TRAVEL MODEL IMPROVEMENT PLAN

Final Report

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Southeast Michigan Council of Governments

Travel Model Improvement Plan

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ABSTRACT

A vision for the continued evolution of the Regional Travel Model and supporting programs at the Southeast Michigan Council of Governments (SEMCOG) is outlined, along with associated data and staff development priorities. It seeks to build upon the commendable investment in urban modeling and data systems that SEMCOG has made over the past decade. The proposed recommendations are based upon a comprehensive review of SEMCOG's mission, analytical requirements, resources and capabilities, peer review recommendations, and the state of their current modeling and data programs. Five tracks of further development are recommended. Two are focused on meeting the traffic monitoring and travel survey requirements of the agency, and are required regardless of which of the remaining recommendations are embraced. The priorities for model development include the continued evolution of SEMCOG's trip-based modeling system, which will serve the agency while person and commercial activity-based models are implemented. The resulting system will enable SEMCOG to best meet current and anticipated local and federal transportation planning requirements.

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List of Acronyms

4D	Density, diversity, design, and destinations
AB[M]	Activity-based [model]
DDOT	Detroit Department of Transportation
DTA	Dynamic traffic assignment
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GPS	Global Positioning System
MDOT	Michigan Department of Transportation
MGF	Michigan Geographic Framework
MOVES	Motor Vehicle Emissions Simulator
MPO	Metropolitan Planning Organization
MSA	Method of successive averaging
RDF	Regional Development Forecast
RTCD	Regional Traffic Count Database
RTM	Regional Travel Model
SEMCOG	Southeast Michigan Council of Governments
SHRP 2	Strategic Highway Research Program 2
SMART	Suburban Mobility Authority for Regional Transportation
SUE	Static user equilibrium (traffic assignment method)
TAZ	Traffic analysis zone
TMIP	Travel Model Improvement Program
TRB	Transportation Research Board
USDOT	U.S. Department of Transportation

Overview

A variety of information sources and decision support systems are used to inform policy and investment decisions for transportation infrastructure in metropolitan areas. Travel demand forecasts, which depict the likely performance of the transportation system under a wide range of future scenarios, are a key tool used in this process. Their use is federally mandated for the development of transportation plans in metropolitan areas, as well as the evaluation of proposed public transportation investments. Originally designed to help planners and policy-makers evaluate large-scale infrastructure investments, such as urban freeways and fixed guideway transit systems, these models are now routinely used to assess a much wider set of policy and investment options at a variety of geographic and time scales.

The travel modeling process used in most metropolitan areas today is rather well defined at a broad level, consisting of five principal models. The details of their implementation varies somewhat between metropolitan areas, owing in part to difference in analytical requirements, capabilities of the modelers, available data, and resources available for supporting the modeling program. The Southeast Michigan Council of Governments (SEMCOG) current Regional Travel Model (RTM) can be described as a best practice system, on par with other leading metropolitan planning organizations (MPOs) across the country. It also includes a commendable data program that rivals other large MPOs supports their models.

Given the progress to date it might be tempting to declare victory and shift the focus from aggressive development to less costly applications. However, changes in society, travel choices and behavior, the rapid advent of *info*structures (traveler information, personal navigation, and real-time guidance and control systems) and substitutes for travel, and technology and economic changes all dictate the continued evolution of travel analysis capabilities at SEMCOG. This document establishes a recommended roadmap for guiding continued model and data improvements at the agency. In a nutshell, the major recommendations include:

- A gradual transition from the current trip-based modeling system to an activity-based travel demand modeling system
- The parallel development of a simplified dynamic traffic assignment capability to support the operational analyses anticipated by SEMCOG staff
- Building on successes developed elsewhere rather than underwriting the full development of data and models
- Take more advantage of interacting the RTM and UrbanSim, a land use model being deployed by SEMCOG

- Importing an updated commercial vehicle model, most likely from innovative work being undertaken in Chicago or the Strategic Highway Research Program 2 (SHRP 2)
- Expansion of the Regional Traffic Count Database to include vehicle classification counts at a wider number of locations throughout the region
- Participation in the next statewide household travel survey program managed by the Michigan Department of Transportation (MDOT)
- A major focus on developing staff skills and capabilities in conjunction with model and data development (see Appendix C)

All of these recommendations are motivated by SEMCOG's current and anticipated analytical requirements, which are summarized in the third chapter. Indeed, their rather unique need to accommodate operational analyses and the expectation that equity analyses will become much more important when allocating dwindling funds influenced our recommendations. Both require a model operating at finer levels of geography and time than currently undertaken, especially for network analyses. More detailed traffic operational models dictate the need for comparable levels of detail in the RTM, which in turn can best be met by activity-based travel demand models. Suggested further reading for those not familiar with these concepts or the forces driving their adoption across the country are summarized in Appendix D.

