Status of Activity-Based Models and Dynamic Traffic Assignment at Peer MPOs

Task Order 15.2, Final Report 2 of 3

prepared for

Metropolitan Washington Council of Governments/
National Capital Region Transportation Planning Board

prepared by

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October 15, 2015

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1.0 Background

The National Capital Region Transportation Planning Board (TPB) is the Metropolitan Planning Organization (MPO) for the Washington, D.C. metropolitan area and one of several policy boards that meet at the Metropolitan Washington Council of Governments (COG). TPB is staffed by COG's Department of Transportation Planning (DTP). Cambridge Systematics (CS) has been asked by the COG/TPB staff to develop a multi-year, strategic plan for the development of its regional travel demand modeling process. This effort is being completed under Task Order No. 2 of Fiscal Year 2015 (Task Order 15.2) of COG Contract #14-056, "Assistance with the development and application of the MWCOG/NCRTPB travel demand model." This consultant-assistance project was started in 2005 and is now in its tenth year. A consultant may hold the contract for no more than three years before the contract must be rebid.

This report is the second of three developed under Task Order 15.2. It focuses on understanding the current status of modeling practices at metropolitan planning organizations (MPOs) that are considered peers to the TPB. To develop the list of peer MPOs, the 20 largest MPOs in the U.S., based on 2010 population in the modeled area, were selected (TPB is #9 in this list). Additionally, three other smaller MPOs were added to this, due to their reputation for innovation. The complete list is shown in Figure 1.1, along with the principal city associated with each MPO.

Section 2.0 of this report describes the status of Activity-Based Travel Demand Models (ABMs) at these MPOs. Section 3.0 describes the status of land use forecasting. Section 4.0 describes the status of Dynamic Traffic Assignment (DTA) models at the peer MPOs. Additionally, Section 4.0 includes a discussion of the use of a special modeling approach that uses TRANSIMS, which many consider a type of DTA, to analyze and rank new road projects in Norther Virginia for the Northern Virginia Transportation Authority (NVTA). Although this latter case is not an MPO, it was included in this report at the request of COG/TPB staff because it is an example of using DTA in the Washington, D.C. area. Section 5.0 describes some details of the survey, and, finally, Section 6.0 describes some summary findings.

Figure 1.1 List of MPOs considered peers of the TPB

1. Southern California Association of Governments (SCAG; Los Angeles)
2. New York Metropolitan Transportation Council (NYMTC; New York City)
3. The Chicago Metropolitan Agency for Planning (CMAP)
4. Metropolitan Transportation Commission (MTC; San Francisco)
5. North Jersey Transportation Planning Authority (NJTPA; Newark, Jersey City, New Jersey)
6. North Central Texas COG (NCTCOG; Dallas and Fort Worth)
7. Houston-Galveston Area Council (H-GAC)
8. Delaware Valley Regional Planning Commission (DVRPC; Philadelphia, Pennsylvania)
9. **National Capital Region Transportation Planning Board (TPB; Washington, D.C.)**
10. Atlanta Regional Commission (ARC; Atlanta, Georgia)
11. Southeast Michigan COG (SEMCOG; Detroit)
12. Maricopa Association of Governments (MAG; Phoenix, Arizona)
13. Puget Sound Regional Council (PSRC; Seattle, Washington)
14. Boston Region MPO
15. San Diego Association of Governments (SANDAG)
16. Metropolitan Council (Twin Cities of Minneapolis and Saint Paul, Minnesota)
17. Denver Regional COG (DRCOG; Denver, Colorado)
18. Baltimore Regional Transportation Board (BRTB; Baltimore, Maryland)
19. Southwestern Pennsylvania Commission (SPC; Pittsburgh)
20. East-West Gateway Council of Government (EWGCOG; Saint Louis, Missouri)
21. Sacramento Area COG (SACOG; Sacramento, California)*
22. Portland Metro (METRO; Portland, Oregon)*
23. Mid-Ohio Regional Planning Commission (MORPC; Columbus, Ohio)*

* Although these three MPOs were not part of the list of the 20 largest MPOs in the U.S., they were added to the list of peer MPOs due to their reputation for innovation.

2.0 Status of Activity-Based Modeling at Peer MPOs

Definitions: A **trip-based travel demand model**, also known as a four-step model (4SM), is an aggregate travel demand model that uses trips as the basic unit of analysis. It is still the dominant type of regional travel demand model used in the U.S., though there is a trend, particularly at the larger MPOs of moving toward activity-based models. The 4SM is aggregate in the sense that it models aggregate trip flows between zones, typically for one or more discrete time-of-day periods.

A **tour** is a sequence of connected trips. A home-based tour starts and ends at home. A work-based sub-tour begins and ends at work. A **tour-based travel demand model** (TBM) adds a layer of complexity to a trip-based model. It can be applied at either the aggregate or disaggregate level (disaggregate means modeling individual persons or households). Tour-based models consider decisions made at both the trip and tour level, but choices for trips are generally constrained to be consistent with the tour of which it is a part.[1] By grouping trips into tours, one avoids some of the loss of information that occurs with trip-based models. For example, a trip-based model commonly has a trip purpose called "non-home-based" (NHB), such as a trip from work to a lunch location. In a tour-based model there is no such thing as a NHB trip.

An **activity-based travel model** (ABM) is a tour-based model that recognizes that travel is a derived demand – derived from the fact that individuals and households choose to undertake **activities** that typically located at dispersed locations, which gives rise to travel. The following features are typically included in a full ABM:

- Simulation of individual people as opposed to households, and therefore consideration of individual characteristics such as age, gender, and worker status;
- Complete daily activity patterns, and therefore how other activities a person does affect specific tours;
- Intra-household interactions, including joint travel and school escorting;
- Time of day choice, and therefore peak spreading, with most modern ABM models including half-hour resolution; and
- Simulation of value of time from a distribution.

In general, all ABMs are TBMs, but not all TBMs are ABMs. NCHRP Synthesis 406 notes

> *The literature is not in agreement as to a precise definition of what constitutes a tour-based model versus an activity-based model. Some would argue that a model is not truly activity-based unless it involves a list of activities and whether they occur in-home or out-of-home. Although there is some intuitive appeal to such a definition, such a distinction is a minor point compared with the large differences with traditional trip-based models. Therefore, in colloquial use, the two terms are often used interchangeably. That practice is continued in this report.*[2]

Similarly, in this report, the two terms are often used interchangeably.

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[1] Rick Donnelly et al., *NCHRP Synthesis 406: Advanced Practices in Travel Forecasting*, National Cooperative Highway Research Program, A Synthesis of Highway Practice (Washington, D.C.: Transportation Research Board of the National Academies, 2010), 9.

[2] Ibid., 10.

2.1 Overview

ABMs first came into practice in the U.S. in the 1990s with the development of a model in Portland, Oregon[3]. This model was used for specific planning studies, although Metro (the Portland MPO) continued to maintain their conventional four-step model for many other planning functions. The first ABM developed as the main modeling tool for a U.S. jurisdiction was for San Francisco County[4]. This model, which became operational around 2001, became the only model used for this jurisdiction, which is not an MPO (MTC, the San Francisco MPO later adopted an ABM). The first MPOs to use ABMs as their main modeling tools were NYMTC and MORPC, around 2003 (NYMTC's Best Practices Model is sometimes describe as an activity-based model, other times as a "journey-based" model).[5] The remainder of the decade saw several other MPOs, including SACOG, DRCOG, and MTC, adopt ABMs[6]. More MPOs have adopted ABMs in recent years while many others currently have such models under development, as discussed in Section 2.2. The methodologies used in these models have continued to evolve and improve.

While the methodologies of the existing ABMs differ from one another in various aspects, most of them use similar approaches based on the concept of daily activity patterns. This concept evolved from the research of Bowman and Ben-Akiva in the early to mid-1990s[7] and was further developed by other researchers and model developers[3]. There also has been a body of research by academics both inside and out of the U.S. that has contributed to the understanding of the activity-based modeling approach, and ABMs have been implemented in several locations around the world (for example, ALBATROSS[8] and TASHA[9]). One MPO that

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[3] Bowman, John L., Mark A. Bradley, Yoram Shiftan, Keith Lawton, and Moshe E. Ben-Akiva. *Demonstration of an Activity Based Model System for Portland.* Antwerp, Belgium. 1998. http://www.jbowman.net/refereed/1998.Bowman_et_al.Demo_for_Portland.pdf.

[4] Cambridge Systematics, Inc. *San Francisco Travel Demand Forecasting Model Development Executive Summary Final Report.* (San Francisco County Transportation Authority. October 1, 2002). http://www.sfcta.org/sites/default/files/content/Planning/DataMart/executivesummary.pdf.

[5] *Report on Findings of the Peer Review Panel for the North Carolina Department of Transportation (NCDOT), February 10-11, 2004*, Transportation Model Improvement Program (TMIP) (Federal Highway Administration, 2004), 7, http://www.fhwa.dot.gov/planning/tmip/resources/peer_review_program/ncdot/ncdot_report.pdf.

[6] MWCOG/Cambridge Systematics survey of peer MPOs to assess the state of modeling practice, conducted March 6-25, 2015.

[7] Rossi, T., B. Winkler, T. Ryan, K. Faussett, Y. Li, D. Wittl, and M. Abou Zeid. "Deciding on Moving to Activity-Based Models (or Not)." Presented at the Transportation Research Board 88th Annual Meeting, Washington, D.C., 2009.

[8] Arentze, T., Hofman, F., Van Mourik, H., and Timmermans, H. Spatial transferability of the Albatross model system: Empirical evidence from two case studies. Transportation Research Record: Journal of the Transportation Research Board, 1805, 1-7., 2002

[9] Roorda, M. J., Miller, E. J., and Habib, K. M. N. Validation of TASHA: A 24-h activity scheduling microsimulation model. Transportation Research Part A: Policy and Practice, 42, 360-375., 2008.

has an ABM based on a different approach is the Los Angeles MPO, whose model is based on the research of, and was developed by, Bhat, Pendyala, and Goulias.

The concept of "families" can be applied to describe sets of models developed by the same modeling consultants for different regions. Naturally, particular consultants have some similarities in the methodologies which they apply, although there often are significant differences among models within the same "family." The main similarities among models within the same "family" are in their software implementation.

The model input data for ABMs is essentially the same type of data, and from the same sources, as input data for trip-based models, with the exception of a synthetic population, which is created by a component known as a synthetic population generator. In the existing ABM implementations in the U.S., the highway and transit assignment processes generally are independent of the activity-based demand models. **Disaggregately applied ABMs, though, hold the promise of eventual integration with disaggregate assignment models, such as dynamic traffic assignment (DTA) procedures**. Refer to Task Report 1, Section 3, for further information.

It should be noted that the ABM components do not cover everything that is needed in a regional modeling process; they simulate only travel made by residents of a region within that region. Other model components, which may address travel into, out of, and through the region (external travel), truck travel, and travel to and from "special generators" such as airports, must be included separately.

A typical way in which ABMs fit into the overall regional modeling process is depicted in Figure 2.1.

2.2 Modeling Approach

The basic tenet of activity-based modeling is that travel demand derives from the desire to participate in different activities; many of which require travel to different locations. Unlike trip-based models, ABMs consider the linkages among all of the activities and travel made by a person over the course of a day, as well as (in most cases) the activities and travel made by other household members. This requires a "tour-based" approach, where the individual trips comprise tours that begin and end at a person's home or workplace. The trips comprising each tour are interrelated in terms of locations, activity timing, and travel mode choice. If a person makes multiple tours in a day, these tours also are interrelated in terms of tour purposes and timing. Most modern ABMs consider the effects of intrahousehold interactions, such as joint activities.

A fundamental difference between ABMs and conventional trip-based models is that ABMs are applied *disaggregately*, meaning that all of the activities and travel of every individual in the modeling region, as represented by a synthetic population, are simulated. In a conventional trip-based model, segments of travelers, households, or trips are modeled together, with choices being simulated through splitting of segments (for example, splitting total person trips into trips by mode, or splitting daily trips into trips by time period). The disaggregate approach conveys many advantages, most notably the substantial reduction in aggregation error, but also the ability to report model results by any segment of the population that can be defined by the model's variables (income level, worker status, vehicle availability, age, gender, etc.).

While the approaches used in activity-based modeling continue to evolve, most models use an approach that is based on the overall concept of daily activity patterns. The idea is that a set of activities for work, school, shopping, and other purposes is simulated for each person. The locations and timing of the activities are simulated, and the travel associated with the sequence activities is organized into tours. The travel choices, including mode, time, and destinations, are simulated at the tour level and for each trip between intermediate stops on a tour.

There are several advantages to ABMs over conventional trip based models. These include:

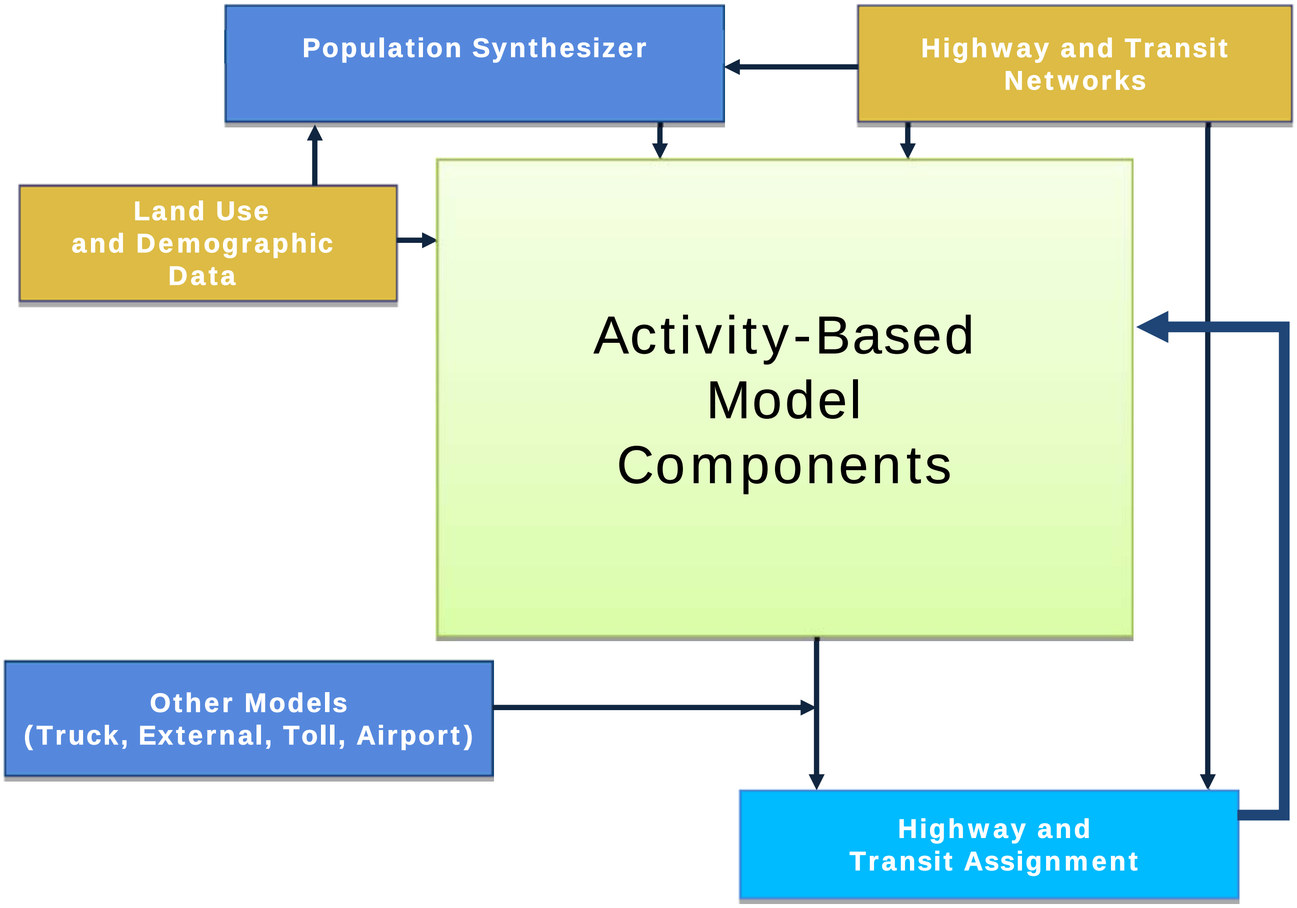
- More accurate representation of travel behavior, and therefore more accurate results for policy/project testing;
- Consideration of trip chaining;
- Disaggregate application – reduces aggregation error;
- Can be easier to understand for decision makers and public (who are not necessarily familiar with four-step models); and
- Ability to perform certain types of analyses more readily, such as environmental justice, road pricing, and peak spreading.

