Australasian Transport Research Forum 2010 Proceedings
29 September – 1 October 2010, Canberra, Australia
Publication website: http://www.patrec.org/atrf.aspx

Migrating to advanced travel models: lessons learnt to date

Rick Donnelly[1], William A. Davidson[2]

[1]Parsons Brinckerhoff, Inc., 6100 Uptown Boulevard, N.E., Albuquerque, NM 87110 USA

[2]Parsons Brinckerhoff, Inc., 303 Second Street, Suite 700, San Francisco, CA 94107 USA

Email for correspondence: donnellyr@pbworld.com

Abstract

Considerable progress has been made in the development and deployment of innovative new transport planning models, particularly in activity-based travel demand and dynamic network modelling. The underlying theoretical aspects of such models are well documented in the literature. However, the practical lessons learnt to date by the pioneers in these areas and the obstacles they have overcome are not well known. The authors conducted a study in 2009 for the National Cooperative Highway Research Program in the USA to identify the major themes and key experiences to date in this area. This paper describes the principal findings from the study. The major benefits derived from such models are described in the words of their developers and users. The majority of the paper is devoted to describing implementation and institutional themes, such as data, cost and scheduling, and methodological issues. The latter include topics such as transferability and portability, software and hardware issues, and challenges in model estimation and validation. The institutional issues include the motivation for moving to advanced models, partnerships with other agencies, training and education, and peer review. The paper concludes with the identification of key remaining issues facing agencies moving towards advanced models.

1. Introduction

At the beginning of the 21st century, clear indications of a paradigm shift in transportation modelling are apparent. A growing number of agencies across the U.S. are abandoning established traditional modelling techniques and exploring advanced practices in travel forecasting (Transportation Research Board, 2007). Research was undertaken by the authors for the National Cooperative Highway Research Program in the USA to evaluate the benefits advanced models might offer, summarize the implementation and institutional issues that form barriers to change, and distil lessons learnt from those agencies that have invested in advanced modelling practices. The findings were based on narrative interviews with agencies that have pioneered these models, literature reviews, and practical experience gained by leaders in the field of advanced travel forecasting.

Advanced transportation modelling is defined as those practices that go beyond the traditional four-step travel demand modelling approach. Specifically, this includes five areas of modelling:

- Tour- and activity-based (AB) person travel models,
- Land use models (especially those formally integrated with transportation models),
- Freight and commercial movement models,
- State-wide models, and
- Dynamic network models.

All of these advanced models, with the possible exception of dynamic network models, were found to have been successfully used to address policy and investments options at urban and state-wide levels. Several of these analyses simply could not have been credibly evaluated with traditional four-step models.

This paper summarizes the key benefits expected or obtained, obstacles overcame, and major lessons learnt by the pioneers in advanced travel modelling. The full results of the research are described in Donnelly et al. (2010).

2. Benefits of advanced models

Once advanced models were applied and implementation obstacles surmounted, most agencies reported significant benefits from using them. A frequently mentioned example was the elimination of non-home-based trips in tour- and activity-based person travel demand models. This trip purpose is the most uncertain one in traditional models, as neither origin nor destination is at the home, and therefore no household structure or socio-economic data can be associated with or used to constrain these trips. In tour-based models, a person may make several trips throughout a day, and their home location, work location, income and modal availability are known for every trip simulated. Each trip can be attributed to single persons or households, which allows analysing, for example, vehicle-kilometres of travel generated by different neighbourhoods or the impact of a toll road on low- and high-income households.

Tour- and activity-based person travel models also allow the splitting of time into much finer temporal units than traditional models. The latter commonly differentiate at most four periods of the day. If the effects of congestion pricing are to be analysed, tour- and activity-based travel models permit the tracking of how far different household types are willing to deviate from their preferred travel time to reduce or avoid a toll. These models further explicitly consider household interactions, such that if in a one-car household someone uses the car for a work trip, other household members cannot use it for a different trip at the same time.