It must be emphasized that a roadmap is not a detailed trip plan, nor does it provide details about all aspects of implementing it. Rather, it takes a "big picture view" at a scale larger than seen while making the trip. This travel model improvement plan for SEMCOG takes a similar approach. It identifies the key components of the ideal modeling system and the time and resources required to reach each milestone. The details of implementing each component are best left to the development team assigned to it.

Previous Model Development

Over the past decade SEMCOG has made a substantial investment in upgrading their travel modeling suite and supporting data programs. Over that period of time they have gone from fairly rudimentary tools to a best practice modeling system on par with many metropolitan planning organizations (MPOs) today. They have made equally commendable progress in the data systems used to support modeling and performance monitoring in the region. This chapter briefly describes the current state of the SEMCOG modeling system, which provides a point of departure for the later recommendations described in this report.

The recent evolution of the SEMCOG model is shown in Figure 1. It is a trip-based modeling system that embodies the elements of the so-called sequential or “four step” modeling paradigm. This approach has been successfully used in urban transportation planning for over 50 years. As shown in the Figure 1, the model has been successively enhanced, with each upgrade denoted by a numeric suffix. The E1 model was the first of this series, which replaced an earlier simpler modeling suite based on an obsolete software platform and lacking what are today considered to be essential modeling elements, such as a mode choice model and time-of-day factoring. The E5 model is currently in use at SEMCOG.

An E6 version of the model is currently under development, with delivery expected in the summer of 2012. It is the most ambitious of the E series of updates. When complete it will include updates to almost all of the major model components using the most currently available data. Several components are being re-estimated, and all will undergo validation, testing, and implementation in the TransCAD environment. When complete the E6 update will provide SEMCOG with a best practice modeling system.

Unless otherwise indicated the descriptions of the models contained in this chapter are based upon the E5 model currently in use at SEMCOG. They and Cambridge Systematics, their modeling consultant, have extensively documented the model structure separately. This chapter does not aim to replicate that documentation, but instead offer observations and recommendations from our review of the models. The models and supporting data are described in enough detail to appreciate the changes outlined later in this report.

Data Systems

SEMCOG has made a commendable investment in data and information systems to support a wide variety of reporting and monitoring needs, to include travel model development and application. It must be stated at the outset that the data programs and systems SEMCOG have put in place are highly commendable, both in terms of their breadth and quality of implementation. They exceed the investments in data made by most of the largest MPOs, and some – such as the Network Manager and Regional Travel Count Database – are among the best known in practice. Several issues with these data programs are described below, but cannot distract from the laudable investment that SEMCOG has made. It is hoped that such forward thinking continues within the agency, for it well prepares them to usefully inform policymaking in spite of the ever-changing issues and priorities facing the region.

Inventories

Many of the most important inputs to the regional travel model are not model parameters, but rather the detailed population and employment forecasts that define the region. SEMCOG has continually updated their Regional Development Forecast (RDF) to provide such information for communities and sub-community areas within Southeast Michigan. The 2035 RDF data have been translated into the zonal estimates of population and employment required by the model. These data were also used in the implementation of UrbanSim at SEMCOG, which will assure consistency between the two modeling platforms.

An abstract representation of the region's transportation network is also required for model development and application. SEMCOG overhauled its network database as a result of recommendations made by a USDOT Travel Model Improvement Program (TMIP) peer review panel in 2004. Their Network Manager is based upon detailed roadway alignment and attribute data from the Michigan Geographic Framework (MGF), with enhancements made within Southeast Michigan. A transit network developed in-house in 2005 complements them.

Traffic counts are used to validate the regional travel model, as well as separately reporting estimates of travel and network performance. The Regional Traffic Count Database (RTCD) contains over 100,000 counts conducted at over 25,000 locations over the past decade. This allows time series analyses as well as providing current count data for model testing. These data have been supplemented with vehicle classification counts conducted every five years, with 2009-11 being the most recent. Vehicle classification counts from other agencies within the region are also used when available. These data have been supplemented with a travel time survey database developed in 2007-09. The latter is particularly useful for validating the trip distribution model as well as traffic assignment, and will be required for developing estimates of travel time reliability in the future.