There are also potential disadvantages to ABMs, including:

- More complexity: more components, and more complex formulations than conventional models;
- Greater expense to develop;
- Longer run times;
- Need to manage simulation error;
- Potentially greater hardware requirements; and
- The need for custom software (though there are now a few common platforms).

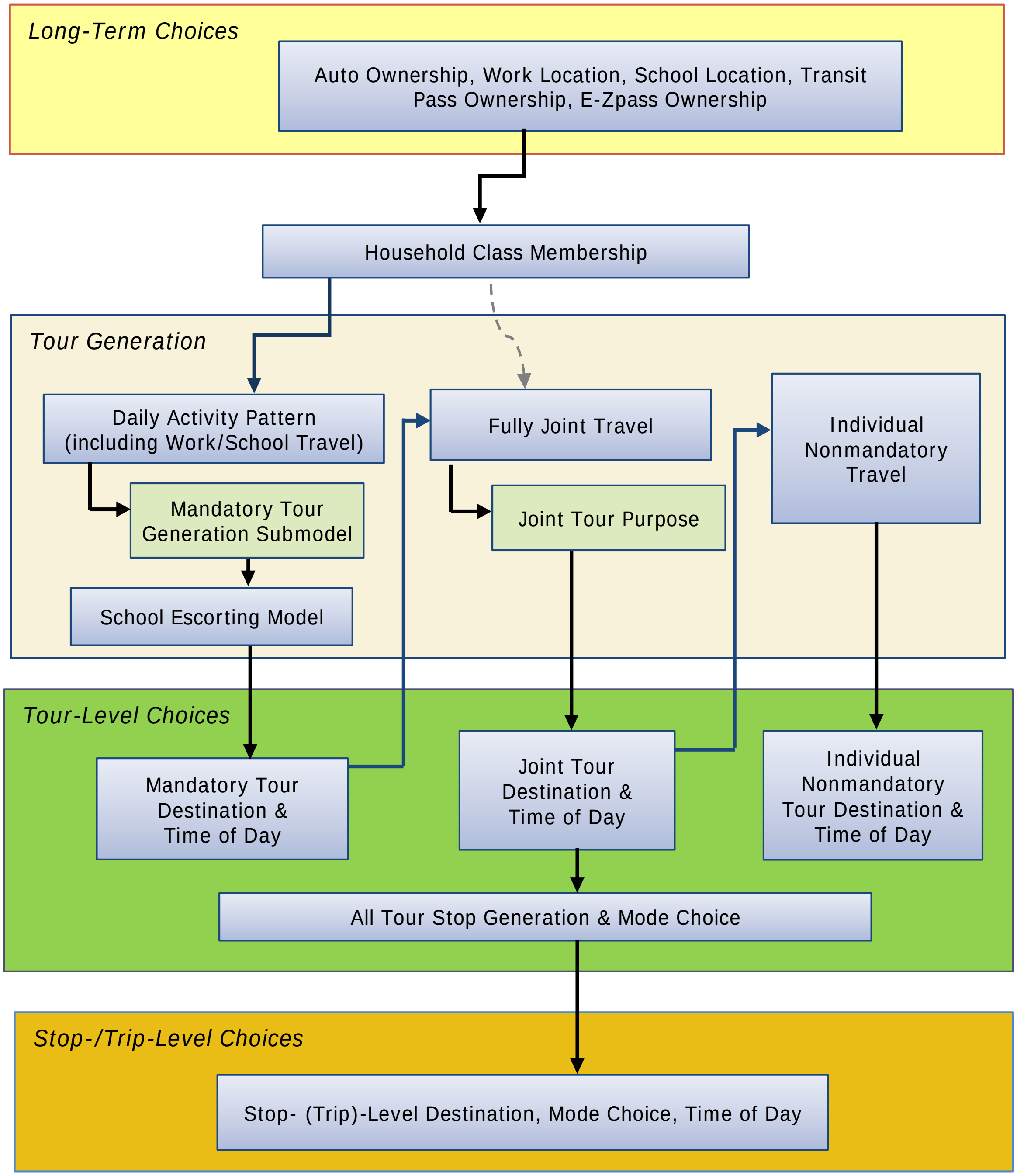
Two examples of how the activity-based modeling process works are depicted in Figures 2.2 and 2.3, which show the models for Baltimore and Southeast Florida, respectively. Although the two model structures have differences, these figures also illustrate the similarities in two different approaches to ABMs.

Figure 2.1 How Activity-Based Components Fit into the Overall Modeling Process



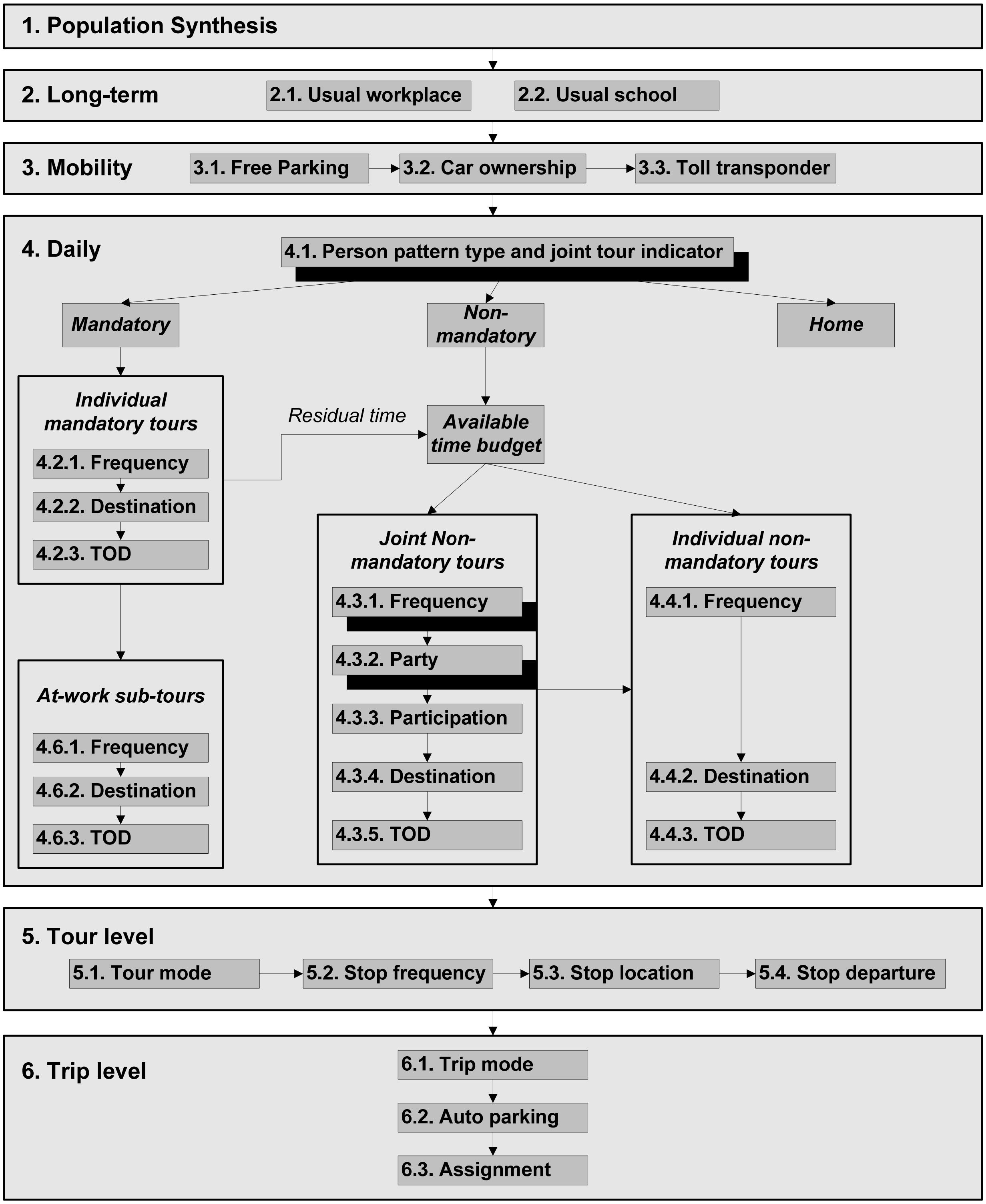
Source: Cambridge Systematics, Inc.

Figure 2.2 Model Process Flow for Baltimore InSITE Model – Activity-Based Components



Source: Cambridge Systematics, Inc.

Figure 2.3 Model Process Flow for Southeast Florida Model – Activity-Based Components



Source: Parsons Brinckerhoff Inc. Southeast Florida Regional Planning Model – SERPM 7.0, Coordinated Travel – Regional Activity Based Modeling Platform (CT-RAMP) Model Development Report – DRAFT, February 2015.

2.3 ABM Transferability

Most of the ABMs developed in the U.S. have parameters that were estimated from local household survey data sets. There have been some cases where parameters for some or all model components have been transferred from another region, though these are mainly cases of "asserted transferability" rather than demonstrated transferability. There have been some studies of transferability of ABM parameters, though there is not yet a sufficient body of work to determine their transferability or identify conditions under which transferability is enhanced.

A recent (2014) report done for the Federal Highway Administration (FHWA), *Guide for Travel Model Transfer*, provides some insights into ABM transferability in an appendix (Appendix D)[10]. However, ABM transferability is a field where research is continuing, and there are some newer studies that have not yet been released, as well as ongoing research.

2.4 Current Practice at Peer MPOs

In March 2015, as part of this task, a survey was conducted of the travel modeling managers at the 20 largest MPOs in the U.S., plus three additional MPOs known for their innovation in modeling techniques (Portland Metro, SACOG, and MORPC). A list of the 23 MPOs was presented in Figure 1.1 on p. 2. We thank the MPO staff who completed the survey. A list of these staff can be found in Appendix A.

The following sections summarize results from the MPO survey analysis: first, presenting findings regarding activity-based modeling practice; second, presenting land use forecasting methods that are being used; and third, providing findings on DTA modeling practice. Appendix B documents the survey instrument. A summary table of survey results can be found in Table 6.1.

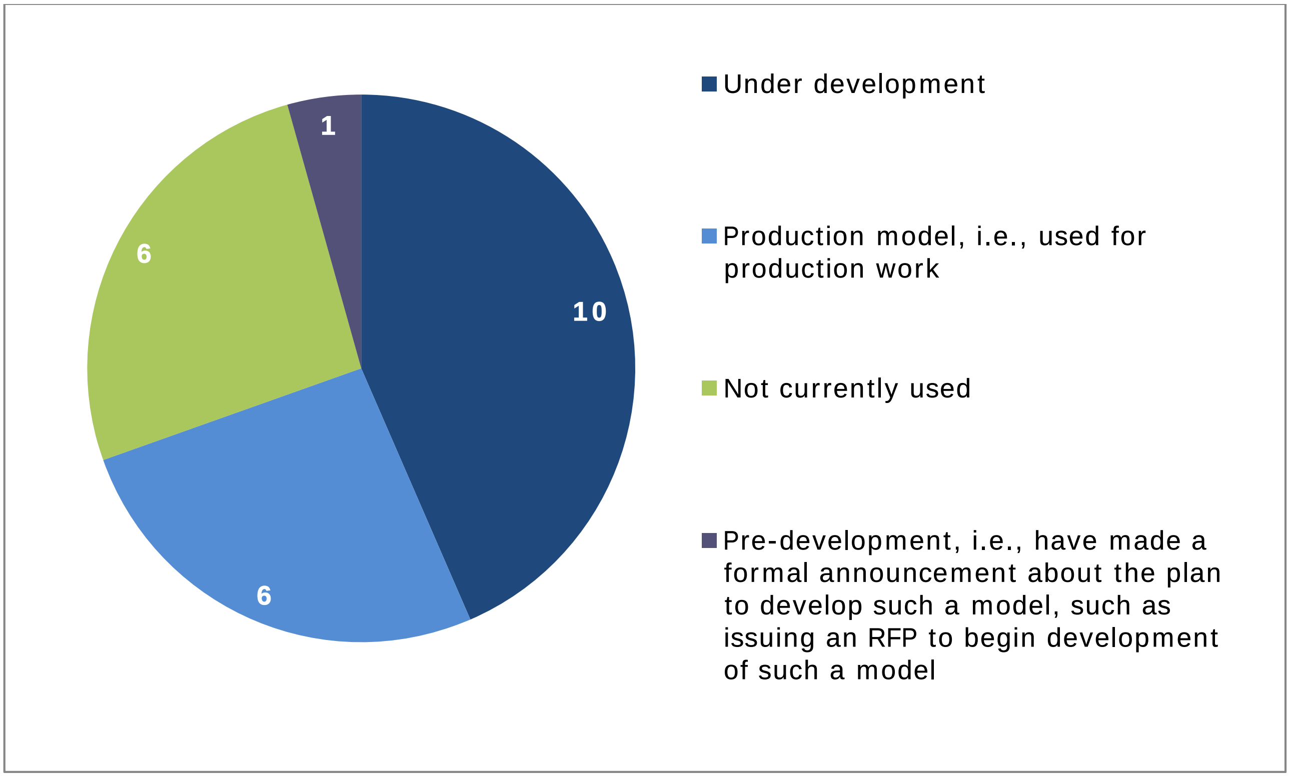
2.4.1 Status of Models

Of the 23 MPOs that responded to the survey, six (26 percent) have production-use ABMs and ten (43 percent) are currently developing an ABM (see **Error! Reference source not found.**). Thus, 16 (70 percent) are either developing an ABM or are using one in production. The six MPOs with production-use ABMs are NYMTC, MTC, SANDAG, SACOG, MORPC, and DRCOG. The ten MPOs currently developing an ABM are CMAP, Metropolitan Council, BRTB/BMC, ARC, Portland Metro, DVRPC, PSRC, SCAG, H-GAC, and MAG. The Boston MPO is in a "predevelopment" stage regarding its ABM. So while a majority do not yet have a working ABM, within a few years, about two-thirds

[10] Rossi, Thomas F., and Chandra R. Bhat. *Guide for Travel Model Transfer*. Travel Model Improvement Program (TMIP). (Federal Highway Administration. October 2014).

http://www.fhwa.dot.gov/planning/tmip/publications/other_reports/travel_model_transfer/fhwahep15006.pdf.

