips back to individual persons or households, for such applications as environmental justice analysis and allocating greenhouse gas emissions back to emitters.

Activity-based models have proven to be successful in evaluating peak spreading and congestion pricing. By splitting time of day into finer temporal units than traditional models commonly do, and considering the context of the trips, time-of-day analysis is more complete. The ability to implement distributed values-of-time was found to be a major advantage in modeling congestion pricing scenarios (Erhardt et al. 2008; Sall et al. 2009). Another important advantage of microscopic modeling approaches is that the model design allows for the model to be more easily extended in the future (Vovsha et al. 2002). Because of the disaggregate nature of these models, it is actually quite easy to add a new descriptive variable to the model system. In an activity-based model, it is as simple as adding a column to a table, whereas in a trip-based model, it involves further segmentation of trip matrices, which can quickly become unwieldy. Further, the ability to simulate individual travelers greatly enhances the types of policies that can be tested.

Dynamic network models are developed to keep track of single vehicles on the network and, therefore, define speeds and congestion with much higher precision than traditional assignments. This allows for identifying bottlenecks in the network, as well as a much more precise estimation of traffic emissions (Mahmassani et al. 1993; Van Aerde & Yagar 1988; Hicks 2008).

Land use models are implemented for two reasons. First, they allow testing land use policies, such as an urban growth boundary or transit-oriented development. Second, land use models that are integrated with travel models allow simulating the interaction between land use and transportation (Wegener 2004, p. 130). This interaction includes the effect that a new highway may trigger land use changes as well as that new land use development may worsen congestion.

Freight and commercial movement models are implemented to account for a growing share of traffic congestion (Kuzmyak 2008). Freight and commercial vehicles react quite differently on many transportation policies. Depending on the goods transported or the

services provided, these trips may be much more sensitive to changes in travel time or tolls and, therefore, deserve attention.

Statewide models are implemented to analyze policies and travel at the regional level (Horowitz & Farmer, undated). While an additional highway may relieve congestion locally, it may alter long-distance trip routing significantly. Regional models that ideally are integrated with local travel models reveal the impact of policies on the big picture beyond the often artificial boundaries of a city or a MPO. This may be particularly helpful for analysis of freight movements.

The majority of agencies that did decide to move towards advanced travel models were motivated by asking policy questions that go beyond simple traffic analysis. In a policy context where the questions asked are more complicated than “how many lanes?,” the development of advanced models turned out to be more likely, as there was more support by decision-makers to build models beyond the four-step travel model.

3. Obstacles to implement advanced models

While the advantages of advanced travel models may be clear, for many agencies there have been implementation and institutional obstacles to be overcome. This is not surprising as major change often calls for taking risks and addressing difficulties with new approaches. It is worth noting that pioneers in advanced modeling mostly perceived changes to be gradual, whereas those recently starting to work with this kind of modeling tend to experience changes to be more rapid.

Several practitioners noted the perceived complexity of advanced modeling techniques as an important obstacle. They explained that the increase in complexity lays in the structure of the model, data requirements, and the computational burden. However, it was pointed out that explaining an advanced modeling approach to decision-makers and the public may in fact be easier, as simulated behavior commonly is closer to reality and requires less abstract thinking than aggregate traditional approaches.

Model calibration of advanced models becomes more challenging, as with more simulated detail more model output variables need to be analyzed. Accepted standards on how to validate these advanced models remain the same as with traditional models. It is a reasonable expectation that advanced models should validate at least as well as traditional four-step models.

Being in an early stage of development, very few advanced models have been transferred from one location to another. Commonly, the development costs are a significant issue with the development of custom software contributing significantly to the cost. Currently, Atlanta (ARC) and San Francisco Bay Area (MTC) are jointly developing an activity-based model and sharing the software development costs. Most activity-based models and land use models are based on open-source code that is assembled to fulfill the particular agency's needs. Most dynamic network models, in contrast, are supported by commercial vendors.

In the search for ever more detailed models, the hardware requirements are significantly larger for most advanced travel models. Even with clusters that consist of several computers, run times may become a problem. Many agencies said that overnight runs are the upper limit to reasonably make use of a transportation model, and the most successful models in application are able to achieve an overnight run, even with very sophisticated model forms.

Data requirements are not a more complex issue for activity-based models than for traditional four-step models. Required travel surveys commonly look alike, regardless of how advanced the person travel model is. Land use models, obviously, require additional data for every zone, though many of these data are generally available with a reasonable effort. For freight modeling and dynamic network models, however, lack of data may be a serious obstacle to calibrate and fully validate the model.

