

## **VALIDATION AND ASSESSMENT OF ACTIVITY-BASED TRAVEL DEMAND MODELING SYSTEMS**

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### **Introduction**

The past decade has seen the rapid development of activity- and tour-based travel demand modeling systems. Several MPO's in the United States and metro areas in Europe have implemented such model systems to take advantage of their explicit recognition of the derived nature of travel demand and inter-dependencies among trips. Despite the theoretically and behaviorally appealing basis of activity- and tour-based travel demand models, their widespread adoption and implementation appears to be hindered by the absence of a detailed validation and assessment of this new wave of model systems. Many MPO's have expressed a strong need for a detailed validation and assessment of activity-based model systems before they would consider adopting them in their respective regions. These sentiments were expressed 10 years ago in New Orleans at the TMIP Conference on Activity-Based Travel Modeling and more recently in various e-mail forums such as the TMIP Listserv. The planned conference in Austin offers an ideal opportunity to bring model developers and MPO staff together to discuss the methods and basis for validating and assessing activity-based models.

### **Validation of Activity-Based Travel Demand Models**

Validation of travel demand models generally involves the refinement and adjustment of model components and parameters to ensure that predictions replicate a variety of base-year travel conditions and statistics within an acceptable margin of error. There are numerous measures against which model predictions are often compared; these include aggregate measures of travel such as vehicle miles of travel (VMT), vehicle hours of travel (VHT), mode split (by purpose), trip length distributions (by purpose), and total trips and trip rates (by purpose). These measures may be compared across the entire study/model area and for specific planning districts or market areas. In addition, model predicted volumes are often compared against observed ground counts for major corridors (such as interstate highways and bridges) and across screenlines and cutlines. Thus, in general, the traditional notion of model validation has centered around the replication of observed base-year travel conditions within a certain margin of acceptable error. Existing four-step models that are in use to develop long-range transportation plans (LRTPs) and undertake major investment studies have been subjected to such validation procedures to replicate base year travel conditions.

Activity-based travel demand models, like trip-based models, could (and may have to be) refined and adjusted so that they replicate base-year travel conditions. Unless activity-based travel demand models replicate base-year travel conditions, at least to the extent that existing four-step models do, it is unlikely that MPO's will be motivated to make the transition to innovative model systems. Areas that have transitioned to tour-based or similar model systems have indeed subjected their models to validation procedures to ensure that the model predictions replicate a host of base year travel conditions.

If it is accepted that activity-based travel demand models should be validated to base year travel conditions (similar to existing four-step models), then two questions arise:

1. Should activity-based travel demand models be held to a higher standard of validation?
2. Should activity-based travel demand models be able to replicate base year travel conditions with fewer adjustments/refinements (or none at all) when compared with existing four-step models?

There are no easy answers to these two questions. If MPO's would be motivated to transition to the new wave of model systems only if activity-based models are "better" than existing four-step travel models, then the more important question is: What constitutes a "better" model? If a "better" model is defined in terms of meeting a higher standard of validation with the same number of or fewer adjustments to model components/parameters, then it is likely that the answer is a "yes" to both questions posed above. Clearly, these two questions and the definition of a "better" model are open to debate and it is envisaged that this white paper and the presentation at the conference will help stir discussion among the conference participants. The debate concerning the validation of activity-based travel demand models also speaks to the merit of performing *comparisons to existing four-step models*. There is no doubt that any model, whether an existing four-step travel demand model or a newer tour- or activity-based model, can be adjusted, refined, tweaked, and – if all else fails – hammered to replicate base year conditions. Thus, simply performing comparisons of base year outputs from four-step travel models and activity-based travel models alone (relative to base year travel patterns) is not adequate. This, we believe is an important issue because the state of the practice appears to be focused on using replication of base year travel patterns as the sole or primary yardstick to assess the performance of models. On the other hand, the primary objective of travel model development is forecasting future travel patterns when conditions may be quite different from base year conditions or assessing travel pattern shifts after the implementation of a major change in transportation services or policies, not replicating base year patterns. Thus, the emphasis needs to be on capturing travel behavior patterns adequately from base year data, so that these behavioral patterns may be reasonably transferable in space and time.

The above discussion raises the issues of assessing the performance, usefulness, and robustness of alternative travel demand modeling systems in the contemporary and emerging planning context, without a simple naïve focus on replicating base year travel patterns. This issue is discussed next.

## **Assessment of Activity-Based Travel Demand Models**

As mentioned earlier, the question regarding what constitutes a “better” model is a very important question that is open to debate. It appears that there is a belief that the superiority of a model is best judged in terms of the validation to base year traffic conditions. However, given that any model can be potentially adjusted to replicate a given set of base year traffic conditions, such validation measures are *not always the most useful way to judge the quality of a travel demand model*.