Figure 2.4 Status of Tour-Based / ABM



of them can be expected to (the six with ABMs plus the ten whose ABMs are currently under development).

Six MPOs indicated that they currently were not using or developing an ABM: COG/TPB, NJTPA, SPC, SEMCOG, NCTCOG, and EWGCOG. Previously, NCTCOG performed work on developing an ABM (CEMDAP), but this effort is not currently a priority and the MPO has “no active plans to implement an ABM.”[11]

A total of 19 of the surveyed MPOs currently use conventional four-step models. This includes the 17 MPOs that do not yet have working ABMs, plus two MPOs that have working ABMs (DRCOG and SANDAG). DRCOG, which reported that it does not have a production four-step model, also reported that the region’s previously developed four-step model is still used both by the regional transit agency for Federal Transit Administration (FTA) New Starts submissions, as well as by some consultants who do not have the resources to run the new ABM.

As indicated in the cross tabulation of ABM and four-step model status in Table 2.3, of the 23 MPOs surveyed, 19 have production four-step models (18 under the “Production” column and one under the “Other” column). Six of the 23 MPOs have production ABMs (NY, SF, San Diego,

[11] Parsons Brinckerhoff, Inc., Westat, and Dunbar Transportation Consulting, *Activity-Based Modeling Framework*, Final Project Report (North Central Texas Council of Governments, June 2014), 1.

Sacramento, Columbus, and Denver) and 6 do not currently use an ABM. In total, 10 MPOs are developing ABMs and 1 MPO has an ABM in pre-development (Boston).

Table 2.3 ABM – Four-step Model Status Cross Tabulation

ABM X Four-Step Model Status		Four-Step Model Status				
		Production model	Not currently used	Not currently used, but was used formerly	Other (please explain)	Grand Total
ABM Status	Production model	1	3	1	1	6
	Under development	10				10
	Pre-development	1				1
	Not currently used	6				6
	Grand Total	18	3	1	1	23

2.4.2 Platforms and Software

Figure 2.5 summarizes responses to the survey question regarding travel forecasting software used by each responding MPO. Survey respondents were able to select that they used more than one software package, and some agencies indeed indicated use of multiple commercial packages and/or custom software. Three noted the use of FORTRAN programs as part of their model software.

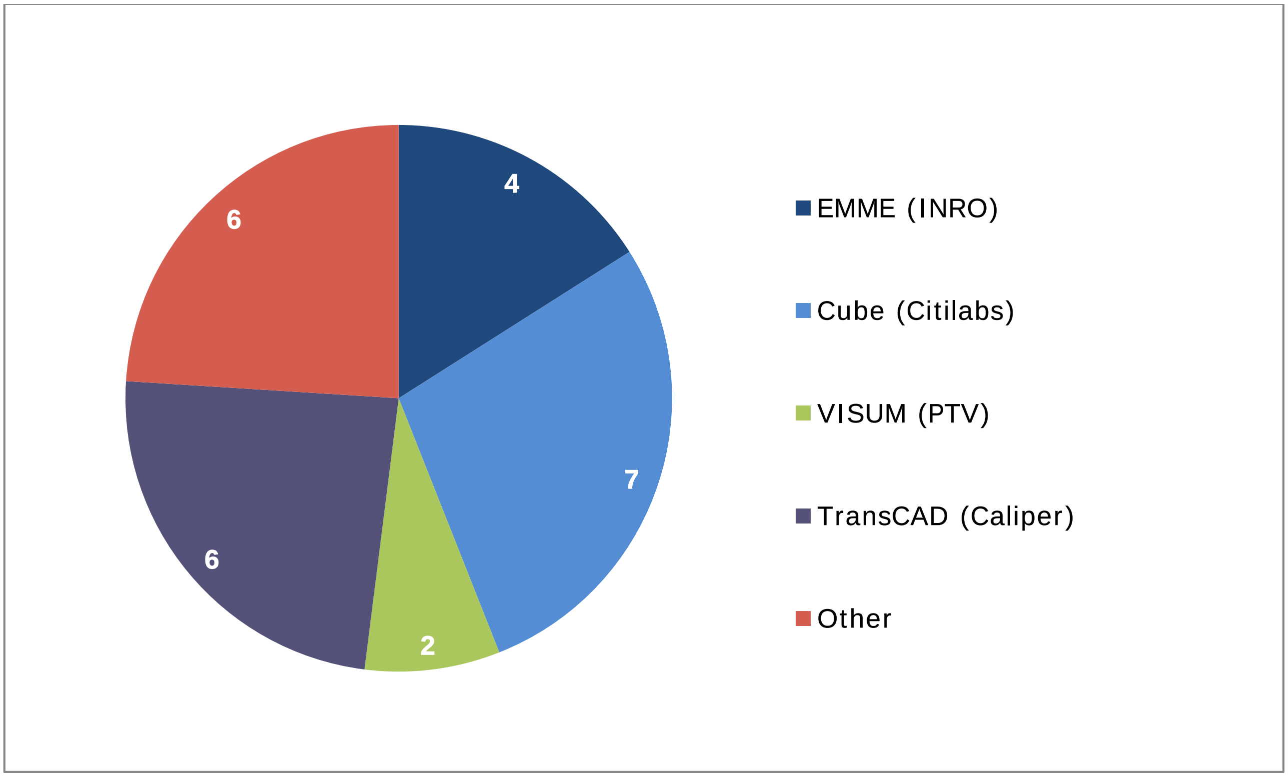
There is a diversity of software used in the application of ABMs. The three major ABM software frameworks developed by U.S. ABM consultants are all used (or will be used, for the models under development); these are CT-RAMP, DaySim, and TourCast. In addition, agencies use the proprietary modeling packages commonly used for four-step modeling for some functions with their ABMs, such as network maintenance and skimming, matrix manipulations, and highway and transit assignment. The packages reported to be used include Cube, EMME, TransCAD, and VISUM. The two most popular packages were Cube (7 MPOs or 28%) and TransCAD (6 MPOs or 24%).

Six survey respondents indicated which platform currently was being used for their ABMs; three of which are using CT-RAMP (San Francisco, San Diego, and Columbus); one is using DaySim (Sacramento); and two MPOs (Denver and New York) are using other platforms.

Of the models under development, the intended ABM platforms are distributed among TourCast (Twin Cities, Baltimore, and Houston); CT-RAMP (Chicago, Atlanta, and Phoenix); DaySim (Philadelphia and Seattle); and Dynamic Activity Simulator of Households (DASH) (Portland).

The MPOs that currently are using ABMs for production work primarily used either TransCAD (New York, San Diego, and Denver) or Cube (San Francisco and Sacramento), with San Diego also using internally developed software.

Figure 2.5 Travel Forecasting Software Being Used



Note: More than one TDM software could be selected.

The travel demand modeling (TDM) software that those MPOs developing ABMs intend to use is somewhat more diverse, with three intending to use Cube (Twin Cities, Baltimore, and Houston); two intending to use TransCAD (Boston and Los Angeles); two intending to use EMME (Portland and Seattle); one intending to use VISUM (Philadelphia); and one more still researching options (Boston).

The average time reported by the 6 MPOs that are using ABMs in Production mode, to develop an ABM, is 4.5 years, with a range between 3 and 6 years.

2.4.3 Benefits/Barriers

According to the survey respondents, the primary benefits of ABMs for their purposes are modeling individual household and personal behavior (6 responses); the ability to model spatial, temporal, and modal aspects of individuals (6 responses); and the ability to model tours/journeys as opposed to individual trips (6 responses); see Figure 2.6. Other perceived benefits include the sensitivity to a broader range of policies, demographic segments, or transportation phenomena such as peak spreading (5 responses); recognizing intertrip dependencies and travel scheduling (5 responses); and the ease of explanation of the modeling process to elected officials and the public (1 response). Indeed, in free-form responses, two MPOs noted easier analysis of specific market segment patterns such as for older adults, Millennials, urban center residents, age, income, and race/ethnicity.

Figure 2.6 Perceived ABM Benefits

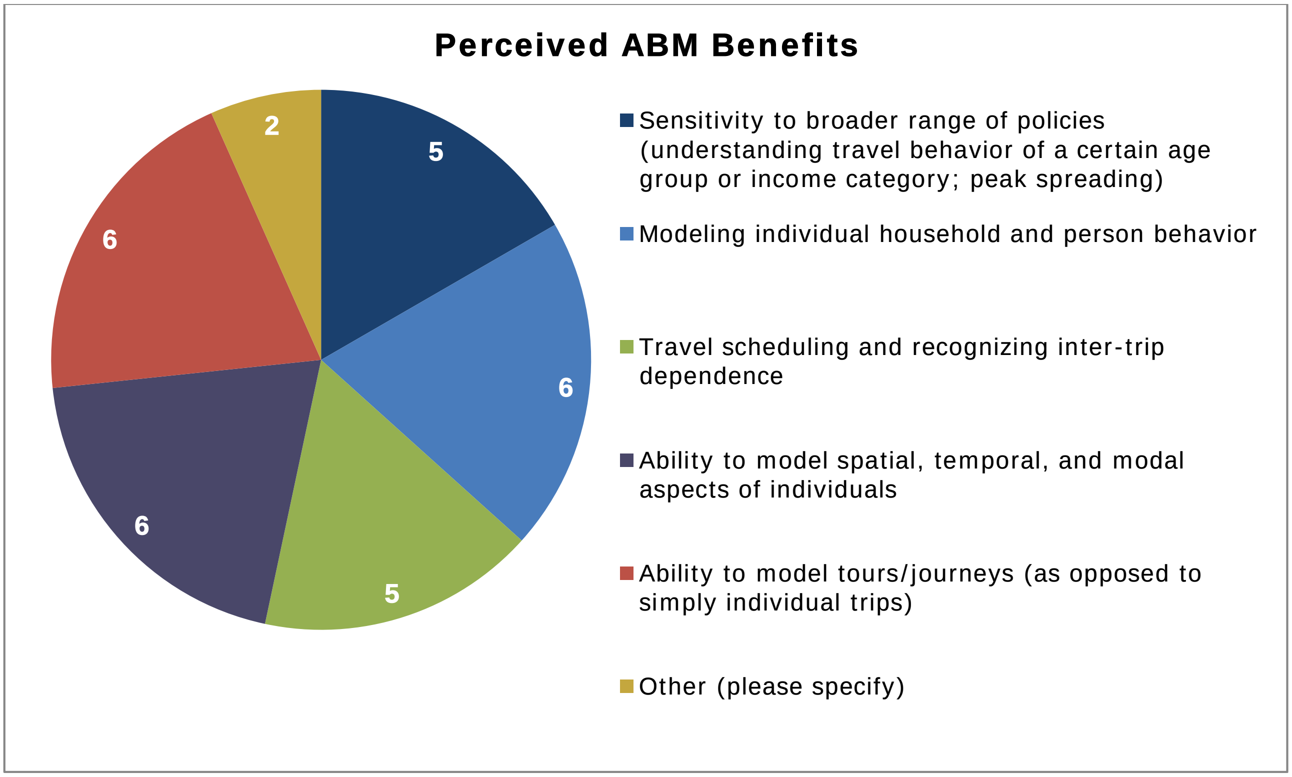
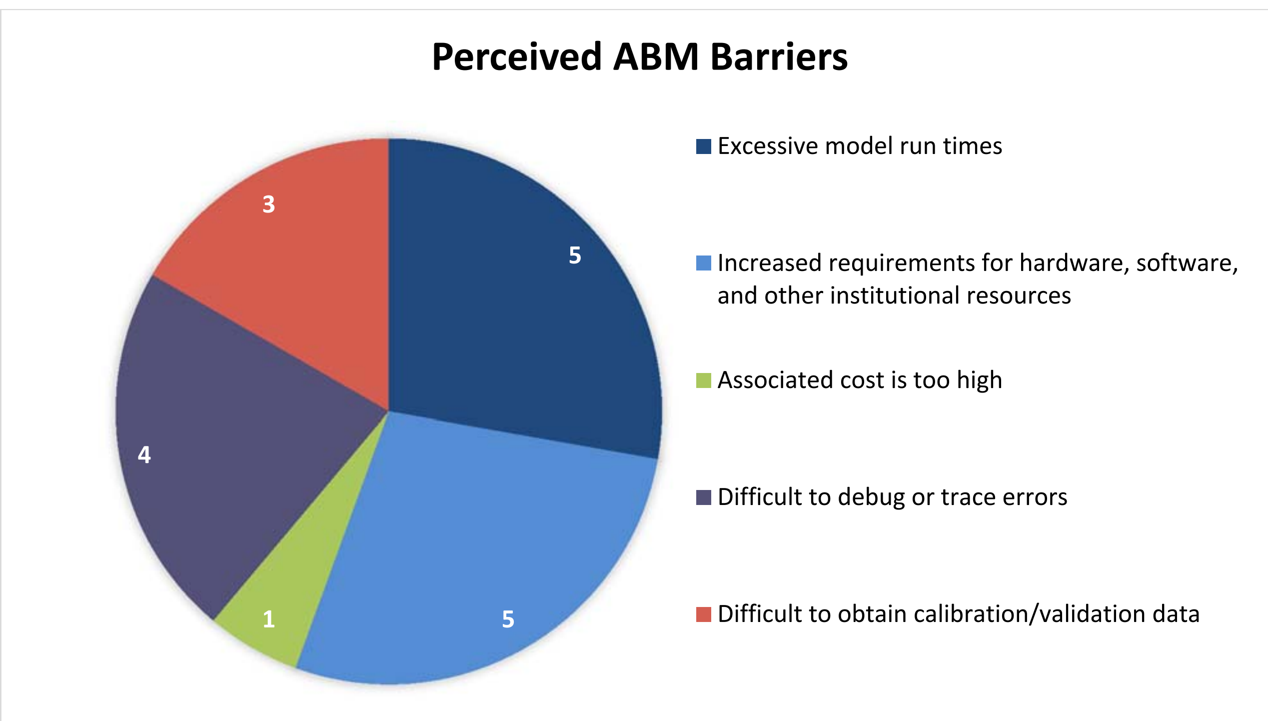


Figure 2.7 Perceived ABM Barriers



Perceived barriers to ABM development and use include excessive model run times (5 responses), increased requirements for hardware, software, and other institutional resources (5 responses), difficulty in debugging or tracing errors (4 responses), difficulty in obtaining calibration/validation data (3 responses), and the high associated costs (1 response); see Figure 2.7. At the same time, one MPO (H-GAC) took time to note in the free-form comments that the run times are not excessive (though they are longer than four-step model) and that they were able to readily assemble the necessary data.