The majority of advanced models took more time to develop than anticipated. It was noted, however, that the same is true for virtually every model development project since the dawn of time. Meeting the schedule was revealed as a bigger obstacle than finding the necessary funding. In most cases, funding was provided by the MPO or the state DOT. The lack of funding for education and training was identified as a serious difficulty. Developing a model in phases with well-defined milestones turned out to be important.

The most frequently mentioned issue by the interviewed agencies was the lack of sufficiently trained staff. Several of those agencies that do have the right staff said that those persons have to cover a wide range of tasks, leaving them too little time to focus on model development and application. If a consultant delivers a model, it was emphasized several times that it is crucial to go through an extensive training session before the model is handed over to the agency.

4. Lessons Learned

The final question in every interview asked agencies working with advanced models what they would do differently if they had the chance to do it all over again. This led to interesting lessons learned that may help agencies considering adoption of advanced modeling practices. The interviewees made very clear that the right model has to be chosen based on the needs of that agency. Planning departments that mostly care for highway volumes at an aggregate level don't need to depart from traditional four-step models. However, in most agencies that decided to move towards more advanced modeling techniques, decision-makers quickly caught up with asking more advanced policy questions. Most commonly, however, the rise of new policy questions triggered the development of more advanced models.

A large number of agencies pointed out that a long-range modeling development plan was invaluably helpful to convince management to implement advanced transportation models. Such a plan was used to educate staff and decision-makers as well as to ensure funding. The written document could be referred to for justification of the ongoing effort and to remind executives of the modeling vision they had agreed on. All successful advanced modeling projects have been guided by such a long-range plan.

A champion who is leading the modeling effort was present in most agencies that have moved towards advanced transportation modeling. This champion was not necessarily the technical leader of the modeling team, but often someone who was closer to decision-makers and was able to translate policy needs into modeling concepts. Having the support of mentors or key executives strengthened the role of the champion. In a few cases, the role of the champion was taken over by a consultant, convincing agencies to implement advanced modeling approaches. The cases with an in-house champion tended to be more successful in the long term, as the model was used in application after the initial development project was completed and the consultant contract finished.

The staff education and qualification was mentioned in many interviews, as technical skills alone are not sufficient to move to advanced transportation modeling. Staff being equally interested in model development and model application appears to be rare. No satisfying solution was found for this important topic, other than the necessity of a continuous education and training of staff members.

Repeatedly, interviewed agencies brought up the issue of how much work should be outsourced and how much work should be accomplished in-house. For some tasks it appeared to be more efficient to outsource the work, as highly specialized training of staff members could be applied only once. In other cases, however, outsourcing meant reducing the possibilities of staff members to developing further competence in advanced modeling, making the agency more dependent on external support.

The most successful models analyzed in this report followed the Agile Development paradigm, which proposes to start with the simplest model possible and improve detail over time. This approach proved to be much more successful than starting with the big design up front that tries to build large complex models in one step.

Overall, this research showed that there is a large number of planning agencies that have implemented or are eager to implement advanced transportation modeling approaches. While not every advanced methodology is the right fit for every agency, the planning problems at hand as well as those expected in the near future should guide the selection of the appropriate modeling approach. It has been enlightening to see how many agencies are making great contributions in answering challenging policy questions with advanced travel modeling.

The full report is scheduled to be published in early 2010 as NCHRP 20-05 Task 40-06: Advanced Practice in Travel Modeling.

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willing to share their experiences in the interviews. These agencies are listed below, sorted by the topics covered in the interviews. The work was funded by the Transportation Research Board and Parsons Brinckerhoff.

Person Travel Models
Boise (MPO for northern Ada County and Canyon County)
Chicago Metro Agency for Planning
Denver Regional Council of Governments
Federal Transit Administration
Metropolitan Washington Council of Governments
Michigan DOT
Mid-Ohio Regional Planning Commission
New York Metropolitan Transportation Council
Ohio DOT
Oregon DOT
Portland Metro
Puget Sound Regional Council
Sacramento Area Council of Governments
San Diego Association of Governments
San Francisco Bay Area Metropolitan Transportation Commission
San Francisco County Transportation Authority
Southern California Association of Governments

Land Use Models
Metropolitan Council Twin Cities
Montgomery County (Alabama) MPO
Ohio DOT
Oregon DOT
San Diego Association of Governments
San Francisco County Transportation Authority
Sacramento Area Council of Governments

Freight
Ohio DOT
Oregon DOT
Portland Metro

Dynamic Traffic Assignment Models
Chicago Metro Agency for Planning
Northwestern University

TRANSIMS
Federal Highway Administration
Portland Metro
Sacramento Area Council of Governments

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