The quality of a travel demand model system is potentially better judged based on an assessment of its ability to respond to a range of scenarios and policies of interest. It is in this context that a true assessment of model applicability can be performed and comparisons between existing four-step travel models and newer activity-based model systems become meaningful. Thus, assuming that there are two models – an existing four-step travel model and a newer activity-based travel model – that have been validated to a set of base year traffic measures, then here is how the performance/usefulness/applicability/robustness of the model systems can be assessed and compared:

### ***Changes in Land Use, Socio-Economic, and Demographic Characteristics***

Travel demand models should be responsive to changes in land use, socio-economic, and demographic characteristics, i.e., the inputs that play a key role in driving travel forecasts. Activity-based model systems should be subjected to a wide range of sensitivity tests where population and employment characteristics are altered, both across the region and in selected zones, land use subdivisions, or market areas. Typical characteristics that might be subjected to change include population and employment totals, household distributions by zone, income, car ownership, size, dwelling unit type, and number of children, employment distributions by zone and occupation/industry/type, and person distributions by age, employment status, and gender. All of these variables should be subjected to a range of changes including very small and very large changes.

### ***Changes in Multimodal Transport Network Characteristics***

Travel demand models should be responsive to changes to transport network characteristics. Changes to transport network characteristics directly impact modal level of service attributes such as distance, time, and cost. There are a variety of ways in which these changes can be introduced. First, attributes associated with existing modal facilities may be changed. Attributes such as highway network speeds and transit route frequencies may be altered. Second, new facilities may be introduced. New highway links, new transit routes, new transit stops, new bicycle and pedestrian facilities, and so on may be introduced into the system. One of the key considerations in determining the efficacy of a model is to examine the ability of the model to quantify *induced or suppressed travel demand* that might occur as a result of the modal change.

### ***Implementation of Transportation Policies***

Travel demand models should be responsive to a range of contemporary and emerging transportation policies and issues. These include, but are not necessarily limited to:

- Pricing policies such as value pricing, variable (time of day) pricing, area-based congestion pricing, parking pricing, tolls, public transit fare policies (free fare zones,

- free intermodal transfers, etc.), cash subsidies, fuel prices and taxes, employer reimbursement schemes
- Policies aimed at encouraging alternate mode use including HOV/HOT lanes, rideshare programs, mixed land use development, transit- and pedestrian-oriented development, neo-traditional neighborhood development, new transit/bicycle/pedestrian facilities and services
- Alternative work/school arrangements such as satellite or home-based telecommuting, flexible work hours, distance-learning classes

Travel demand models should be able to provide quantifiable impact measures, by market segment, that answer a range of questions that policy-makers might be interested in addressing. Market equity, social exclusion, environmental justice, quality of life, and environmental (emissions) impacts of policy measures need to be addressed by travel demand models.

Some of the policies identified here can be easily accommodated or reflected by simply adjusting a modal level of service variable associated with one or more facilities. For example, a new toll on a bridge can simply be reflected by imposing a cost on the specific highway links that represent the bridge. Other policies may be more subtle or abstract and may not be as easy to capture or reflect in a model. For example, how does one represent a flexible work hour policy to reflect its impacts on travel behavior? Potentially, activity-based travel demand models that include consideration of work constraints, flexibility and rigidity of different activities, and activity inter-dependencies would be able to accommodate the effects of a flex work hour policy.

### ***Consideration of New Technologies***

Technology is playing an increasingly bigger role in shaping human activity patterns, residential and work location choices, travel behavior, use of time, and freight logistics. The interactions between technology and travel behavior are closely intertwined with people's use of time. On the one hand, technology may substitute for travel while, on the other hand, technology may complement or lead to more (spontaneous) travel. Similarly, there are a wide range of new transportation technologies including traveler information and guidance/navigation systems, intelligent transportation systems, and alternative fuel vehicle technologies that impact travel behavior. Travel demand models used for forecasting should be capable of reflecting the telecommunications – travel behavior interaction.

### ***Changes to Spatial and Temporal Resolution***

Many of the current implementations of tour-based model systems are based on the traditional zone-based spatial representation of a region and discrete time-of-day periods. Until such time that models are able to move towards a truly continuous representation of the space-time domain (which is happening at a rapid pace in the research and development arena), the rather discrete representation of space and time is likely to continue. In that case, it would be desirable to have a model system that is reasonably robust to changes in spatial and temporal resolution. It is very possible that zone systems will be altered, zones will be split, and new zones will be added in a future year scenario. In general, a travel demand model should be aspatial and thus unaffected by the definition of the zonal system. If it is desired to have additional time of day periods in a future year scenario, then it should be easy to re-estimate and re-calibrate the components of the model system affected by the re-definition of time periods.