Surveys

Travel surveys are collected to understand the relationships between individual and household characteristics and the travel behavior that results from their activities. This information is used to build travel demand models that capture the unique travel patterns of the residents of Southeast Michigan.

Household Travel Surveys

SEMCOG has been fortunate in that it was able to leverage a statewide travel survey of 14,000 households conducted in 2004 by the Michigan DOT (MDOT). The MITravelCounts survey was performed to gather data for a major update of their statewide model, and was designed to support both trip and activity-based travel modeling. MDOT collected additional survey records in 2009-10, and is considering conducting a second statewide survey in 2014 or 2015. SEMCOG has already begun coordinating with MDOT on that effort, and should remain a driving force in its planning and specification.

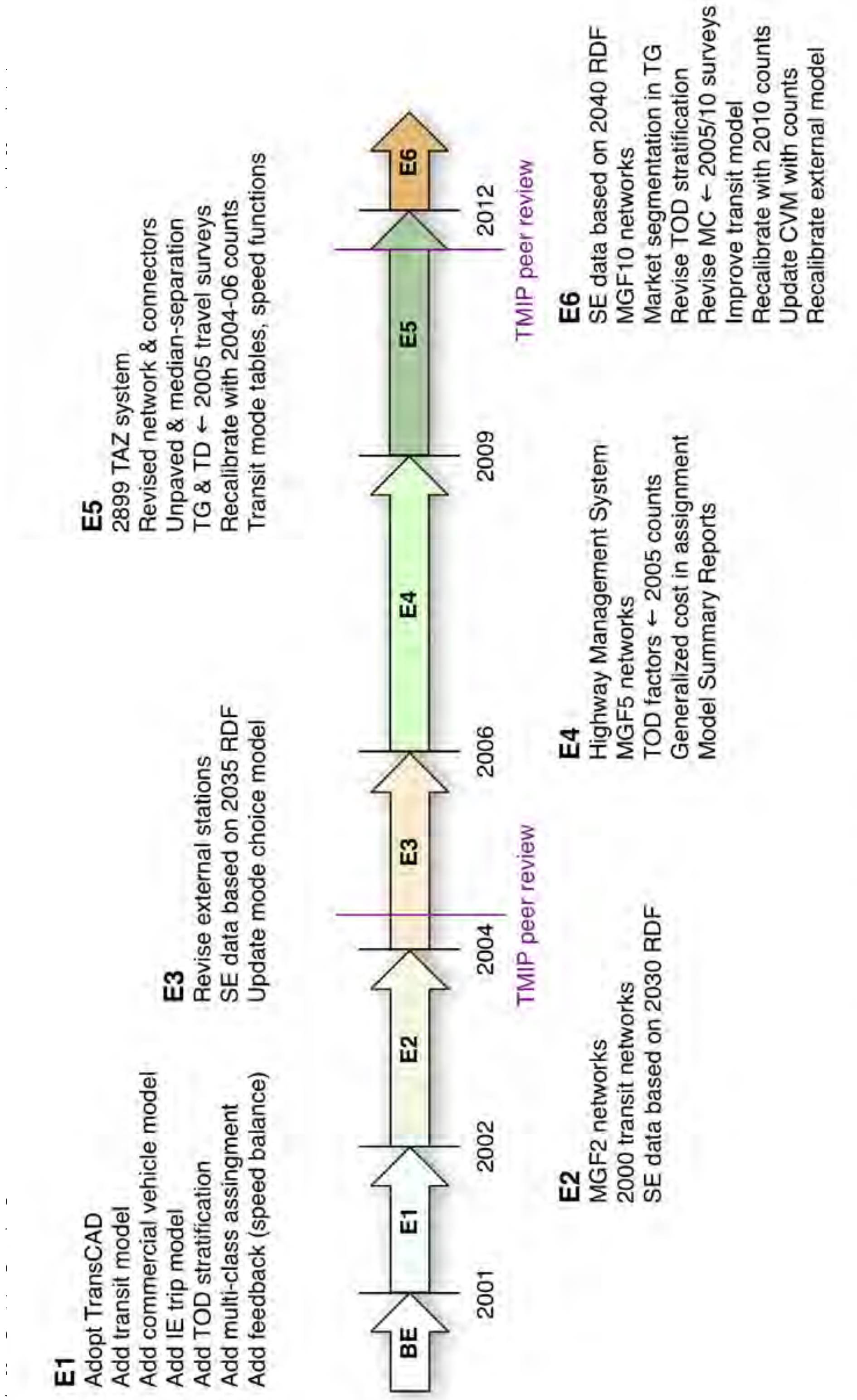

Figure 1: Evolution of the current SEMCOG model

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activity-based person travel model, discussed later in this report.

