Using Activity Based Models for Policy Decision Making

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Metropolitan Planning Organizations (MPOs) are faced with a wide variety of planning and policy initiatives for which information on travel demand is required. The Denver Regional Council of Governments (DRCOG) is the MPO for the rapidly growing Denver area, where the region has developed a comprehensive planning process to deal with the issues confronting the area's residents, workers, and visitors.

The regional planning process in the Denver area begins with the plan known as MetroVision, which provides the overall framework within which are developed other key MPO planning elements such as the Regional Transportation Plan (RTP), the Transportation Improvement Program (TIP), and the Air Quality Conformity analysis. As DRCOG began the design of a new regional modeling system, and given that initial project planning suggested that DRCOG should focus its efforts on the next generation, tour/activity modeling systems, DRCOG management essentially charged the project team to answer the question "What good are these models? Can they better support regional planning, and if so, how?"

MetroVision is composed of six "core elements", intended to guide the regional planning process:

- Extent of Urban Development – promoting a more orderly, compact pattern of development.
- Semi-Urban Development – minimizing the extent of low-density, large lot development.
- Urban Centers – encouraging the development of higher-density, mixed-use, transit and pedestrian-oriented centers throughout the region.
- Freestanding Communities – maintaining as self-sufficient communities several towns currently separate from the larger urban area.
- Balanced, Multi-modal transportation system – providing environmentally sensitive and efficient mobility choices for people and goods.
- Environmental Quality – establishing a permanent, integrated parks and open space system, and preserving the region's air, water, and noise environments.

To ensure that the new model developed for the Denver Region would address MetroVision and the plans developed under its umbrella, DRCOG conducted the Integrated Regional Model (IRM) Vision Phase. The Vision Phase involved evaluation of other advanced modeling projects throughout North America and Europe, together with the convening of panels of modeling experts, regional engineers and planners, and regional policy-makers who provided overall project guidance. These steps ensured that the model design would be informed by the latest practical efforts in model design and implementation, and most importantly, by the model's ultimate customers, those in the DRCOG region who will use the model's results.

During the IRM Vision Phase, the Policy Panel developed a list of the top ten core planning issues that the travel demand model needs to support:

1. Effects of development patterns on travel behavior
2. Sensitivity to price and behavioral changes
3. Effects of transportation system and system condition
4. Need for improved validity and reliability
5. Ability to evaluate policy initiatives
6. Better analysis of freight movement
7. Ability to show environmental effects
8. Modeling low-share alternatives
9. Better ability to evaluate effects on specific sub-groups
10. Reflect non-system policy changes (TDM, ITS)

These issues were "boiled down" in the vision process to keep the list short. More specific, high-interest policy issues in the Denver Region include:

- The Colorado Tolling Enterprise (CTE) - established two years ago by the state legislature, the CTE has been working to identify a set of corridors with the potential for toll facility establishment. The CTE has identified about six such corridors in the Denver area and is conducting its own evaluation of these corridors, expected to be submitted to the regional planning process for inclusion in the regional plan. These efforts also have caused planners conducting several Environmental Impact Statements in the region to take a harder look at toll options in their alternatives analyses.
- The effects of MetroVision Urban centers and other transit-oriented developments - support of such development patterns is intended to foster a more balanced transportation system, reducing the number and lengths of trips, foster additional bicycle/pedestrian use, etc. The MetroVision 2030 Update developed in 2004 included approximately 70 such centers, and the evaluation of the effects of these centers is a key aspect of the regional model's usefulness. These will be evaluated again during the MetroVision 2035 process just getting underway.
- Effects of the MetroVision Urban Growth Boundary - the extent of the Urban Growth Boundary/Area currently is set at approximately 750 square miles for the year 2030, and the extent to which it may need to be expanded for 2035 will be a key part of the MetroVision 2035 process.
- Re-examination of lower-density development, referred to as "semi-urban" – issues include defining semi-urban, estimating how much of it is there, how much should there be, and what are its transportation and air quality effects.
- The FasTracks ballot initiative of 2004 – passage of this initiative kicked off a project to build about 130 miles of rapid transit to all parts of the region by the year 2017. The ability to evaluate the effects of such a system will be critical over the next decade.
- Air quality - as always, evaluation of the effects on air quality of various policy/transportation initiatives will continue to be a key issue in regional planning.
- Highway project planning – this also will continue to be a core focus of the planning process in the region.