### ***Accommodation of Emerging Behavioral Paradigms/Concepts***

In the recent past, there has been a growing body of literature – both theoretical and empirical – documenting a variety of behavioral phenomena inadequately captured by traditional travel demand modeling paradigms. Despite the concern about the absence/lack of a sound behavioral theory driving or underlying innovative model development, there is a growing body of rigorous work that is helping to identify behavioral paradigms and concepts that ought to be incorporated into models of activity and travel demand. While one may debate the need to accommodate these behavioral concepts from a practical standpoint, (i.e., what difference does it make to the final answer), there is no doubt that the profession should move in the direction of recognizing behavioral relationships that have been clearly established in the literature, if nothing else than to make the models more defensible and explicable. Some of the concepts include, but are not necessarily limited to the following:

- **Interdependencies and Interactions**: There are a host of interdependencies and interactions that are key to activity-travel demand modeling. These include modal, temporal, and spatial (location) interdependencies among trips in a chain and among chains in a daily activity-travel pattern, interdependencies in activity engagement across days and weeks, interactions among household members, and residence – work/school location interdependency.
- **Constraints and Flexibility**: There is much to be learned about constraints and flexibility associated with various activities and their attributes. On the other hand, there is much that has been discovered as well. There are a host of constraints that play a key role in shaping activity-travel patterns, including modal, situational, institutional, household (obligatory), and personal constraints.
- **Positive Utility of Travel**: There is some evidence that suggests that travel is not purely a disutility that is minimized by individuals. A model system that could potentially accommodate alternative utilitarian paradigms might be able to capture the situations where travel, by itself, is offering a positive utility.
- **Time Use and Activity Patterns**: Travel demand is inextricably tied to the demand for pursuing activities that are distributed in time and space and the time available to pursue them. Thus, time use and activity analysis play an important role in modeling travel demand. History dependency in time allocation and activity participation, in-home vs. out-of-home activity substitution and generation, induced demand, and travel efficiency (say, through chaining of trips) are but a few of the concepts that merit recognition.
- **Behavioral Processes and Decision Rules**: Recent work in activity-travel modeling has focused on the behavioral processes and decision-making rules that people employ when scheduling and executing activities and trips. Rule based heuristics, in addition to random utility theory based models, are being incorporated into models to reflect these behavioral processes in microsimulation frameworks. Understanding behavioral processes is key to developing robust model structures, specifications, and forms.

### ***Comparisons Between Model Systems***

The discussion so far has dwelled on the many considerations upon which one might be able to assess the performance of an activity-based travel demand model system. However, the following questions remain:

1. How does one know/determine whether the activity-based travel demand model is giving the right answer or level of sensitivity for a particular scenario?
2. In comparing the outputs (in response to a scenario analysis) between an existing four-step travel demand model and an activity-based travel demand model, how does one know/determine which one is right or more accurate (in cases where it is not obvious)?

## Conclusions and Content of Presentation

The discussion in this white paper raises important questions regarding the potential adoption of new and innovative activity-based travel demand modeling systems in practice. The proposed presentation serves as a first attempt to deliver the following information with a view to stimulate discussion among conference participants on how best to validate and assess activity-based model systems vis-à-vis existing four-step models:

1. *Model validation guidelines* for activity-based travel demand models including information on what base year traffic conditions activity-based travel demand models should replicate, the margins of error that are acceptable, and the extent to which refinements and/or adjustments of model components and parameters are acceptable
2. *Model assessment guidelines* for activity-based travel demand models including the ranges of sensitivity tests, policy measures, land use scenarios, and technologies to which the activity-based models should be subjected, the model outputs that should be examined, and the acceptable ranges of responses in model outputs
3. *Model comparison guidelines* for comparing activity-based travel demand models with existing four-step travel demand models including the development and presentation of a *comprehensive matrix* that clearly shows how and where four-step models, tour-based models, and activity-based microsimulation models are applicable to addressing a range of issues and scenarios
4. *The design of comprehensive experiment(s)* for performing controlled comparisons of activity-based travel model outputs and existing four-step travel model outputs. There are a variety of scenarios and policies that have played out and have been observed in the real world, thus providing real-world data against which model predictions can be assessed. Both activity-based and existing four-step travel models can be applied to these situations and the outputs can be assessed against real-world observational data.

The presentation will also include results of model validation and assessment exercises that have been undertaken using FAMOS (the Florida Activity Mobility Simulator) and CEMDAP (Comprehensive Econometric Microsimulator of Daily Activity Patterns) to illustrate how the guidelines presented can indeed be used to assess and validate activity-based travel demand models.