Transit On-Board Survey

Most household travel surveys fail to obtain enough observations from transit users, for they typically represent a small segment of the population. In order to estimate robust mode choice models household travel surveys are typically supplemented by transit on-board surveys. SEMCOG obtained data collected by the Detroit Department of Transportation (DDOT) and Suburban Mobility Authority for Regional Transportation (SMART) in 1998-99, totaling approximately 11,500 transit trips in the region. However, the majority of the data (7,115 observations from SMART) did not collect origin-destination data in a format useable for model estimation. This markedly reduced the utility of the data for mode choice model development in the E5 and earlier versions of the model. In addition, the data were aged and therefore unusable for FTA New Start analyses. These limitations were overcome in the 2010-11 on-board transit surveys that SEMCOG collected from seven agencies operating within Southeast Michigan. These include 9,327 observations from DDOT and another 4,574 from SMART riders, as shown in Table 1. These data are being used for the E6 model update.

While on-board passenger surveys are designed and conducted by the transit agencies primarily for their own needs SEMCOG should define standards that inform the agencies about the types of data and levels of detail required for urban modeling. This will hopefully maximize the utility of the data and reduce the amount of work and loss of precision when reconciling them.

Table 1: SEMCOG 2010-11 transit on-board survey results by transit agency

Transit agency	Average daily riders	Sample goal	Total completes	Total boardings	Response rate (%)
Ann Arbor Transit (AATA)	22,010	2,532	2,557	12,758	20.0
Blue Water Area Transit (BWAT)	2,625	280	286	1,267	22.6
Detroit Department of Transportation (DDOT)	124,514	9,688	9,327	76,817	12.1
Detroit People Mover (DPM)	4,011	400	396		
Lake Eerie Transit (LET)	877	110	98	511	19.2
Suburban Mobility Authority for Regional Transportation (SMART)	33,876	4,574	4,538	20,484	22.2
University of Michigan	34,227	1,293	1,293	11,931	10.8
Total	222,140	18,877	18,495	123,768	14.9

Source: SEMCOG

External and Commercial Travel Surveys

The external and commercial travel components of the regional travel model depend upon data unique to those travel markets. SEMCOG last conducted intercept surveys at selected external stations in 1994. These surveys collect information about the characteristics of the intercepted trip only, and limited data about the traveler. Intercept surveys are difficult to conduct, expose surveyors to danger, and are highly unpopular with motorists and politicians. However, it is difficult to envision how this important part of travel can be accounted for without current data.

The commercial vehicle survey data are only slightly more current, having been collected in 1999. Market and distribution patterns are likely to be quite different than they were almost 15 years ago. The sample size was arguably too small from which to build robust models, as revealed by the compromises required for the E5 commercial vehicle model. The data were used as efficiently as possible given the sample size. This calls into question whether such data are as stable over time as person travel data. Ideally such data would be updated as often as the household travel survey data. However, it is readily acknowledged that the size of survey required to obtain statistically stable estimates is likely to be larger and more expensive than the household travel survey, owing to the diversity of firms in the local economy and the variances associated with their travel behavior. Merely repeating the 1999 survey would convey some benefit in terms of making the data more current, but would not likely result in a significant improvement in the performance of the model. Instead, a new approach to modeling commercial vehicles will be proposed in later chapters of this report.

Market Coverage

The SEMCOG model covers the seven counties of Southeast Michigan, which includes Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne counties. The region was home to approximately 4.7 million residents in 2010, and roughly corresponds to the Detroit Consolidated Metropolitan Statistical Area (CMSA). In the same year the estimated employment was 2.5 million workers. The E5 model divides population and employment into 2,811 internal traffic analysis zones, which forms a polygon layer over the seven counties, as well as 88 external stations. The latter includes major roadways entering and leaving the region at its outer boundary.

The overall structure of the model is summarized is Figure 2. The model proceeds in a linear fashion, although a feedback mechanism is used to ensure that the interzonal travel times obtained at the end are consistent with those used earlier in the model. Internal and external person trips are modeled separately, which is common practice. The chain of models in the center of Figure 2 models trips made within the SEMCOG region, also known as internal trips. They are complemented by a somewhat unique and interesting external trip model. The commercial travel model, shown on the right in Figure 2, is more advanced than comparable models found in most MPOs in the USA. These components are described in the following sections.

Internal Person Travel Demand

The majority of travel within the SEMCOG region is by residents traveling between points within the seven-county region. Four models are used to generate these flows.