Many advanced models, and in particular the person travel models, are implemented in a microsimulation framework. One important advantage of such an approach is its flexibility, in that the structure and internal relationships can usually be far more easily changed than in purely mathematical models. For example, an agency might wish to test the impact of only allowing vehicles with license plates ending with odd or even digits within a congested area. The microscopic model simply extends the characteristics of vehicles by including license plate numbers, and is then ready to simulate such a policy.

Dynamic networks models are developed to keep track of single or small groups of vehicles on the network, and therefore define speeds and congestion with much higher accuracy and precision than traditional static assignments are capable of. This allows identifying bottlenecks in the network, as well as a much more precise estimation of traffic emissions. Such models considered in this research include dynamic traffic assignment (DTA) carried out at the metropolitan level, as well as large scale traffic simulations such as TRANSIMS. It was clear from the interviews that several agencies viewed linking tour- or activity-based travel models with DTA as the next logical step in the evolution of advanced models.

Land use models are implemented for two reasons. On the one hand, they allow the testing of land use policies, such as an urban growth boundary or transit-oriented development. On the other hand, they can be integrated with travel models to simulating the interaction between them. This interaction includes the effect that a new highway may trigger in land use patterns as well as new land use development that may worsen congestion. A number of integrated land use-transportation models have been developed over the past decade, with UrbanSim, PECAS, and TRANUS being the most widely used in North America.

Freight and commercial movement models are implemented to account for their growing share of traffic congestion. However, many users were interested in far more than just their impact on traffic flows. The importance of freight mobility as a driver of economic competitiveness and market accessibility were mentioned often. Most agencies were also interested in the emerging importance and role of distribution centres and the structure of truck tours. Freight and commercial vehicles react quite differently to many transportation policies and network conditions. Depending on the commodities transported or the service provided, these trips may be much more sensitive to changes in travel time or tolls and person travel. Such cases require models that are appropriately sensitive to such dynamics. Unfortunately, while disappointment with freight models constructed as analogues of person travel models was often cited few success stories of advanced models emerged. Tour-based freight models from Oregon and Alberta (Canada) appear to be the only operational models of their type in North America, although efforts by other researchers are underway.

State-wide models are implemented to analyse policies at the regional level. While an additional highway may relieve congestion locally, it may alter long distance trip routing significantly. Regional models, which in an ideal world are integrated with local travel models, reveal the impact of policies on the big picture beyond the often artificial boundaries of a city or metropolitan planning organization. From a methodological standpoint most of the state-wide models reviewed were neither innovative nor advanced. Rather, they were interesting within the context of this research because some states have moved to using advanced techniques in such models or are moving there now, while others are focusing their attention on improving the integration between urban and state-wide models. Three quarters of U.S. states employ state-wide models, although most are extensions of the traditional three- or four-step modelling paradigm.

The majority of agencies that decided to move towards advanced travel models were motivated by the need to address policy issues that go beyond simple traffic analyses. In fact, most did not cite traffic capacity or congestion issues as their principal motivation for moving to advanced models. In a policy context where the questions asked are more complicated than “how many lanes?” users of advanced models reported a number of reasons for migrating to them. Their clients were interested in cost-benefit and equity analyses, the relationship between transport and the economy, the effect of pricing and tolling strategies on travel behaviour and choices, and environmental impacts of transport demand. The ability to be able to usefully inform decision-making about these wider aspects of transport, and thereby build support and funding for modelling programmes, was frequently mentioned as key benefit of advanced models.

3. Obstacles to adopting advanced models

As clear as the advantages of advanced travel models were for many agencies, implementation and institutional issues hindered their adoption in many cases. This is hardly surprising, as most paradigm shifts call for taking risks and overcoming difficulties with new approaches. It was interesting to note that the pioneers in advanced modelling mostly perceived changes associated with the paradigm shift to be gradual. By contrast, those contemplating the transition to advanced models or who have begun more recently tended to view such changes as more radical and revolutionary.