2.4.4 Applications of Models

The uses and intended uses for the ABMs recorded in the survey are numerous; Figure 2.8 illustrates.

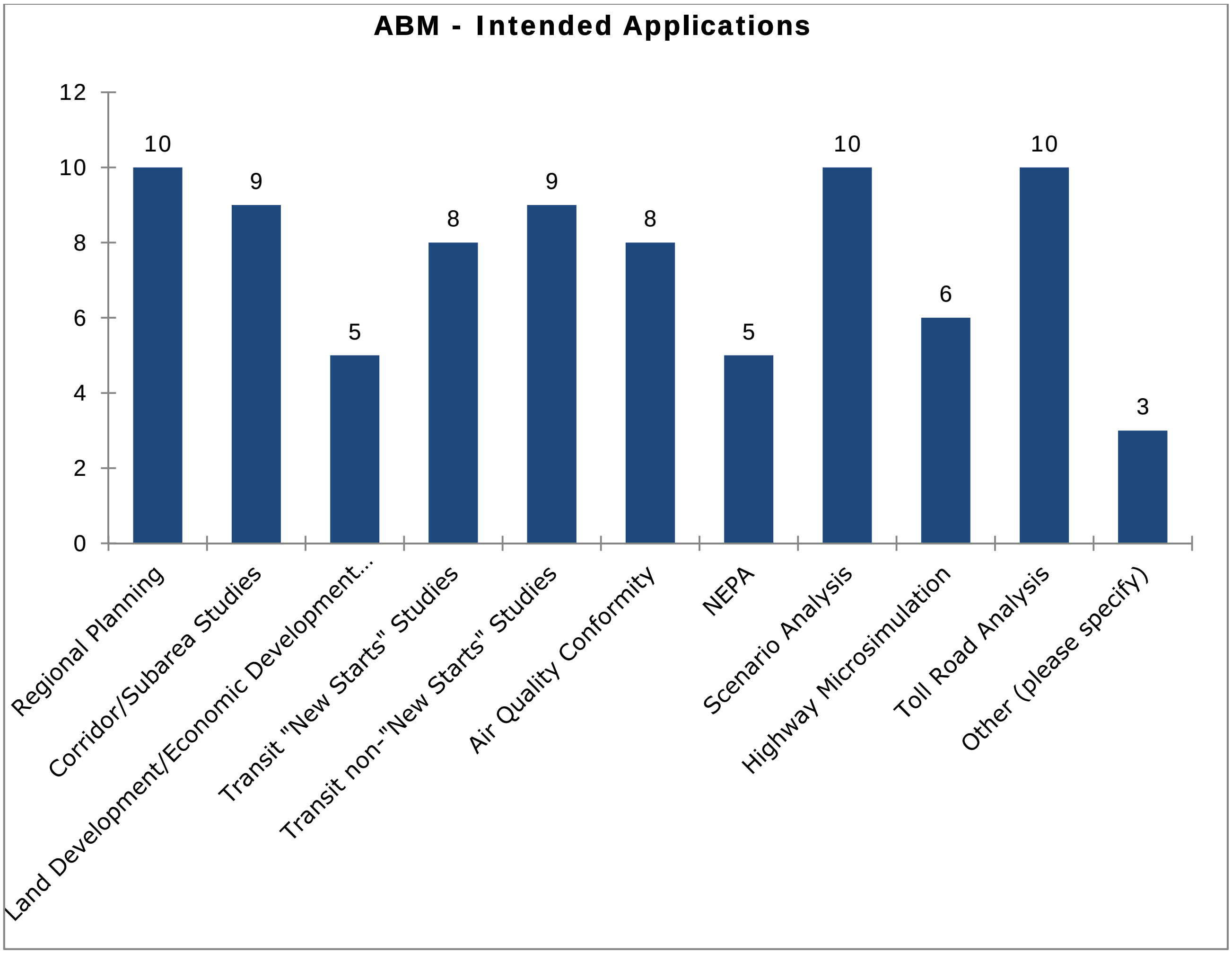
About 10 MPOs indicate that they use or intend to use their ABM for regional planning purposes, another 10 for scenario analyses, and 9 for corridor and/or subarea studies.

Many respondents answered that they use or intend to use ABMs for transit, eight for "New Starts" studies, and nine for non-"New Starts" transit studies. Eight MPOs identified air quality conformity as a use or intended use, and five identified NEPA. Houston identified the production of data for environmental justice analysis as a use.

Toll road analysis was another common use, with 10 responses. Highway microsimulation had 6 responses, and land development/economic development studies had 5 responses.

The Twin Cities MPO listed freight analysis as a use or intended use of activity-based modeling, while two MPOs (ARC and H-GAC) listed integration with dynamic traffic assignment in their modeling process.

Figure 2.8 ABM – Intended Applications

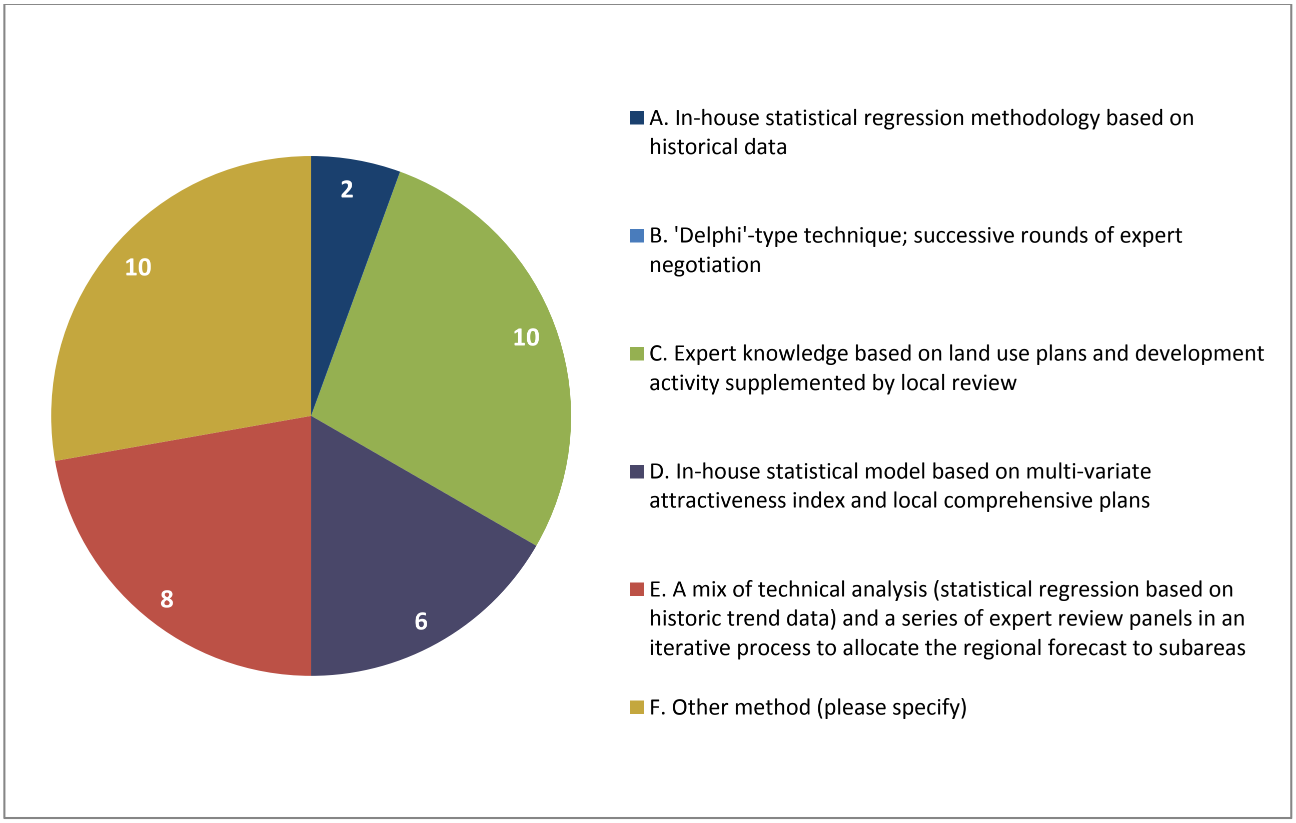


3.0 Land Use Forecasting Techniques/Model

The survey yielded reports of a wide array of techniques being used for land use forecasting (See Figure 3.1). Most (14 MPOs) relied on expert knowledge based on land use plans and development activity, supplemented by local review. Eight MPOs indicated that they use a mix of technical analysis (statistical regression based on trend data) and a series of expert review panels in an iterative process to allocate the regional forecast to subareas. Six respondents used in-house statistical models based on a multivariate attractiveness index and local comprehensive plans, three used "Delphi"-type techniques (successive rounds of expert negotiation), two relied on in-house statistical regression based on historical data, and 10 responses indicated use of some other method.

In land use modeling, six MPOs use UrbanSim, four use PECAS, two use DRAM/EMPAL, two use Cube Land, and six others use or are developing other methods.

Figure 3.1 Technique Used for Land Use / Forecasting



For the MPOs that participated in the survey, most land use forecasting occurred at the transportation analysis zone (TAZ) level (8 responses) or parcel level (7 responses). Two use a grid with cells, and six use different methods – some of which are combinations of resolutions.

4.0 Status of DTA at Peer MPOs

4.1 Overview of DTA

ABMs simulate the development of regional transportation demand while DTA models simulate usage of the transportation supply.

Both ABMs and traditional four-step travel models include a traffic assignment step as part of the process of arriving at roadway segment-level demand. Virtually all regional travel models currently incorporate static traffic assignment methods. These methods produce estimates of travel times, costs, and volumes across relatively broad time periods.

However, in many cases, the analysis and management of transportation network performance requires information about time-varying travel times, costs, and flows. Increasingly, transportation policies incorporate time-varying assumptions. Static traffic assignment approaches cannot represent time-varying flows and congestion or the impacts on travel times and costs with sufficient detail for some analyses. By contrast, dynamic network models have the ability to represent time-varying network time and costs; in addition, they can provide more information on network performance by time of day, which can be used as input into travel model demand components.

Features that distinguish dynamic network methods from static network approaches include the following:

- DTA can be applied at a micro-, meso-, or macroscopic level.
- DTA models can be classified as simulation-based or analytical.
  - Simulation-based DTA models form the great majority of applications.
  - Analytical DTA models use volume-delay or other density-flow curves instead of simulating individual vehicles. Analytical DTA models are faster to run and are easier to calibrate. However, even though they can model time-dependent inputs, fundamental laws of traffic flow, such as the continuity of traffic flow over time, are violated. As a result, they offer a relatively minor improvement over static approaches and their capability to model congestion, its causes, and drivers' reaction is limited.
- In terms of spatial extent, static models are used at the regional or metropolitan scale. Static models are not capable of modeling intersections and corridors properly using analytic functions. In contrast, simulation-based DTA models can be used at any spatial scale from intersection to region.
- In the context of long-range travel demand modeling, both DTA models and static traffic assignment models are based on the Wardrop[12] principle. The difference between the two is that DTA models are based on a *time-varying* version of the Wardrop principle: at equilibrium and *for a given start time*, no driver can unilaterally change paths and improve his or her travel time. For short-range applications when limited information or incidents disrupt the habitual behavior of travelers, DTA models can be used to assess the impact of disequilibrium conditions. DTA models can incorporate more complete representations of transportation network attributes and configurations, including detailed representations of intersection controls, including signal synchronization and other advanced network control schemes.
- DTA models use more realistic flow models to propagate traffic on links rather than using simplified volume-delay functions (VDFs). VDFs may produce unrealistic estimates of network times and volumes.

[12] Wardrop, John Glen. "Some Theoretical Aspects of Road Traffic Research." *Proceedings of the Institution of Civil Engineers* 1, no. 3 (January 1952): 325–62. doi:10.1680/ipeds.1952.11259..

- DTA models provide more detailed estimates of network system performance, which may be essential for accurately evaluating the impacts of alternative transportation policies, systems management, or pricing strategies.

- DTA models provide a different solution (time-dependent flows and travel times) to the same inputs based on the type of simulation they perform and the procedural way they work to achieve equilibrium.

In DTA, simulated drivers try to avoid congestion and select the best route through the network, based on: prior experience, available (and often limited) route information, roadway preferences, and a number of personal characteristics, including value of time (VOT) and travel time reliability. Analytical DTA models use mathematical functions to represent the macroscopic relationships between flow, density, and travel time at the link level. Simulation-based DTA models use miscroscopic, mesoscopic, or macroscopic simulations to represent traffic dynamics, trading off computational tractability with traffic modeling fidelity[13]. For analytical DTA models, there is no distinction between micro, meso, and macro models, as they all use volume density curves. At one end of the spectrum, traffic microsimulation in a DTA context can be used when the utmost fidelity is required. Mesoscopic and macroscopic simulation models, in contrast, are less sensitive to network inputs and weaving phenomena but can simulate driver route choices and congestion over larger regions. Regardless of the traffic simulation fidelity, DTA models have the advantage of simulating both route choice and traffic based on discrete choice and traffic flow theory.

4.1.1 DTA and Static Traffic Assignment Used in Demand Forecasting

Most regional travel demand models assign vehicle trips to their roadway network using static, deterministic user equilibrium (SUE) methodology. This methodology has several benefits:

- Deterministic methodologies result in the same answer each time the model is run with the same inputs;

- Static user equilibrium is relatively quick and easily adapted to distributed processing;

- Years of research and use have led to widespread understanding of the underlying methodology and assumptions;

- The network and validation data needs are relatively small and have been collected for a long period of time to allow for easy "backcasting"; and

- The algorithm is computationally efficient and included in most (if not all) current transportation modeling packages.