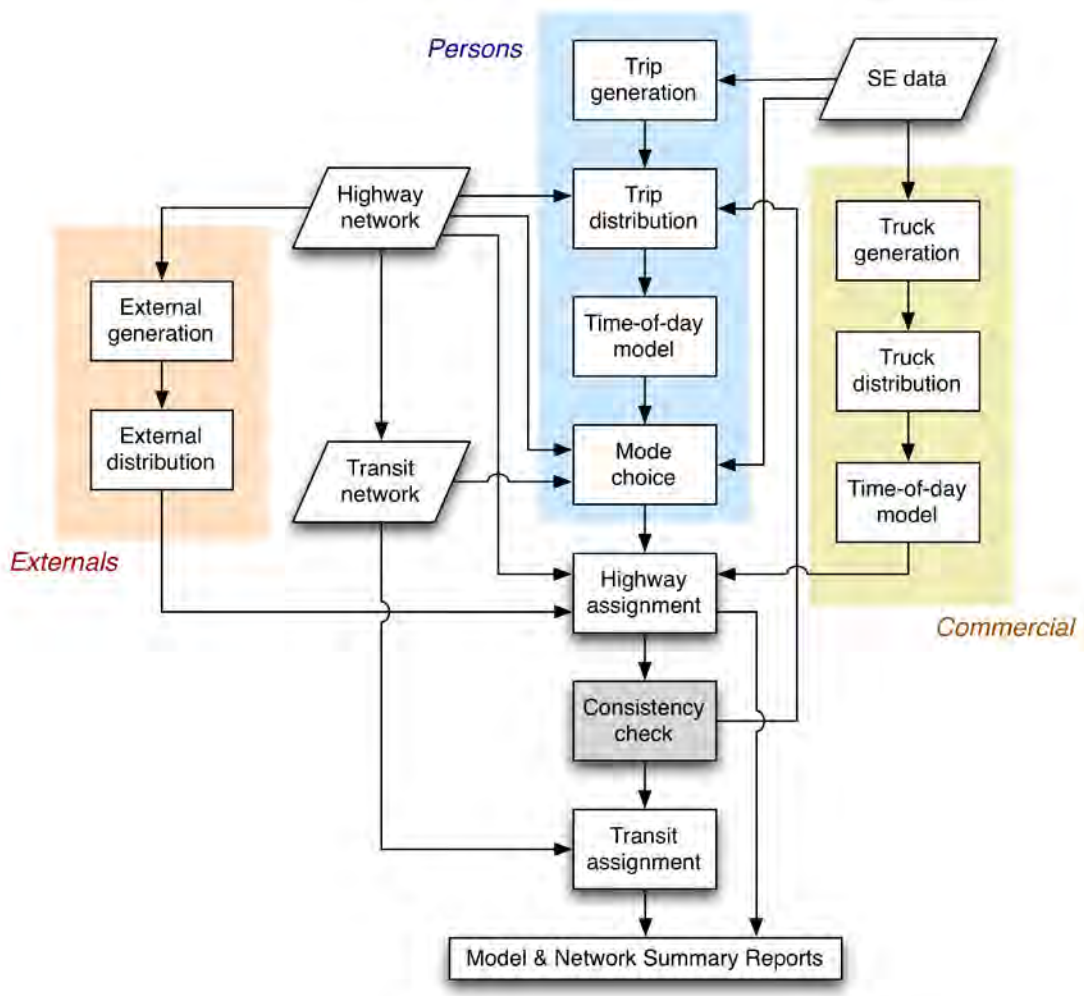


Figure 2: Structure of the E5 SEMCOG modeling system

Trip Generation

Market segmentation is used to differentiate households by characteristics thought to influence travel behavior. Households are defined in terms of number of workers (zero through 3+ workers per household) and auto ownership (zero to 3+ autos per household) for home-based work trips, and household size (number of residents) and auto ownership for all other home-based trips. Six trip purposes are used in the model:

- Home-based work (HBW)
- Home-based shopping (HBSH)
- Home-based school (HBSC)
- Home-based other (HBO)
- Non-home-based work-related (NHBW)
- Non-home-based other (NHBO)

Classical cross-classification models are used for trip productions, based upon data from the 2004 MI TravelCounts and 2005 SEMCOG supplemental household travel surveys. The reported trip rates and balancing processes obtain reasonable results and are comparable to those used in other large MPOs. Linear regression models are used to calculate trip attractions as a function of employment and number of households. This model was estimated at the district level but applied at the zonal level, a common practice dictated by the relatively small sample size of the household travel survey. The model appears to replicate well the total number of trips by purpose for the region calculated from the expanded travel surveys.