Several practitioners noted the perceived complexity of advanced modelling techniques as a significant barrier to their adoption. They explained that the increased complexity pervaded all aspects of advanced models, to include their structure, data requirements, and computational burden. However, it was pointed out that explaining an advanced modelling approach to decision-makers and the public may in fact be easier, as simulated behaviour is closer to reality and requires less abstract thinking than aggregate traditional approaches. Further, the complexity is often necessary for policy analysis, such as in having a time-of-day model in an advanced model that addresses peak spreading when peak period pricing is introduced, versus a traditional model with fixed time-of-day factors that are arguably simpler but cannot answer the policy question.

Model calibration becomes more challenging, as more simulated detail equates to more output variables that need to be analysed. Appropriate methods and criteria for calibrating and validating advanced models have not coalesced, and many aspects of their performance remain open questions. That said, it is reasonable to expect advanced person travel models to validate at least as well as traditional four-step models. The case for other types of advanced models (e.g., dynamic network models, land use models) is less clear, as there has not been as extensive experience with them. The pioneers in those realms are still discovering the limits of such models and reasonable acceptance criteria.

Being in an early stage of development, very few advanced models have been transferred from one location to another. The development costs are a significant issue, as no commercial standard software for advanced person travel models exists. Currently, Atlanta (ARC) and San Francisco (MTC) are jointly developing an activity-based model and sharing the software development costs. Most activity-based and land use models developed to date have been based on open source code that is further customized to fulfil the particular agency's needs. The case is somewhat better for dynamic network and land use models, as several packages are readily accessible. Some have been developed by academics, while others are maintained by consultants or software vendors. No advanced freight modelling software is widely available, although tour-based models from Oregon and Alberta have been adapted in other locales.

The hardware requirements are significantly greater for most advanced travel models than for traditional models. Even with clusters that consist of several computers, long run times remain a significant issue. Many agencies defined overnight runs (up to 16 hours) as the upper limit for reasonably making use of an advanced model for policy advice.

Data requirements are typically not more onerous for activity-based models than for traditional four-step models. The methods required for travel surveys are quite similar, although larger sample sizes might be required if highly detailed travel markets will be analysed (as is also the case for traditional models). Land use models obviously require additional zonal and regional data, although many of them are generally available with a reasonable level of effort. For freight modelling and dynamic network models, however, lack of data is a serious impediment to their wider development, validation, and application.

The majority of advanced models took more time to develop than anticipated. It was noted, however, that this undesirable outcome is hardly unique to the advanced models considered in this research. Meeting the schedule was revealed as a bigger obstacle than finding the necessary funding. In most cases, funding was provided by the metropolitan planning organization or the state department of transportation. While funds were generally available for model development, the same was often not true for education and training. Developing a model in phases, with well-defined milestones, has emerged as one effective method for reducing the risk of schedule delays or financial losses on such projects.

Another frequently mentioned issue by those interviewed was the lack of sufficiently trained staff. Several of the agencies fortunate enough to have appropriate staff noted that they have to cover a wide range of assignments, often leaving them too little time to focus on model development and application. If a consultant delivers a model, the importance of extensive training throughout the life of the development work was emphasized several times by agencies interviewed during this study.

4. Lessons learnt

Every interview ended by asking the respondent(s) what would do differently if they had the chance to do it all over again. This provided very interesting insights that are important for the profession at large to learn from. The respondents made it very clear that the model must be designed to meet the unique needs of their agency. Planning departments that only report roadway volumes and levels of service at an aggregate level might not need to depart from traditional four-step models. However, in cases where complex policy and investment questions that transcend just transportation are being asked the value of advanced models was readily apparent. The changing policy environment and current policy issues, most of them unanticipated when traditional models were developed, are pushing the development of advanced models forward.