Historically, the aggregate approach of static user equilibrium has been sufficient for evaluating capacity-increasing projects such as freeway expansion, and can be used to predict volumes

[13] Helbing, D., "Traffic and related self-driven many-particle systems," Reviews of modern physics 73.4 (2001): 1067.

and travel times on lower-congestion networks. However, as our cities' transportation networks become more and more congested and our ability to match travel demand with increased capacity diminishes, travel modelers need to be able to confidently evaluate the efficacy and feasibility of mitigations and planning measures other than adding lanes for single-occupancy vehicles.

Several problems limit the analysis that can be achieved with static user equilibrium:

- Aggregate link-based travel time functions are calculated irrespective of upstream and downstream congestion and ignore the effects of bottlenecks, intersection geometry and delay, transit vehicle interaction, and queuing.

- Links can be assigned more vehicles than their ultimate capacity, resulting in volume-to-capacity ratios of greater than 1.0.

- Aggregate representation of travel conditions over an entire time period implies that every vehicle traveling over the same link for a particular time period will experience the same travel time on that link, and that travel time is affected by every other vehicle which traverses that link during that time period. As demand increases during peak periods, peak periods become longer, making the reliability of a single travel time representing an entire period suspect.

- Aggregate representation of demand makes it difficult and inefficient to represent variation among individual travelers, such as distributed values of time (VOT) or reliability.

Although DTA borrows the same equilibrium principle from static traffic assignment models, it is not a direct substitute. DTA can be better understood as a large-scale simulation of all the drivers and their actions and interactions with traveler information and the roadway network. At equilibrium, both approaches will produce driver paths that are optimal with respect to driver preferences, but dynamic models have the advantage of incorporating preferences, past experience, and interaction with traveler information at the disaggregate individual level.

The major benefits of using a DTA model are the following:

- Congestion and spill-back effects are properly modeled. Travel times, as a result, are more realistic as compared with the congested times coming from volume-delay functions used in static traffic assignment models, such as the Bureau of Public Roads (BPR) function, conical functions, or Akcelik functions.

- More detailed supply-related scenarios pertaining to signal optimization, synchronization, and other strategies can be modeled.

- More detailed demand-related scenarios pertaining to the use and perception of driver information or response to congestion can be modeled.

- **Disaggregate detail about individual simulated travelers from an ABM can be leveraged into the DTA.** For example, simulated individual value of time can be incorporated into the driver simulation. This way, there is continuity and consistency between the disaggregate nature of both the ABM and the DTA. When a static model is used to perform traffic assignment, valuable traveler information is lost since average values at the TAZ level are instead calculated and used for route choice.

DTA models can take a lot longer to build and calibrate compared to static models because they are much more sensitive to supply and demand inputs, and occasionally may even gridlock if there is excess demand or there are network errors. Below is a comprehensive list of barriers faced when developing and applying DTA models:

- Network development can take significantly longer and allows much less room for error. Network problems can lead to oversaturation or gridlock, but can be hard to detect.
- Higher resolution traffic count data across a greater proportion of links is required to calibrate a model.
- Achieving a high level of equilibrium convergence, which is often indicated by having a relative gap that is below some threshold, is not a given at the outset of the model development. Good convergence might be achieved only after making several network corrections and running a series of calibration steps.
- Iterations can be time consuming. A direct comparison between static and DTA models cannot be made because it depends on the level of traffic fidelity used and the particulars of each DTA model. In general the modeler should expect the DTA model to run a few times longer than the static model. However, this depends on the number of classes used in the static model. Using a large number of classes (e.g., 10) in a static model to better approximate the distribution of VOT and other characteristics would increase the static model run times .
- The large amount of time-dependent output data requires special postprocessing procedures to implement, although DTA packages are becoming more and more capable in this field.

4.1.2 DTA Model Input

Inputs to a DTA model, at a minimum, consist of detailed network information and time-dependent demand tables. Network inputs vary depending on the simulation fidelity. They range from planning-level node-link-capacities in macro models to very detailed network and lane geometry in micro models. Traffic signal information is often among the most important inputs to DTA, but it is not always easy to obtain, especially for large, multijurisdictional regions. When a coarse solution is adequate, signal operations can be simplified. However, in most DTA software tools, signal information needs to be imported from field data.

Input DTA demand, in its simplest form, is a time-varying version of the peak-period demand tables. Diurnal curves are often applied to obtain different time profiles for different trips and parts of the network. Advanced traveler information in the form of individual trips can be passed to a DTA model for simulation. In this case, detailed individual characteristics about the passengers can be used for pretrip and enroute route choice decisions, enhancing the behavioral realism of the simulation.

4.1.3 DTA Model Output

DTA models output both aggregate and disaggregate measures. Aggregate measures include, at a minimum, time-dependent static measures, such as flows, travel times, vehicle miles traveled (VMT), and vehicle hours traveled (VHT). Additional aggregate measures, such as queues, densities, bottleneck location, length, and dissipation time, also are typical outputs. Disaggregate model output includes detailed vehicle trajectories containing the position of each vehicle in each time step. Such model output can be obtained from all types of simulation-based DTA models. Trajectories have potential to inform a variety of analyses. For example, for operational studies, the latest version of the Highway Capacity Manual (HCM) contains the methodology and the software to extract HCM-defined measures such as control delay from simulated trajectories. For planning studies, the Strategic Highway Research Program (SHRP) L04[14], presented a methodology to incorporate reliability performance measures into planning modeling tools based on simulated trajectories.

In mesoscopic and macroscopic DTA models, because vehicle-to-vehicle interactions are not modeled in detail, there is limited value in analyzing second-by-second trajectories. Instead, in such models it is typical to calculate vehicle arrival times at the end of each link and use this information for all further calculations.

4.1.4 DTA for Policy Analysis

DTA greatly expands the range of policy questions to be analyzed because the same model provides both regionwide planning-level and corridor-specific operational-level measures. For planning studies, DTA models can be used for the same types of analyses as static models, such as capacity expansion and tolling studies, but with the benefit of providing better estimates of travel times and traffic congestion. For operational studies, and depending on the level of traffic fidelity used (micro, meso, macro), DTA models can extend the application of traffic simulation models into applications in which more realistic route choice behavior is warranted, including, but not limited to, construction, workzone, tolling, or real-time information provision scenarios.

4.1.5 TRANSIMS

TRANSIMS (TRansportation ANalysis SIMulation System) is a set of transportation modeling software that was originally developed in the 1990's by the Los Alamos National Laboratory

[14] Mahmassani, Hani S., et al. *Incorporating Reliability Performance Measures into Operations and Planning Modeling Tools*. Transportation Research Board, 2014.

and was ultimately evolved into an open source software project[15]. The majority of TRANSIMS deployments were funded through FHWA grants and the developed models have not been adopted for use for production runs for MPO planning or analysis functions (an exception in Northern Virginia is described below).

The TRANSIMS modeling software includes both some ABM and some DTA capabilities. On the ABM side, TRANSIMS includes a population synthesizer and an activity generator. On the DTA side, TRANSIMS includes a multimodal route planner and a traffic microsimulator. The population synthesizer is designed to use census data sets (STF3 and PUMS) as input to create a synthetic household population. The activity generator is designed to generate trip plans for each of the synthetic households using sample records from a detailed household trip survey. The route planner is a multimodal trip router that uses experienced network travel times from previous iterations to find the shortest generalized cost path for each individual to complete their own trip. The traffic microsimulator then simulates the movements of vehicles using those paths across the network infrastructure by using a cellular automata methodology to estimate travel times and operations assessments (speeds, delays, queues) across the transportation system while not violating the maximum capacity of the roadways and control devices such as signals and stop signs.

While the TRANSIMS software has both ABM and DTA components, the majority of the TRANSIMS deployments to date do not rely on the ABM related components and instead use outputs from an existing ABM or 4-step model to estimate the traveler, or more frequently just the vehicular origin-destination demands for travel as an input to the traffic assignment process. The main focus in these cases was to use TRANSIMS to replace the static traffic assignment component of the travel demand model to make estimates of traffic congestion and resulting travel times.

The attributes input for a TRANSIMS network are similar to those needed for other DTA modeling packages. Often, practitioners rely on synthesized or estimated roadway characteristics to construct the networks due to the time that would be required to code network elements to match real-world conditions. One differentiation is that instead of TAZ centroids, TRANSIMS uses individual activity locations along roadways, which in theory are meant to represent the driveways of individual activity locations. However, in practice, these are generally simply disaggregations of the existing TAZs using the roadway classification and/or zonal land use density parameters.

Based on professional experience in developing and using TRANSIMS models, one of the large disadvantages of the TRANSIMS system is the computation time needed to provide a convergence of travel times. A testament to this is that the 1990's design of the TRANSIMS traffic microsimulator used clusters of workstation computers with parallel processing techniques. With improvements in computing power, updates to the software in the last decade allow it to run on a single workstation; but it still requires significant time to perform

[15] Open source software for TRANSIMS can be downloaded from http://code.google.com/p/transims/

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simulations. While the simulator has the ability to change the sizes of the cells used in the simulation, thereby changing the fidelity and computational requirements for the simulation, cells must be kept relatively small (generally equal to one or two vehicles in length) for realistic simulation results. TRANSIMS applications generally require many iterations (100-250 is not uncommon) to approach a stable, or converged, relative gap in the traveler travel times.

As with other DTA software, under certain congested conditions, the simulation of vehicles can create gridlock conditions where throughput drops to zero creating pockets of unrealistic queues, congestion, and travel times. These gridlock conditions complicate and extend the convergence process. Also, comparable to other simulation-based DTA software, the stochastic nature of simulated vehicle movements within the simulation complicate the convergence process and the relative gaps that are typical in static assignment models cannot realistically be achieved.

TRANSIMS Application for Northern Virginia

A recent modeling application using the TRANSIMS software was undertaken for VDOT to develop congestion reduction and mobility improvement evaluation and ratings for transportation projects in Northern Virginia subject to HB-599 (2012) legislation[16]. TRANSIMS was used to estimate the congestion impacts of individual projects through a multi-resolution approach.

This TRANSIMS application began with the existing COG/TPB Cube model network and vehicle trip tables. These were converted to TRANSIMS formats and a process was undertaken to synthesize the additional input details needed: network details (geometric details, lane use, signals and control devices, turn bays, etc.) and trip-making details (zone to activity location disaggregation, time of day disaggregation). During this process, portions of the TPB network were replaced with county-level models that had better network coverage and more network details.

The TRANSIMS model was then calibrated for a regional assignment to existing conditions data sets. Using this existing calibrated network as a base, the future year network for committed projects was then included and the future year demands were then simulated for the region. A subregional subarea was then extracted for the Northern Virginia counties, and a Northern Virginia-only subarea was simulated using a tighter convergence process than was used for the regional assignment.

As the purpose of the study was to estimate the individual congestion and mobility improvements for each project by itself, a third subarea analysis was undertaken for each analyzed project both with and without the subject project added to the network. This local subarea was determined for each project individually by using the TPB model and traditional

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[16] AECOM, *Evaluation and Rating of Significant Projects in Northern Virginia, Technical Report*, Virginia Department of Transportation April 29, 2015, http://www.virginiadot.org/Final_Report_-_v10.pdf

static modeling practices for project analysis to assess the areas of influence of each project (determined as where significant volume changes with and without the project in the TPB model were seen).

Using this project influence subarea definition for each project, a local subarea model was extracted from the Northern Virginia-only model and simulated with and without the subject project in order to determine the changes in congestion as measured by changes in delays and other measures of effectiveness for each individual project. This local subarea analysis process was undertaken both for computational efficiency (to complete the project on time) and to lessen stochastic noise effects in rerouting trips and the resulting changes in congestion levels that were unrelated to the examined improvement project.

While the TRANSIMS process undertaken for the Northern Virginia evaluation study applies some DTA techniques (e.g., estimates of congestion and impacts on travel patterns in discrete time periods), the multiple layers of modeling and detailed input requirements create computational and technical challenges. Nevertheless, the Northern Virginia Transportation Authority is ready to invest further in the development of a TRANSIMS-based platform for its next round of analysis.

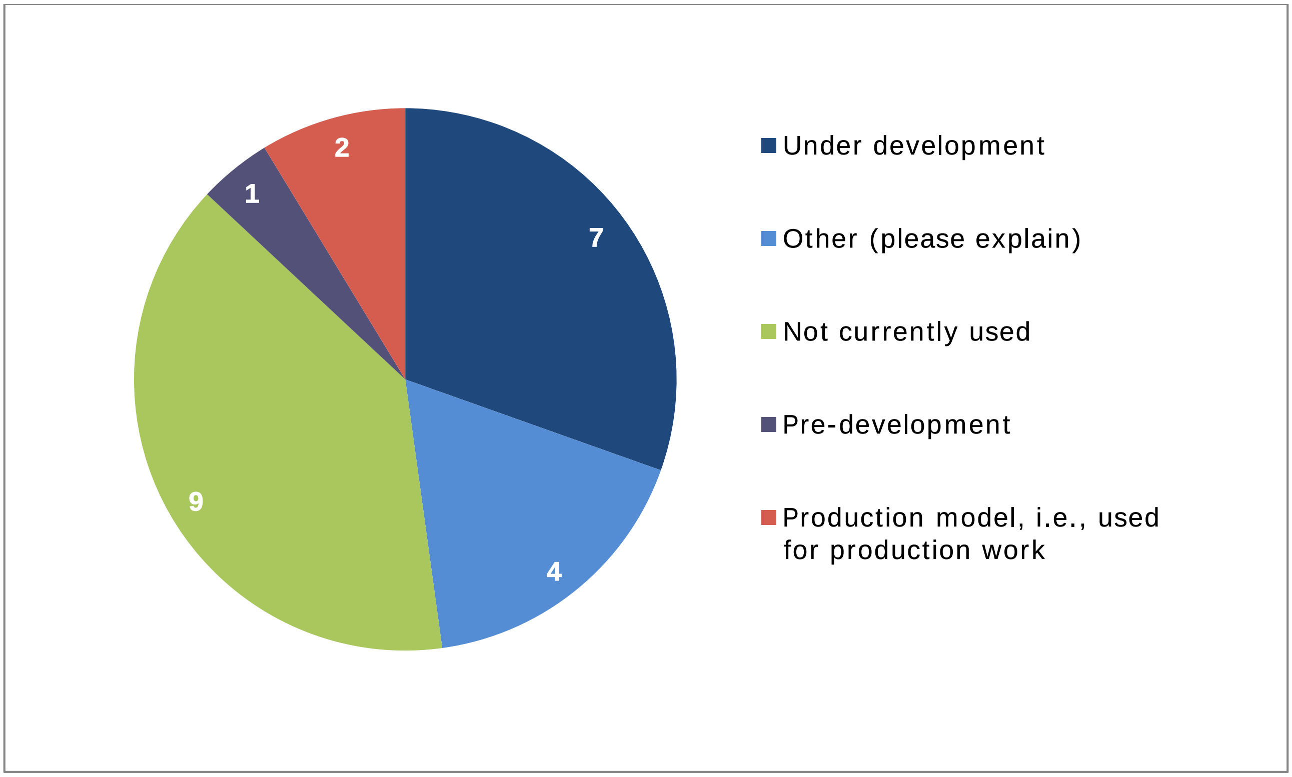
4.2 Survey of Practice

4.2.1 Status of Models

As illustrated in Figure 4.1, only two MPOs (Portland and Phoenix) reported having DTA models in production. Both MPOs reported using the DTA model for corridor/subarea studies, but Phoenix uses the model for regional planning as well. Seven others reported having DTA models under development (Chicago, Twin Cities, Baltimore, Atlanta, Detroit, San Diego, and Columbus), with one other in a “predevelopment” stage (Los Angeles). One of the remaining 13 MPOs reported having calibrated a corridor-level DTA model.