The trip generation model follows typical practice, although is somewhat dated in design. It is surprising that a home-based university (HBU) trip purpose is not used, given that the University of Michigan, Wayne State University, and several community colleges are within the region. The 2004 TMIP peer review panel recommended the development of a HBU trip purpose as well. The model also does not include segmentation of households by income quartiles, which is commonly employed for HBW trip generation to better match up workplace and residential locations. The E6 model is expected to include both capabilities. Because such changes will affect every component of the model their deferral until a large-scale overhaul on the scale of the E6 update appears wise.

Trip Distribution

Trip distribution models link daily trip productions and attractions by trip purpose, creating trips between and within zones. The widely used gravity model formulation has been adopted at SEMCOG, where the probability of choosing a destination is directly proportional to the relative attractiveness of each zone and inversely proportional to its distance. The latter is represented within the E5 model as friction factors, which are an inverse function of weighted average travel times between zone pairs. The friction factors are derived from estimated travel times associated with the origins and destinations by trip purpose reported in the travel surveys.

Trip distribution models are calibrated by successively adjusting the friction factors so that the observed and modeled trip length frequency distributions match within acceptable tolerances. The modeled and observed average trip lengths are also compared. A feedback loop is used in the model to update the zone-to-zone travel times used in trip distribution, as they are assumed to be those that motorists would encounter in the real world. One or more cycles through this feedback loop are completed until there are no significant changes in the zone-to-zone travel times estimated within the model.

The results of the E5 calibration were paradoxical. The average trip lengths and shape of the trip length frequency distributions matched well for all trip purposes. However, when the results of the HBW trip distribution were compared to Census Journey-to-Work (JTW) data from 2000 large differences were discovered. These are summarized in Figure 3. The flows are summarized at the county level. It can be seen that over 80 percent of the HBW flows occur between 12 interchanges, with half of them representing intra-county flows. The percentage difference between the modeled flows and those summarized from the JTW data are large in most cases.

Surveyed

	Detroit	Wayne	Oakland	Macomb	Washtenaw	Monroe	St Clair	Livingston
Detroit	361,950	101,671						
Wayne	99,674	722,366	121,905			**807,287**		
Oakland		128,474	883,670	124,058		**18.6%**		
Macomb			129,810	469,688				
Washtenaw					288,700			
Monroe								
St Clair							108,999	
Livingston								

Modeled

	Detroit	Wayne	Oakland	Macomb	Washtenaw	Monroe	St Clair	Livingston
Detroit	248,515	130,683						
Wayne	145,703	551,703	125,179			**942,423**		
Oakland		111,837	855,192	111,866		**22.9%**		
Macomb			176,093	404,817				
Washtenaw					232,221			
Monroe								
St Clair							87,369	
Livingston								

Percent difference

	Detroit	Wayne	Oakland	Macomb	Washtenaw	Monroe	St Clair	Livingston
Detroit	-31.3	28.5						
Wayne	46.2	-23.6	2.7			**16.7**		
Oakland		-12.9	-3.2	-9.8				
Macomb			35.7	-13.8				
Washtenaw					-19.6			
Monroe								
St Clair							-19.8	
Livingston								

Figure 3: Comparison of HBW trips to Census Journey-to-Work Summaries

It must be acknowledged that some of the discrepancy is the result of comparing data from two different sources. Both are small sample surveys that employ different survey expansion techniques. Thus, a high degree of correlation between them would not be expected. However, the error levels revealed in the bottom of Figure 3 are high compared to other regions.

These findings underscore the importance and timeliness of the E6 model update. It is expected that segmenting HBW trips by income will reduce some of the error reported in Figure 3. The feasibility of using destination choice (DC) models in place of the simpler gravity model will also be investigated as part of the E6 update. DC models use a discrete choice formulation similar to that used in the mode choice model, where the utility of alternatives – competing destinations in this case – are enumerated. The utility function can include a large number of explanatory variables to represent traveler, household, and trip attributes. The limited experience to date with DC models has been encouraging, in most cases providing a significant improvement over gravity models. It is expected that the same outcome will be obtained during the E6 model update. Doing so will move SEMCOG into best practice in this part of their modeling work.