In addition to providing guidance concerning the needs that a new model must address, the Vision Phase validated DRCOG planners' initial impression that an activity based modeling approach would best meet those planning analysis needs for the region. While it is clear that activity based modeling as it can be implemented now cannot fully address all of the issues discussed above, it is superior to conventional four-step modeling in many respects. DRCOG and its consultant team have concluded detailed design of an activity based model, considering the region's planning needs and resource constraints, and model development is now in process.

The activity based modeling approach chosen by DRCOG is based on that used in the model developed for the San Francisco County Transportation Authority (SFCTA) in 2000-2001, but includes enhancements informed by the capabilities of some of the activity based models implemented more recently in other areas. The approach includes microsimulating the daily activity patterns of individuals in a synthetic population; determination of "regular" workplaces and school locations in relation to the home location; the modeling of the times of day, destinations, and modes of tours and trips, and the use of conventional static highway and transit assignment procedures. The model design is described more completely by Cambridge Systematics et al[1].

In general, the activity based modeling approach would be expected to produce more accurate results for policy testing since it is able to consider a wider range of variables and interactions than a conventional trip based model. Trip-based models tend to be relatively insensitive to many input data changes (such as transit-oriented development related land use changes) as they usually do not include enough detail (geographic location, demographic variables, trip-tour relationships, etc.) to permit them to respond fully to such changes. Trip-based model users often resort to "adjustment factors" to account for behavior that cannot be analyzed by these models, with varying degrees of reliability and success; activity/tour based models are expected to provide considerably improved forecasting for all types of policy analyses. Of course, the level of increased accuracy may be expected to depend on how much the analysis of the specific policy depends on the factors that are considered in the activity based approach but not in the trip based approach.

The following discussion summarizes some specifics of how the proposed modeling approach would address some of the specific policy analysis needs described above.

Pricing Analysis. The traffic forecasting procedures for toll facilities and managed lanes have been a topic of considerable discussion recently. Various aspects of existing procedures have been criticized, including the assumed values of time for various market segments of travelers, the aggregate nature of the process (which requires fixed values of time for each segment), the difficulty in modeling time of day outside a tour based approach, and the static nature of the traffic assignment process, which ignores the effects of the buildup and dissipation of queues.

Activity based approaches present some advantages over conventional modeling procedures in addressing some of these issues. One major advantage is that modeling individuals in the synthetic population provides an opportunity to use distributed values of time rather than fixed values for a relatively small number of market segments. For example, say that it would take a value of time of $12/hour for a certain geographic market to find using a particular toll road segment desirable. If the average value of time for the market segment were $10/hour, then the model would estimate that no one from that segment would use the toll road. But if a value of time distribution were used with an average value of $10/hour but with a 20 percent probability

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[1] Cambridge Systematics, Inc., Mark Bradley, and John Bowman. "Model Design Plan for the DRCOG activity Based Model," January 2006.

of having a value of time of greater than $12/hour, there would be demand estimated for the toll road within this market segment.

Another major advantage is that demand for roadways where tolls vary by time of day can be modeled much more accurately. Time of day decisions for activities must consider not only the time when the trip to or from the activity takes place, but also the trip in the other direction and the duration of the activity itself. For example, if someone wishes to consider shifting his departure time for a work trip to avoid a high peak period toll, he/she would likely also need to consider the amount of time needed to be spent at work and whether the time shift for the trip to work might shift the departure time from work to or from a peak period with a high toll. Obviously a model that treats individual trips independently cannot include such considerations.