Both production DTA models were reported to take 2 years to develop. Of the 7 DTA models under development, most models have been in development for 1 to 2 years, and are expected to be completed between 1 and 5 years.

Figure 4.1 Status of Dynamic Traffic Assignment

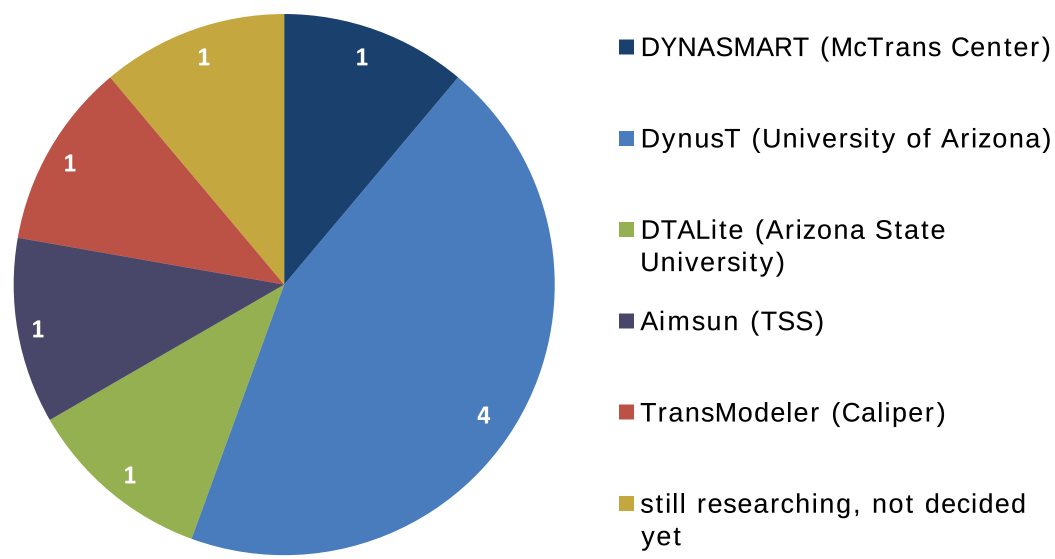


Of the nine MPOs having reported having DTA models currently used in production work or in development, all but one reported also having ABMs in production work or under development. Conversely, of the six MPOs that reported not having ABMs in use, under development, or planned, none reported having DTA models currently, and only one reported having a DTA model under development (Detroit).

4.2.2 Platforms and Software

Of the two dynamic traffic assignment models currently in use for production work, both use the DynusT software from the University of Arizona. Portland also uses Dynameq and Phoenix also uses TransModeler. Of models under development, four intend to use DynusT; and one each of the remaining four intends to use DYNASMART, DTALite, Aimsun, and TransModeler. The Columbus MPO is still researching options and has not yet decided on a software package. Figure 4.2 summarizes responses received regarding usage of specific DTA software packages.

Figure 4.2 Intent to Use Various DTA Software Packages



4.2.3 Benefits/Barriers

The survey explored perceived benefits and barriers among MPOs to adoption of DTA. Both MPOs currently using DTA models see benefits in modeling congestion and travel times more realistically. They also see benefit in using DTA for policy analysis that cannot be effectively performed with static models, as well as in using DTA models as a bridge between planning- and operations-level analyses. One MPO perceives benefit in integrating activity-based modeling with DTA modeling.

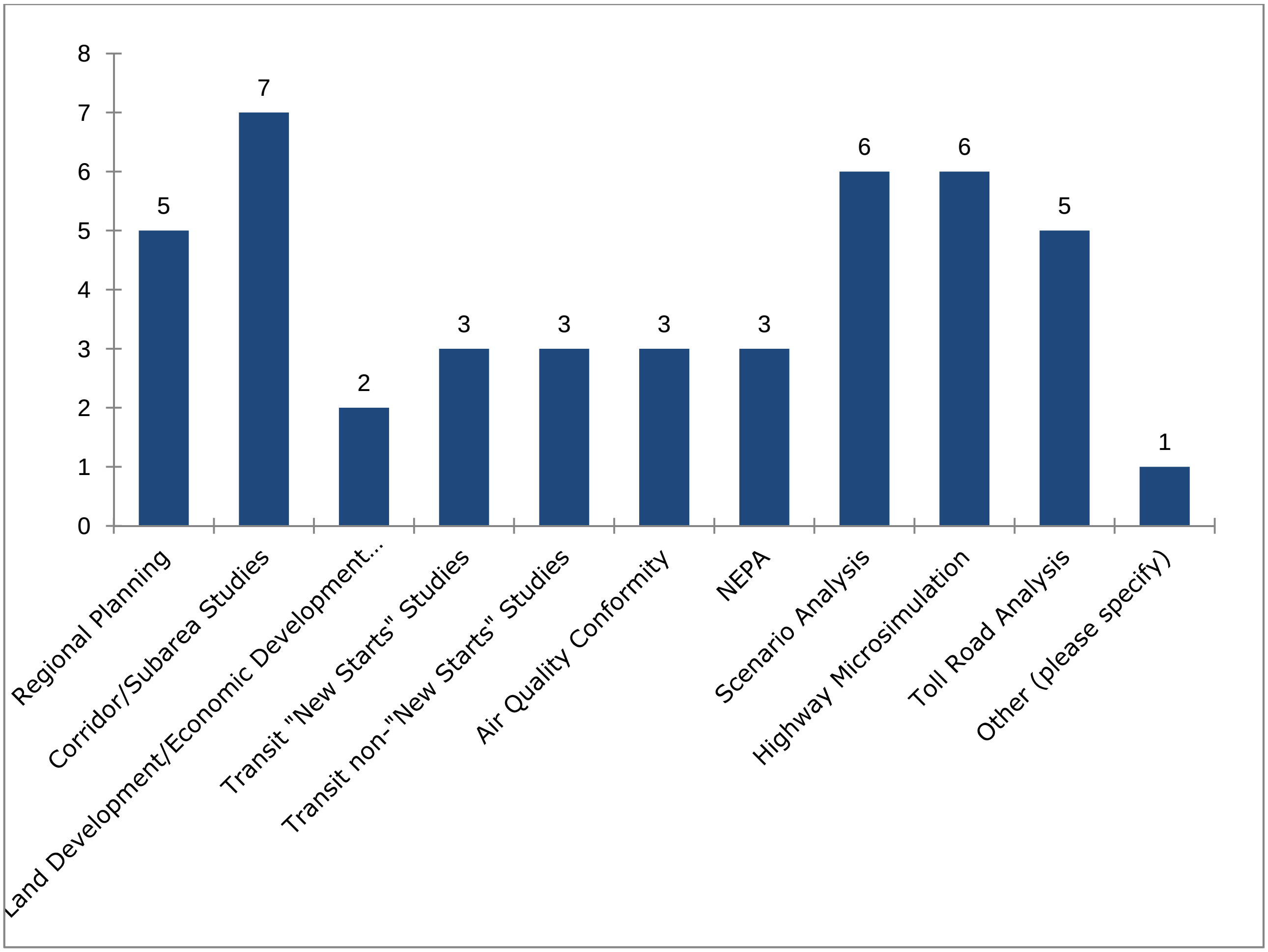
Nearly all the MPOs developing DTA models perceive benefit in modeling congestion and travel times more realistically, for policy analyses that cannot be effectively performed with static models, as a bridge between planning and operations level analyses, and in integrating activity-based modeling with DTA modeling. Other perceived benefits included improved modeling of construction phasing impacts, the ability to use time-dependent shortest path, and freight modeling.

Perceived barriers to using and developing DTA models include difficult-to-interpret results, the availability of necessary data, uncertainty regarding which platform to adopt, model run times, and concern regarding other calibration, data, and application risks.

4.2.4 Applications of Models

Similar to ABMs, the primary intended applications for DTA models are corridor studies (7 respondents) and scenario analysis (6 respondents). Other intended applications include highway microsimulation (6 respondents), toll road analysis (5 respondents), and regional planning (5 respondents). Figure 4.3 summarizes the responses received.

Figure 4.3 DTA – Intended Applications



Fewer MPOs intend to use their DTA models for transit-related studies, with three indicating intent to use for each of “New Starts” and non-“New Starts” transit studies. Fewer MPOs also intent to use DTA models for air quality analysis (3 respondents) and National Environmental Policy Act (NEPA) (3 respondents).

Two MPOs intend to use DTA models for land development/economic development studies. One MPO intends to use their DTA model to support their local jurisdictions’ planning and project design needs.

4.2.5 Cross-Tabulation of ABMs and DTAs

Figure 4.4 below outlines the current status of both ABM and DTA models for all 23 surveyed MPOs. **Currently, none of the MPOs is using both ABMs and DTA models for production work**; however, both Portland and Phoenix, with production DTA models, are developing ABMs; and San Diego and Columbus, with production ABMs, are developing DTA models. Chicago, the Twin Cities, Baltimore, and Atlanta currently are developing both ABMs and DTA models. Washington, D.C.; Newark; Pittsburgh; Dallas; and St. Louis are neither developing nor using ABMs or DTA models.

Figure 4.4 Status of ABM and DTA Models

ABM X DTA Status		DTA Status					
		Production model	Under development	Pre-development	Not currently used	6 Other (please explain)	Grand Total
ABM Status	Production model		2		2	2	6
	Under development	2	4	1	2	1	10
	Pre-development					1	1
	Not currently used		1		5		6
	Grand Total	2	7	1	9	4	23

5.0 MPO Survey Details

5.1 Sample

The 23 MPOs that were part of this survey were listed in Figure 1.1 (on p. 2) and Appendix A. 70 percent (16) of the 23 MPOs, including COG, have a modeled area that is different from their planning area (i.e., it is not unusual to include jurisdictions beyond the planning area).

The 23 participating MPOs make up approximately 45 percent of the population of the United States. A database of MPOs is maintained by the U.S. Department of Transportation's (DOT) Transportation Planning Capacity Building program here: http://www.planning.dot.gov/mpo.asp.

5.2 Methods

The survey consisted of 20 questions, many with multiple parts, which inquired about general MPO characteristics, general travel demand modeling characteristics, and specific characteristics regarding activity-based and DTA modeling. The questions were a mix of multiple-choice and open-ended responses.

The survey was intended to be completed by knowledgeable MPO staff, or consultants designated by MPO staff, and was designed to take about 15 minutes to complete.

Many of the questions asked MPOs to distinguish between models that currently are being used for production work and those under development. In those cases, the words regarding "use" are replaced with "intend to use." Other questions in the survey ask for clarification when necessary, such as when "Other" is selected as an answer.

6.0 Summary Findings

Table 6.1 presents a summary table of the 23 MPOs and their survey responses. To help inform the strategic plan, Section 6.1 synthesizes high-level benefits and barriers to ABM and DTA implementation.

6.1 Summary of ABM and DTA Implementation Benefits and Barriers

6.1.1 Activity-Based Modeling

ABM Benefits/Positives

The primary benefits of ABMs, consistent with responses received from the peer MPO survey, are the following:

- Allow modeling of individual household and personal behavior;
- Provide the ability to model spatial, temporal, and modal aspects of individuals;
- Provide the ability to model tours/journeys as opposed to individual trips;
- Are sensitive to a broader range of policies, demographic segments, or transportation trends such as peak spreading; and
- Recognizing inter-trip dependencies and travel scheduling.

As the survey confirmed, ABMs are currently being used or developed fairly widely among the peer MPO group and a few "typical" approaches are emerging as mainstream practice.

Table 6.1 Modeling Status Summary (Sorted by Population)

MPO Name	MPO Abbreviation	State(s)	Major City	Area (in Square Mile)	Population (2010)	Status of 4-Step Model	Status of ABM	Status of DTA	TDM Software	Land Use Forecasting	Resolution of Land Use Forecast
New York Metropolitan Transportation Council	NYMTC	NY, NJ, CT	NYC	9,738	21,832,100	NCUR	PROD	NCU	TransCAD	Other	TAZ
Southern California Association of Governments	SCAG	CA	Los Angeles	38,000	18,000,000	PROD	UNDER DEV	UNDER DEV	TransCAD	LUM (PECAS)	Multiple
Delaware Valley Regional Planning Commission	DVRPC	PA, NJ, DE, MD	Philadelphia	11,800	11,300,000	PROD	UNDER DEV	NCU	VISUM	Other	TAZ
Chicago Metropolitan Agency for Planning	CMAP	IL, WI, IN	Chicago	7,000	9,000,000	PROD	UNDER DEV	UNDER DEV	EMME	Other	Grid Cell
Metropolitan Transportation Commission	MTC	CA	San Francisco	7,000	7,100,000	NCUR	PROD	UNDER DEV	Cube	LUM (UrbanSim)	Parcel
North Central Texas Council of Governments	NCTCOG	TX	Dallas, Fort Worth	10,000	6,700,000	PROD	NCU	NCU	TransCAD	LUM (DRAM/EMPAL)	Multiple
National Capital Region Transportation Planning Board	**NCRTPB**	**DC, MD, VA, WV**	**Washington, D.C.**	**6,800**	**6,640,189**	**PROD**	**NCU**	**NCU**	**Cube**	**Delphi**	**TAZ**
North Jersey Transportation Planning Authority	NJTPA	NJ, NY, CT, PA	Newark, Jersey City	4,200	6,578,920	PROD	NCU	NCU	Cube	Other	TAZ
Houston-Galveston Area Council	H-GAC	TX	Houston	8,000	5,800,000	PROD	UNDER DEV	UNDER DEV	Cube	LUM (In-house Software)	Parcel