Time-of-Day Factoring

Trip generation and distribution are carried out for all daily trips. However, travelers experience differing levels of congestion and travel times during different periods of the day. A temporal allocation process is carried out after trip distribution to divide the daily trips into four periods of the day:

- AM peak period: 7 AM to 9 AM (two hours)
- Mid-day period: 9 AM to 3 PM (six hours)
- PM peak period: 3 PM to 6 PM (three hours)
- Evening (the remaining 13 hours of the day)

Departure time data from the travel surveys are used along with observed traffic count patterns by hour to derive the percentage of trips beginning in each period. Data from the survey are also used to determine the directionality of flows by period. This process is commonly applied in almost all MPOs, and the period definitions are comparable to those used in other large metropolitan areas. It falls within the realm of best practices in trip-based modeling.

Mode Choice

The final internal model handles the allocation of the interzonal trips by period of the day to transportation modes. Mode choice is modeled as a function of several trip and traveler characteristics in a discrete choice modeling framework. Logit models are used to choose between different modal alternatives, with the one offering the highest utility to the user being chosen. Their estimation and calibration is typically more complex and data-intensive than for other components of the modeling system. Information from the 2004 and 2005 household travel surveys, which typically capture a low incidence of transit usage, were supplemented with transit on-board survey data collected by the DDOT in 2005 and in Ann Arbor in 1996. These represented the most recent data available at the time the model was developed.

Several different model specifications and aggregations of trip purposes were tested, which is common. It was determined that mode choice would be carried out for home-based work (HBW) trips and all other trip purposes combined. Both multinomial and nested logit formulations were tested, with the former chosen for both purposes. Coefficients were estimated for two aggregations of time. The AM and PM peak periods were combined, as were the mid-day and evening peak periods. The validation results appear to fall within reasonable ranges and replicate observed regional mode shares well.

The re-estimation and calibration of the mode choice model is included in the ongoing E6 model update. Preliminary results are not yet available at this writing, but it seems likely that a thorough re-examination of the model is being undertaken. Transit on-board survey data from 2009 is being introduced in place of the 1995-96 surveys, which will result in a more current model. The work effort is far enough along to preclude revising the approach taken, but given the relatively simple modal alternatives it might be argued that formal estimation is not likely to yield a different structure or coefficient values than simply asserting them based on well-documented experience elsewhere. Either approach will require substantial efforts at calibration. It might be argued that the size of the transit-dependent population is higher in Detroit than in other North American cities, which may result in unique estimation outcomes. This would support the case for estimating models specifically for Southeast Michigan. The results of the combined E6 estimation and calibration should be compared to findings elsewhere. If further refinement is still required in light of thorough model assessment it is recommended that more efforts go into understanding the affected travel markets and calibration of imported models rather than continued estimation work.

The documentation does not suggest how much effort has gone into ensuring consistency between the transit path-building and mode choice parameters and assumptions. This will affect the definition of market segments used in trip generation through mode choice. Careful examination and documentation of the coefficient logic should be completed, as well as validation summaries at the district (i.e., sub-county) level. A system of 50 to 60 districts covering the seven-county region would be ideal.

External Trip Models

Trips with one or both ends outside of the seven-county region are included in the left-hand portion of the model stream illustrated in Figure 2. These models are constrained to the observed auto and truck flows crossing the region boundary. Separate sub-models have been implemented for external trip generation, distribution, and time-of-day allocation. These models have been developed using data from an external travel survey conducted in 1994. It is likely that the patterns revealed in those data are obsolete, a finding that appears borne out by the E5 model validation results. Like other parts of the model, the E6 update is expected to result in a much improved set of external travel models. Even without the update this part of the modeling system is considered to be best practice.

External Trip Generation

SEMCOG uses an innovative and unique approach to modeling external trips. In most regions three trip purposes are defined: internal-external (IE), external-internal (EI), and external-external (EE, or through) trips. EE trips are typically small relative to other external trips, and specified as a matrix of estimated flows. The remaining are IE and EI trips that are constrained to the inbound and outbound counts, respectively, at major roadways crossing the region boundary (external stations). Because survey data are costly and intrusive to collect external trip models are often asserted or synthesized. As a consequence there is low confidence in their estimates compared to other parts of the modeling system.

SEMCOG's approach is innovative in that they use the functional classification of the roadway crossing the cordon in place of trip purpose. Five types of roadways are used in place of simply classifying such trips as IE or EI travel:

- Freeways and expressways
- Arterials near expressways
- Arterials not near expressways
- Collectors and local streets
- Bridge and tunnel connections between Detroit and Windsor

For EI trips the productions are the counts at each cordon crossing, while attractions – calculated for each internal zone – are a function of distance to the edge of the region and attractions calculated during internal trip generation. Lower functional classification roadways (e.g., collectors) draw trips from closer to the boundary than freeways, which are more likely to attract trips from across the region. IE trip productions and attractions are calculated in the opposite manner.