Urban Centers and Transit-Oriented Development. There are several advantages to modeling travel by residents, workers, and visitors in these types of developments using the proposed activity based modeling approach. First, many variables in an aggregate, trip-based model must be introduced through the use of segmentation, which significantly limits the number of variables that can be included in the model. Adding further segmentation to a typical cross-classification trip production model (likely with only two or three dimensions) to account for different trip making characteristics in denser, transit-oriented areas would require the household survey data to be segmented by additional dimensions, often beyond the ability to obtain statistically significant estimates of trip rates given the limitations of the existing sample. The activity based modeling approach, where individual daily activity patterns are simulated, permits description of individuals using a much richer set of variables.

Planning judgment and travel behavior data also support the expectation that having a variety of attractions located in close proximity in the urban centers, including workplaces, other businesses, and shopping and entertainment opportunities, would have an effect on trip chaining, as individuals might choose to combine activities that can be accomplished in the same vicinity. Obviously, a tour based approach is required to capture the effects of trip chaining.

Finally, data also suggest that persons living and/or working in higher density transit-oriented areas should have greater opportunities to use transit and non-motorized modes. However, properly reflecting these opportunities in the model requires a combination of capabilities: modeling travel in tours, so that (for example) secondary tour trips/stops/modes can be shown to be compatible with transit as the primary mode of the tour (as they will sometimes be within walking distance); destination choice models that can operate at sufficiently fine geographic detail so as to locate some secondary stops within the TOD; and fine geographic detail on stop locations so that walk distances can be accurately calculated (so that walk choices in the mode choice models are accurately estimated.)

Transportation Project Analysis. The use of disaggregate microsimulation of individuals provides some advantages to the analysis of new transportation projects, particularly the extensive transit investments planned for the Denver area. One of the key questions involved in the analysis of transit investments involves the identification of how specific groups of the population (for example, persons from low income households) benefit from the investments. In conventional models, demographic market segmentation is not carried through beyond the mode choice step, and so some model results cannot be differentiated by market segment. In addition, the market segmentation is limited to a single variable (usually income) in conventional models whereas all characteristics of the simulated individuals can be retained in the activity based approach.

Another way in which transportation project analysis is improved compared to the use of conventional models is that the effects of new projects on travel demand (i.e. induced travel) can be modeled directly. Conventional trip generation models consider only demographic variables and do not consider transportation level of service. The magnitude of the effects of improved transportation level of service stemming from new projects on the amount of travel demand can be estimated through the incorporation of level of service variables in all steps of the demand modeling process. The use of logsum variables from subsequent model steps provides a way to do this while maintaining consistency among the level of service data for all model components.

It is worth briefly discussing some of the ways in which the proposed activity based modeling approach fails to address some of the planning analysis needs. One of the most significant is that a conventional static traffic assignment process will be used. Although it would be desirable to consider traffic microsimulation or dynamic traffic assignment procedures, the ability to implement and validate such procedures when they are applied at a regional level (at least in a region as large as the Denver metropolitan area) has not yet been proven. Lack of a fully disaggregate or at least dynamic traffic assignment procedure will limit the model's ability to analyze the effects of queuing of traffic and to examine variations in traffic flow within peak periods. This inhibits the full exploration of the effects of tolling options and other highway operations analyses.

Another issue is that, despite its use of microsimulation of individuals, the model will still have some aggregate elements. The region will still be divided into analysis zones, which will be used as the basis for highway travel time and some other level of service network skims. This means that aggregation error will still exist in the model (although to a lesser extent than in a conventional model). However, current model design anticipates storing each household and job at the point level, mitigating some aggregation errors by allowing detailed calculation of walk skims.

In conclusion, it is clear that existing modeling tools come up short in their ability to address the planning analysis needs of the Denver region. While the proposed activity based approach is not a panacea for all of the shortcomings, it does provide many improvements to the modeling process that specifically address some of the issues. These include the ability to introduce distributions for the value of travel time in road pricing analyses, the use of a more accurate tour based time of day modeling procedure in road pricing and other analyses, the use of additional segmentation variables in such analyses as the development of urban centers and transit-oriented development, the ability to directly model trip chaining, and the use of transportation level of service variables in all steps of the model to estimate the effects of induced travel demand. These advantages led DRCOG to begin development of an activity based model as the main travel demand estimation tool for future planning analyses.