MPO Name	MPO Abbreviation	State(s)	Major City	Area (in Square Mile)	Population (2010)	Status of 4-Step Model	Status of ABM	Status of DTA	TDM Software	Land Use Forecasting	Resolution of Land Use Forecast
Baltimore Regional Transportation Board	BRTB	MD	Baltimore	3,950	5,332,300	PROD	UNDER DEV	UNDER DEV	Cube	Other	TAZ
Atlanta Regional Commission	ARC	GA	Atlanta	6,402	5,250,000	PROD	UNDER DEV	UNDER DEV	Cube	PECAS	Parcel
Maricopa Association of Governments	MAG	AZ	Phoenix	16,000	4,500,000	PROD	UNDER DEV	PROD	TransCAD	LUM (UrbanSim)	Parcel
Puget Sound Regional Council	PSRC	WA	Seattle	6,267	3,690,900	PROD	UNDER DEV	NCU	EMME	Delphi, LUM (UrbanSim)	Parcel
Metropolitan Council	Metropolitan Council	MN, WI	Twin Cities	10,499	3,540,040	PROD	UNDER DEV	UNDER DEV	Cube	LUM (CUBE LAND)	City
San Diego Association of Governments	SANDAG	CA	San Diego	4,235	3,095,000	PROD	PROD	UNDER DEV	TransCAD	Delphi, PECAS	Parcel
Boston Region MPO	BRMPO	MA	Boston	1,405	3,037,300	PROD	UNDER DEV	NCU	TransCAD	LUM (DRAM/EMPAL)	Parcel, TAZ
Denver Regional Council of Governments	DRCOG	CO	Denver	6,251	2,844,662	NCUR	PROD	UNDER DEV	TransCAD	Other	TAZ
Southwestern Pennsylvania Commission	SPC	PA	Pittsburgh	7,100	2,500,000	PROD	NCU	NCU	Cube	LUM (In-house model)	TAZ
East West Gateway Council of Governments	EWGCOG	MO, IL	St. Louis	4,500	2,400,000	PROD	NCU	NCU	Cube	Other	Grid Cell
Sacramento Area Council of Governments	SACOG	CA	Sacramento	6,000	2,240,000	NCUR	PROD	NCU	Cube	LUM (PECAS)	TBA
Southeast Michigan Council of Governments	SEMCOG	MI	Detroit	4,627	1,802,000	PROD	NCU	UNDER DEV	TransCAD	LUM (UrbanSim)	Parcel

MPO Name	MPO Abbreviation	State(s)	Major City	Area (in Square Mile)	Population (2010)	Status of 4-Step Model	Status of ABM	Status of DTA	TDM Software	Land Use Forecasting	Resolution of Land Use Forecast
Portland Metro	Metro	OR, WA	Portland	3,700	1,800,000	PROD	UNDER DEV	PROD	EMME	LUM (MetroScope)	TAZ
Mid-Ohio Regional Planning Commission	MORPC	OH	Columbus	2,320	1,659,582	NCU	PROD	UNDER DEV	CT-RAMP	Other	Grid Cell, TAZ
Total	--	--	--	185,794	133,605,693	--	--	--	--	--	--

Legend:

PROD – Production model (i.e., used for production work).

UNDER DEV – Under development, predevelopment..

NCU – Not currently used.

NCUR – Not currently used, but was used formerly (i.e., retired).

Note: Area and Population are for the modeled area and were self-reported by the survey respondents. CMAP, Metropolitan Council, BRTB/BMC, ARC, Portland Metro, DVRPC, PSRC, SCAG, H-GAC and MAG are currently developing an AMB. The Boston MPO is in a “predevelopment” stage.

ABM Barriers/Negatives

Negative aspects of ABM and perceived barriers to implementation noted through the survey included:

- Longer model run times as compared with four-step models, although this is becoming more tolerable with faster computing capabilities and software infrastructure; For example, in comparing a four-step model to an ABM in Austin, Texas, Lemp and Kockelman found that "a single run of the activity-based model was approximately 40 times longer" than a run of the four-step model.[17]
- Increased requirements for hardware, software, and other institutional resources compared to traditional demand models;
- Complexity of the models creates more difficulty in application as well as in debugging or tracing errors;
- Increased difficulty in obtaining calibration/validation data, although this can sometimes be mitigated by validation of selected submodels at a more aggregate level; and
- Higher costs associated with model development, application, and maintenance. The number of parameters and models to estimate in an ABM is usually much greater than that for a four-step model. For example, referring again to the 2009 study in Austin, Lemp and Kockelman noted the following:

  > *Of course, there is no questioning that the estimation, calibration, and implementation of an activity-based microsimulation approach is a much more computationally and time-consuming endeavor than its aggregate counterpart. Here, the activity-based model required the estimation of 621 parameters across 43 models, while aggregate model required just 132 parameters across 13 models. (p. 16)*

The ultimate question is whether the benefits of the ABM outweigh its costs.

[17] Jason D. Lemp and Kara M. Kockelman, "Anticipating Welfare Impacts via Travel Demand Forecasting Models: Comparison of Aggregate and Activity-Based Approaches for the Austin, Texas Region," in *Compendium of Papers DVD, Transportation Research Board 88th Annual Meeting* (presented at the Transportation Research Board 88th Annual Meeting, January 11-15, 2009, Washington, D.C., 2009), 17.

6.1.2 DTA Modeling

DTA Benefits/Positives

Positive aspects of DTA modeling and benefits noted through the survey, included:

- Benefits in modeling congestion and travel times more realistically, which translates into better calibration results and forecasts;
- Potential to incorporate consideration of availability of traveler information, attitudes, preferences, and values in route choice modeling;
- The ability to model peak spreading, travel time reliability, and congestion more effectively.

DTA Barriers/Negatives

Negative aspects of DTA modeling and potential barriers to implementation noted through the survey, included:

- Higher level of effort for network development. Network problems can lead to oversaturation or gridlock.
- Requires robust count data and network information to calibrate.
- Achieving a high level of equilibrium convergence, which is often indicated by having a relative gap that is below some threshold, is not a given at the outset of the model development. Good convergence might be achieved only after making several network corrections and running a series of calibration steps.
- Iterations can be time consuming and equilibrium may be reached only after several iterations (depending on the DTA model involved). A direct comparison between static and DTA models cannot be made because it depends on the level of traffic fidelity used and the particulars of each DTA model.
- The large amount of time-dependent output data requires special postprocessing procedures to implement, although DTA packages are becoming more efficient.
- A variety of software with varying approaches and analytical capabilities are being employed in the present application environment (i.e., practice is still developing).

7.0 Conclusions

This report is intended to inform the development of the strategic plan. The following conclusions follow from our review of the status of ABM and DTA that are important to consider in moving forward with a strategic plan:

- Currently, approximately 70 percent of the surveyed peer MPOs are using or developing an ABM. Currently, the same number of MPOs are using ABMs as are not using ABMs, but given the development activity, this is unlikely to remain the case;
- Although there are several aspects of transportation planning applications that aggregate, trip-based models address well, ABMs have the ability to more effectively address complex policy questions[18] and they are well suited to feed into disaggregate traffic assignment methods;
- The time required to develop an ABM is significantly less than what it has been in the past; and
- DTA is not yet state of the practice, particularly at the regional level; only two of the 23 peer MPOs are using it in production.

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[18] Lawe, Stephen, John Gliebe, and John Lobb. *The ARC and SACOG Experience with Activity-Based Models: Synthesis and Lessons Learned*. Final. Washington, D.C.: Association of Metropolitan Planning Organizations and Federal Highway Administration, May 2012, p. 10. http://tfresource.org/The_ARC_and_SACOG_Experience_with_Activity-Based_Models_-_Synthesis_and_Lessons_Learned.

Appendix A. Travel Modeling Mangers who Completed the Survey of MPOs

We wish to thank the MPO modeling managers, listed below, who completed the MPO survey. In many cases, these managers reached out to others on staff, so we wish to thank all staff who contributed to this effort.

MPO Name	**Acronym**	**City**	**Modeling Manager**
Southern California Association of Governments	SCAG	Los Angeles, CA	Guoxiong Huang
New York Metropolitan Transportation Council	NYMTC	New York City, NY	Ali Mohseni
The Chicago Metropolitan Agency for Planning	CMAP	Chicago, IL	Kermit Wies
Metropolitan Transportation Commission	MTC	San Francisco, CA	David Ory
North Jersey Transportation Planning Authority	NJTPA	Newark, Jersey City, NJ	Bob Diogo
North Central Texas Council of Governments	NCTCOG	Dallas and Fort Worth, TX	Arash Mirzaei
Houston-Galveston Area Council	H-GAC	Houston, TX	Chris Van Slyke
Delaware Valley Regional Planning Commission	DVRPC	Philadelphia, PA	Matthew Gates
National Capital Region Transportation Planning Board	NCRTPB	Washington, D.C.	Mark Moran
Atlanta Regional Commission	ARC	Atlanta, GA	Guy Rousseau
Southeast Michigan Council of Governments	SEMCOG	Detroit, MI	Liyang Feng
Maricopa Association of Governments	MAG	Phoenix, AZ	Vladimir Livshits
Puget Sound Regional Council	PSRC	Seattle, WA	Suzanne Childress
Boston Region MPO		Boston, MA	Scott Peterson
San Diego Association of Governments	SANDAG	San Diego, CA	Clint Daniels
Metropolitan Council		Twin Cities of Minneapolis and Saint Paul, MN	Mark Filipi

MPO Name	Acronym	City	Modeling Manager
Denver Regional Council of Governments	DRCOG	Denver, CO	Hamideh Etemadnia
Baltimore Regional Transportation Board	BRTB	Baltimore, MD	Charles Baber
Southwestern Pennsylvania Commission	SPC	Pittsburgh, PA	Chuck Imbrogno
East-West Gateway Council of Governments	EWGCOG	Saint Louis, MO	Lubna Shoaib
Sacramento Area Council of Governments*	SACOG	Sacramento, CA	Bruce Griesenbeck
Portland Metro*	Metro	Portland, OR	Richard Walker
Mid-Ohio Regional Planning Commission*	MORPC	Columbus, OH	Zhuojun Jiang

* Although these three MPOs were not part of the list of the 20 largest MPOs in the U.S., they were added to the list of peer MPOs due to their reputation for innovation.

Appendix B. MWCOG – MPO Survey

Survey of Large MPOs to Assess the State of Modeling Practice

The National Capital Region Transportation Planning Board (TPB) is the Metropolitan Planning Organization (MPO) for the Washington, D.C. metropolitan area, and is one of several policy boards that meet at the Metropolitan Washington Council of Governments (COG). COG/TPB staff is working with Cambridge Systematics, Inc. to develop a multiyear, strategic plan for the COG/TPB models development program. The plan will consider the state-of-the-modeling practice at peer MPOs. Your agency has been identified as a peer MPO of interest. The list of peer MPOs is composed of the 20 largest MPOs in the U.S., based on 2010 population, plus three smaller MPOs that are known for innovative work. This list of peer MPOs can be found in an attachment to the email used to distribute this survey (COG/TPB is #9 on the list). This survey covers modeling techniques that are being used and developed at the peer MPOs. The survey is intended for technical professionals who are using and developing regional travel demand models at these 23 MPOs. It is preferred that the survey be completed by MPO staff, but it may, instead, be completed by consultants designated by the MPO staff. We prefer one response from each MPO, and this response should represent the position/policy of the agency. Please help us ensure that this survey gets to the appropriate individual in your agency. This survey should take about 10 to 15 minutes to complete. We will be happy to share study findings with all participants. If you would like to save a copy of the survey and your responses, you may provide your email address at the end of the survey and a copy will be sent to you in approximately one minute. If you have questions about this survey, please contact Mark Moran, Principal Transportation Engineer, Metropolitan Washington Council of Governments, mmoran@mwcog.org.

IDENTIFICATION SECTION

1. Please provide the following information.
   Respondent's Name
   Respondent's Position/Title:
   Respondent's Years of Experience in Travel Modeling:
   MPO name
   MPO abbreviation

2. Is your MPO associated with a council of governments or a regional council?
   - ❍ Yes
   - ❍ No

2a. Name of COG or regional council

3. Is your MPO planning area different from your modeled area?
   - ❍ Yes
   - ❍ No

4. [Question #4 omitted in final version]

5. State(s) included in modeled area (please use abbreviations. For example, VA for Virginia)

6. Principal city for your modeled area

7. Area (sq. miles) of your modeled area

8. Population (2010) of your modeled area

MODEL STATUS AND TYPES SECTION

9a. Status of trip-based/four-step model

- ❍ Production model, i.e., used for production work
- ❍ Under development
- ❍ Pre-development, i.e., have made a formal announcement about the plan to develop such a model, such as issuing an RFP to begin development of such a model
- ❍ Not currently used
- ❍ Not currently used, but was used formerly, i.e., retired
- ❍ Other (please explain) ____________________

Please explain your choice of "Not currently used, but was used formerly"

9b. Please specify what software was used (please check all options that apply) ***[Variant based on 9a – Production Model]***

- ❑ Cube (Citilabs)
- ❑ EMME (INRO)
- ❑ TransCAD (Caliper)
- ❑ VISUM (PTV)
- ❑ Other (please specify) ____________________

9b. Please specify what software is being used (please check all options that apply) ***[Variant based on 9a – Under Development]***

- ❑ Cube (Citilabs)
- ❑ EMME (INRO)
- ❑ TransCAD (Caliper)
- ❑ VISUM (PTV)
- ❑ Other (please specify) ____________________

9b. What software do you intend to use? (please check all options that apply) ***[Variant based on 9a – Pre-Development]***

- ❑ Cube (Citilabs)
- ❑ EMME (INRO)
- ❑ TransCAD (Caliper)
- ❑ VISUM (PTV)
- ❑ Other (please specify) ____________________

9b. Software used (please check all options that apply) ***[Variant based on 9a – Not currently used]***

- ❑ Cube (Citilabs)
- ❑ EMME (INRO)
- ❑ TransCAD (Caliper)
- ❑ VISUM (PTV)
- ❑ Other (please specify) ____________________

10a. Status of tour-based/activity-based model (ABM)

- ❑ Production model, i.e., used for production work
- ❑ Under development
- ❑ Pre-development, i.e., have made a formal announcement about the plan to develop such a model, such as issuing an RFP to begin development of such a model
- ❑ Not currently used
- ❑ Not currently used, but was used formerly, i.e., retired
- ❑ Other (please explain) ____________________

Please explain your choice of "Not currently used, but was used formerly"

10b. Please specify what software and platform was used (please check all options that apply) ***[Variant 3, based on answer to 10a – Production Model]***

- ❑ CT-RAMP (Parsons Brinckerhoff)
- ❑ DaySim (Resource Systems Group)
- ❑ TourCast (Cambridge Systematics)
- ❑ Cube (Citilabs)
- ❑ EMME (INRO)
- ❑ TransCAD (Caliper)
- ❑ VISUM (PTV)
- ❑ Don't know
- ❑ Other (please specify) ____________________

10b. Please specify what software and platform is being used (please check all options that apply) ***[Variant 2, based on answer to 10a – Under Development]***