A large number of agencies pointed out that a multi-year travel model development plan was invaluable for justifying an investment in advanced transportation models. Such a plan was used to educate staff and decision-makers as well as to justify funding. The written document guided the ongoing effort, reminded executives of the agreed upon modelling vision, and established milestones and criteria for success. All successful advanced modelling projects reviewed in this research were guided by such a long-range plan.

A champion leading the modelling effort was identified as the key ingredient for success in those agencies that have moved towards advanced modelling. This champion was not necessarily the technical leader of the modelling team, but often someone who was closer to decision-makers and able to translate policy needs into modelling concepts. Having the support of upper-level mentors or key executives strengthened the role of the champion. In a few cases, the role of the champion was fulfilled by a consultant. However, those agencies 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 complete and the consultant contract finished.

The critical importance of staff education and professional development was mentioned in many interviews, as technical skills alone were not sufficient to ensure success. Model developers being equally interested in using them in studies and application appears to be rare. In most cases, the software development had to be outsourced, limiting the ability to later make adjustments to the model with internal resources. No universally satisfying solution was found, underscoring the necessity of continuous education and training of staff members.

Some of the most successful models analysed in this report followed the Agile Development paradigm, which employs a large number of small evolutionary steps that each result in a working model that approaches the full desired capability over time. Agile developers start with “the simplest thing that can possibly work.” Complexity and sophistication is added over time, with testing and client reviews concluding each sprint of development. Such sprints typically last from four to eight weeks. This approach proved to be more successful than starting with the “big design up front” that tries to build large complex models in one step.

Repeatedly, interviewed agencies brought up the discussion of how much work should be outsourced versus completed in-house. For some tasks it appeared to be more efficient to outsource the work, as special training of staff members would be required that for that specific task, and with little transferability to others. Such skills are rapidly degraded if not kept current through regular use. In other cases, however, outsourcing reduced the possibilities for agency staff member to further develop their own competence in advanced modelling, making the agency more dependent on external support.

Overall, the study identified a large number of planning agencies that have implemented or wish to implement advanced transportation models. While not every detailed 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 approach. It was encouraging to see how many agencies are making great contributions in answering challenging policy questions using advanced travel modelling that has been unable to do so before their adoption.

5. Conclusions

Several important themes were identified throughout the research. The most significant is that the motivation and need for advanced models tends to follow the nature of the planning issues faced by the agency. Those agencies focused largely on expanding the capacity of the existing transportation system tend to employ modellers in search of the greatest accuracy possible. Evidence could not be found at this time to demonstrate that advanced models are inherently more accurate or better capable of replicating observed traffic flows than their predecessors. Those agencies prioritizing these issues will likely find advanced models of limited appeal.

The users and proponents of advanced models, by contrast, reported that the benefits of advanced models were not in the incremental refinement of existing capabilities, but in their ability to answer a range of questions that could not even be asked of traditional models. Advanced models also provided a wider range of performance measures than could be obtained from traditional models. Agencies dealing with issues of system management, smart growth, pricing, and equity often found themselves compelled to develop advanced models so they could respond to these issues in a timely and credible manner.

While numerous obstacles were overcome along the way, and even more so with subsequent implementations, it is fair to say that tour and activity-based models are a proven technology that can succeed if supported by capable staff with adequate resources. Land use models have been successfully for policy analyses. Freight and commercial models and dynamic network models are a few steps behind, and do not yet enjoy the same track record of success. They do, however, hold significant promise for those willing to push the practice forward. Agencies deploying many of these advanced models in parallel stand to gain even more benefits because of the synergies involved. The evidence is clear that such models are viable and practical tools for meeting current analytical needs, and are becoming the norm for all but basic analyses of the transportation system.

References

Donnelly, R, Erhardt, G., Moeckel, R. and Davidson, W. 2010, *Advanced Practices in Travel* Forecasting, NCHRP Synthesis 406, Transportation Research Board, Washington, D.C.

Transportation Research Board 2007, *Metropolitan Travel Forecasting: Current Practice and Future Direction*, Special Report 288, Washington, D.C.