- ❑ CT-RAMP (Parsons Brinckerhoff)
- ❑ DaySim (Resource Systems Group)
- ❑ TourCast (Cambridge Systematics)
- ❑ Cube (Citilabs)
- ❑ EMME (INRO)
- ❑ TransCAD (Caliper)
- ❑ VISUM (PTV)
- ❑ Don't know
- ❑ Other (please specify) ____________________

10b. What software and platform do you intend to use? (please check all options that apply) ***[Variant 1, based on answer to 10a – Pre-Development]***

- ❑ CT-RAMP (Parsons Brinckerhoff)
- ❑ DaySim (Resource Systems Group)
- ❑ TourCast (Cambridge Systematics)
- ❑ Cube (Citilabs)
- ❑ EMME (INRO)
- ❑ TransCAD (Caliper)
- ❑ VISUM (PTV)
- ❑ Don't know
- ❑ Other (please specify) ____________________

11a. Status of your Dynamic Traffic Assignment (DTA) model

- ❍ Production model, i.e., used for production work
- ❍ Under development
- ❍ Pre-development, i.e., have made a formal announcement about the plan to develop such a model, such as issuing an RFP to begin development of such a model
- ❍ Not currently used
- ❍ Not currently used, but was used formerly, i.e., retired
- ❍ Other (please explain) ____________________

Please explain your choice of "Not currently used, but was used formerly"

[Variant 1, based on answer to 11a – Pre-Development]

11b. What software do you intend to use? (please check all options that apply)

- ❑ Aimsun (TSS)
- ❑ Cube Avenue (Citilabs)
- ❑ DTALite (Arizona State University)
- ❑ Dynameq (INRO)
- ❑ DynaMIT (MIT)
- ❑ DYNASMART (McTrans Center)
- ❑ DynusT (University of Arizona)
- ❑ Paramics (Quadstone or SIAS)
- ❑ TRANSIMS (FHWA)
- ❑ TransModeler (Caliper)
- ❑ VISTA (Vista Transport Group)
- ❑ VISUM (PTV)
- ❑ Don't know
- ❑ Other (please specify) ____________________

[Variant 2, based on answer to 11a – Under Development]

11b. Please specify what software is being used (please check all options that apply)

- ❑ Aimsun (TSS)
- ❑ Cube Avenue (Citilabs)
- ❑ DTALite (Arizona State University)
- ❑ Dynameq (INRO)
- ❑ DynaMIT (MIT)
- ❑ DYNASMART (McTrans Center)
- ❑ DynusT (University of Arizona)
- ❑ Paramics (Quadstone or SIAS)
- ❑ TRANSIMS (FHWA)
- ❑ TransModeler (Caliper)
- ❑ VISTA (Vista Transport Group)
- ❑ VISUM (PTV)
- ❑ Don't know
- ❑ Other (please specify) ____________________

[Variant 3, based on answer to 11a – Production Model]

11b. Please specify what software was used (please check all options that apply)

- ❑ Aimsun (TSS)
- ❑ Cube Avenue (Citilabs)
- ❑ DTALite (Arizona State University)
- ❑ Dynameq (INRO)
- ❑ DynaMIT (MIT)
- ❑ DYNASMART (McTrans Center)
- ❑ DynusT (University of Arizona)
- ❑ Paramics (Quadstone or SIAS)
- ❑ TRANSIMS (FHWA)
- ❑ TransModeler (Caliper)
- ❑ VISTA (Vista Transport Group)
- ❑ VISUM (PTV)
- ❑ Don't know
- ❑ Other (please specify) ____________________

LAND USE SECTION

12. What techniques/methods do you use for land use forecasting? (please check all options that apply) (letters denote methods; numbers denote models)
    - ❑ A. In-house statistical regression methodology based on historical data
    - ❑ B. ‘Delphi’-type technique – successive rounds of expert negotiation
    - ❑ C. Expert knowledge based on land use plans and development activity supplemented by local review
    - ❑ D. In-house statistical model based on multi-variate attractiveness index and local comprehensive plans
    - ❑ E. A mix of technical analysis (statistical regression based on historic trend data) and a series of expert review panels in an iterative process to allocate the regional forecast to subareas
    - ❑ F. Other method (please specify) ____________________
    - ❑ 1. CUF
    - ❑ 2. DELTA
    - ❑ 3. DRAM/EMPAL
    - ❑ 4. IRPUD
    - ❑ 5. LTM
    - ❑ 6. LUCAS
    - ❑ 7. Markov
    - ❑ 8. MEPLAN
    - ❑ 9. METROSIM
    - ❑ 10. PECAS
    - ❑ 11. SAM-IM
    - ❑ 12. SLEUTH
    - ❑ 13. TRANUS
    - ❑ 14. UrbanSim
    - ❑ 15. Other model (please specify) ____________________

13. Resolution for land use forecasting
    - ❍ Parcel
    - ❍ Grid Cell
    - ❍ TAZ
    - ❍ TAD
    - ❍ Other (please specify) ____________________

ABM SECTION

[Variant 1, depending on answer to Question 10a – Production Model]

14a. How many years were required to develop your ABM?

14b. In what year did development finish? (4-digit format between 1980 and 2025)

15. Please indicate the types of studies or applications for which you have used your ABM (please check all options that apply)
- ❑ Regional Planning
- ❑ Corridor/Subarea Studies
- ❑ Land Development/Economic Development Studies
- ❑ Transit "New Starts" Studies
- ❑ Transit non-"New Starts" Studies
- ❑ Air Quality Conformity
- ❑ NEPA
- ❑ Scenario Analysis
- ❑ Highway Microsimulation
- ❑ Toll Road Analysis
- ❑ Other (please specify) ____________________
- ❑ None

[Variant 2, depending on answer to Question 10a – Model Under Development]

14a. How many years have you spent developing your ABM so far?

14b. How many more years do you expect will be needed before the ABM is ready for production use?

15. Please indicate the types of studies or applications for which you intend to use your ABM (please check all options that apply)
- ❑ Regional Planning
- ❑ Corridor/Subarea Studies
- ❑ Land Development/Economic Development Studies
- ❑ Transit "New Starts" Studies
- ❑ Transit non-"New Starts" Studies
- ❑ Air Quality Conformity
- ❑ NEPA
- ❑ Scenario Analysis
- ❑ Highway Microsimulation
- ❑ Toll Road Analysis
- ❑ Other (please specify) ____________________
- ❑ None

[Variant 3, depending on answer to Question 10a – Model Abandoned]

14a. How many years did you spend developing your ABM before abandoning its development?

14b. Why did you abandon its development?

15. Please indicate the types of studies or applications for which you have used your ABM (please check all options that apply)
   - ❑ Regional Planning
   - ❑ Corridor/Subarea Studies
   - ❑ Land Development/Economic Development Studies
   - ❑ Transit “New Starts” Studies
   - ❑ Transit non-”New Starts” Studies
   - ❑ Air Quality Conformity
   - ❑ NEPA
   - ❑ Scenario Analysis
   - ❑ Highway Microsimulation
   - ❑ Toll Road Analysis
   - ❑ None
   - ❑ Other (please specify) ____________________
   - ❑ None

[Variant 4, depending on answer to Question 10a – Pre-Development]

15. Please indicate the types of studies or applications for which you intend to use your ABM (please check all options that apply)
   - ❑ Regional Planning
   - ❑ Corridor/Subarea Studies
   - ❑ Land Development/Economic Development Studies
   - ❑ Transit “New Starts” Studies
   - ❑ Transit non-”New Starts” Studies
   - ❑ Air Quality Conformity
   - ❑ NEPA
   - ❑ Scenario Analysis
   - ❑ Highway Microsimulation
   - ❑ Toll Road Analysis
   - ❑ Other (please specify) ____________________
   - ❑ None

[Questions 16-17 asked of ABM Production Model or Under Development]

ABM 16. How many in-house staff do you have working on ABM DEVELOPMENT?
   - ❍ 0
   - ❍ 1-2
   - ❍ 3-4
   - ❍ 5-6
   - ❍ 7+

ABM 17. How many in-house staff do you have working on ABM APPLICATION?
   - ❍ 0
   - ❍ 1-2
   - ❍ 3-4
   - ❍ 5-6
   - ❍ 7+

[Variant 1, depending on answer to Question 10a]

ABM 18. What are the benefits of developing an ABM to your organization? (please check all options that apply)

- ❑ Ability to model tours/journeys (as opposed to simply individual trips)
- ❑ Ability to model spatial, temporal, and modal aspects of individuals
- ❑ Modeling individual household and person behavior
- ❑ Sensitivity to broader range of policies (understanding travel behavior of a certain age group or income category; peak spreading)
- ❑ Travel scheduling and recognizing inter-trip dependence
- ❑ Other (please specify) ____________________

ABM 19. What barriers did you encounter in trying to develop an ABM? (please check all options that apply)

- ❑ Associated cost is too high
- ❑ Increased requirements for hardware, software, and other institutional resources
- ❑ Excessive model run times
- ❑ Difficult to debug or trace errors
- ❑ Difficult to obtain calibration/validation data
- ❑ Other (please specify) ____________________

[Variant 2, depending on answer to Question 10a]

ABM 18. What benefits do you foresee in developing an ABM? (please check all options that apply)

- ❑ Ability to model tours/journeys (as opposed to simply individual trips)
- ❑ Ability to model spatial, temporal, and modal aspects of individuals
- ❑ Modeling individual household and person behavior
- ❑ Sensitivity to broader range of policies (understanding travel behavior of a certain age group or income category; peak spreading)
- ❑ Travel scheduling and recognizing inter-trip dependence
- ❑ Other (please specify) ____________________

ABM 19. What barriers do you foresee in trying to develop an ABM (please check all options that apply)

- ❑ Associated cost is too high
- ❑ Increased requirements for hardware, software, and other institutional resources
- ❑ Excessive model run times
- ❑ Difficult to debug or trace errors
- ❑ Difficult to obtain calibration/validation data
- ❑ Other (please specify) ____________________

DTA SECTION

[Variant 1, based on answer to Question 11a – Model Developed]

14a. How many years were required to develop your DTA model?

14b. In what year did development finish? (4-digit format between 1980 and 2025)

15. Please indicate the types of studies or applications for which you have used your DTA model (please check all options that apply)

- ❑ Regional Planning
- ❑ Corridor/Subarea Studies
- ❑ Land Development/Economic Development Studies
- ❑ Transit "New Starts" Studies
- ❑ Transit non-"New Starts" Studies
- ❑ Air Quality Conformity
- ❑ NEPA
- ❑ Scenario Analysis
- ❑ Highway Microsimulation
- ❑ Toll Road Analysis
- ❑ Other (please specify) ____________________

[Variant 2, based on answer to Question 11a – Under Developed]

14a. How many years have you spent developing your DTA model so far?

14b. How many more years do you expect will be needed before the DTA model is ready for production use?

15. Please indicate the types of studies or applications for which you intend to use your DTA model (please check all options that apply)

- ❑ Regional Planning
- ❑ Corridor/Subarea Studies
- ❑ Land Development/Economic Development Studies
- ❑ Transit "New Starts" Studies
- ❑ Transit non-"New Starts" Studies
- ❑ Air Quality Conformity
- ❑ NEPA
- ❑ Scenario Analysis
- ❑ Highway Microsimulation
- ❑ Toll Road Analysis
- ❑ Other (please specify) ____________________

[Variant 3, based on answer to Question 11a – Abandoned]

14a. How many years did you spend developing your DTA model before abandoning its development?

14b. Why did you abandon its development?

15. Please indicate the types of studies or applications for which you intend to use your DTA model (please check all options that apply)
    - ❑ Regional Planning
    - ❑ Corridor/Subarea Studies
    - ❑ Land Development/Economic Development Studies
    - ❑ Transit "New Starts" Studies
    - ❑ Transit non-"New Starts" Studies
    - ❑ Air Quality Conformity
    - ❑ NEPA
    - ❑ Scenario Analysis
    - ❑ Highway Microsimulation
    - ❑ Toll Road Analysis
    - ❑ Other (please specify) ____________________

[Questions 16-17 asked of DTA Production Model or Under Development]

DTA 16. How many in-house staff do you have working solely on DTA model DEVELOPMENT?
- ❍ 0
- ❍ 1-2
- ❍ 3-4
- ❍ 5-6
- ❍ 7+

DTA 17. How many in-house staff do you have working solely on DTA model APPLICATION?
- ❍ 0
- ❍ 1-2
- ❍ 3-4
- ❍ 5-6
- ❍ 7+

[Variant 1, depending on answer to Question 11a]

DTA 18. What are the benefits of developing a DTA model, to your organization? (please check all options that apply)
- ❑ Policy analyses that cannot be effectively performed with static models. (For example, detailed pricing studies that require accurate travel time information by small time slices)
- ❑ Integration of ABM with DTA model
- ❑ Modeling congestion more realistically and ability to get more realistic travel times
- ❑ Using a simulation-based DTA model as a bridge between planning and operations level analyses.
- ❑ Other (please specify) ____________________

DTA 19. What barriers did you encounter in trying to develop a DTA model? (please check all options that apply)
- ❑ Not feasible in my region because it will take too long to run.
- ❑ Requires more data than available or accessible
- ❑ Satisfied with the modeling performance I get from the existing static model
- ❑ Not quite sure what DTA is and how it can help my agency
- ❑ Results are difficult to interpret

- ❑ Requires significant resources that we do not currently have
- ❑ Unclear about benefits
- ❑ Unsure which platform to adopt
- ❑ Other (please specify) ____________________

[Variant 2, depending on answer to Question 11a]

DTA 18. What benefits do you foresee in developing a DTA model? (please check all options that apply)

- ❑ Policy analyses that cannot be effectively performed with static models. (For example, detailed pricing studies that require accurate travel time information by small time slices)
- ❑ Integration of ABM with DTA model
- ❑ Modeling congestion more realistically and ability to get more realistic travel times
- ❑ Using a simulation-based DTA model as a bridge between planning and operations level analyses.
- ❑ Other (please specify) ____________________

DTA 19. What barriers do you foresee in trying to develop a DTA model? (please check all options that apply)

- ❑ Not feasible in my region because it will take too long to run.
- ❑ Requires more data than available or accessible
- ❑ Satisfied with the modeling performance I get from the existing static model
- ❑ Not quite sure what DTA is and how it can help my agency
- ❑ Results are difficult to interpret
- ❑ Requires significant resources that we do not currently have
- ❑ Unclear about benefits
- ❑ Unsure which platform to adopt
- ❑ Other (please specify) ____________________

EMAIL ADDRESS/CLOSING

20. Please supply your email address if you would like to receive a copy of your responses and be notified when study findings are available (optional)

    Please verify your email address.

    If you have questions about this survey, please contact Mark Moran, Principal Transportation Engineer, Metropolitan Washington Council of Governments, mmoran@mwcog.org.