External Trip Distribution

A gravity model formulation with calibrated friction factors is used for each external trip purpose. The friction factors were iteratively adjusted to replicate the observed trip length frequency distributions and average trip lengths by purpose (roadway type). Despite using this fitting process the model over-estimates average trip lengths between seven and 62 percent. The lowest differences were found on the border crossings with Windsor and freeways/expressways (7 and 15 percent, respectively), which are within expected tolerances. Not surprisingly, collectors and local streets posted the highest error, although this appears to be attributable to the small number of survey records for such roadway types. Given the age of the data used to build this model the results appear satisfactory. It is hard to envision how a better model could have been crafted given the available data.

Updating the model with new data should be a high priority irrespective of the future approach chosen for model evolution. This can take the form of a new external travel survey. However, the statewide model used by the Michigan DOT should be the first choice for updating the external models. It has been developed using the 2004 statewide travel survey, and recent validation results are highly encouraging. Using these data the external end(s) of the trips can be coded, providing insight into trip purpose, origin or destination within the SEMCOG region as well as outside of it, and other trip attributes. Moreover, the statewide model should be capable of providing an EE trip matrix with far more detail and information than possible through other means.

Time-of-Day Factoring

Traffic count data from the external stations revealed peaking characteristics that were used to allocate daily trip matrices to the same time periods used for internal trips. The model is thereby constrained to match observed patterns, obviating the need for extensive calibration or validation of this process. The E5 model documentation does not describe the degree of fit obtained, but is assumed to yield satisfactory results.

Commercial Vehicle Travel

An equally innovative approach to modeling travel by commercial vehicles is included in the E5 model. It is shown as the right-most stream of the model shown in Figure 2. While some MPOs include freight models or trip matrices in their modeling stream very few attempt to include all commercial vehicles. Examples of the latter include service vehicles and other non-recurring commercial trips as well as routine travel by refuse collection trucks, school buses, and others. Collectively all commercial vehicle travel is thought to account for between 10 and 20 percent of the total vehicle miles of travel within an urban area. This component is based upon a survey conducted in 1999, which is probably at the end of its utility. It is widely thought that changes in distribution patterns, supply chains, markets, technology (including substitutes), and the economy result in much faster changes in commercial travel than found in person travel. They further call into question the utility of data collected almost 15 years ago.

Commercial Trip Generation

Trips are generated for three types of trucks: light, medium, and heavy. These classifications serve as surrogates for trip purpose, obviating the need for mode choice (i.e., the mode is already chosen in trip generation). Because the 1999 survey was small the usual estimation of trip generation parameters at the zonal level could not be accomplished. A system of 248 districts was developed that enabled a more statistically stable outcome, although the resulting rates were intended for application at the traffic analysis zone level. A number of explanatory variables were investigated, with zonal size (acres), households, and employment proving significant. Different categories of employment were found to be significant for each truck type.

Perhaps not surprisingly, the goodness of fit measures were mediocre. However, this outcome is not uncommon, as commercial travel is characterized by larger variances than person travel. Moreover, the small size of the sample likely contributes sampling error to the mix. Collecting a larger sample will help reduce the error somewhat, but cannot overcome the inherent variation in the data. Moreover, recent research suggests that facility size or floorspace correlates much better with truck trip generation than employment does (Holguin-Veras et al. 2011). Thus, it may not be possible to significantly improve the trip generation model without using the land use data produced by UrbanSim in conjunction with the zonal population and employment estimates.

Commercial Trip Distribution

A gravity model formulation with calibrated friction factors was developed for each truck type. The friction factors were iteratively adjusted to replicate observed trip length frequency distributions and average trip lengths for each truck type. It is assumed that the model correctly mimics the patterns revealed in the 1999 commercial vehicle survey, but no calibration or validation statistics are reported in the E5 model documentation. Time-of-day factors were also derived from the survey and used to convert daily trip tables into the four time periods used elsewhere in the model. These should be compared to observed truck count patterns by time of day from selected locations within the region.

Data from the statewide model is used to generate EE commercial trip matrices. These data record the ultimate origin and destination of the trips, as well as the external stations they pass through in the SEMCOG region.

Network Assignments

The final part of the E5 modeling system is shown in the lower part of Figure 2. The flows from all of the model components discussed thus far – internal person trips, external travel, and commercial vehicles – are combined and assigned to an abstract representation of the regional transportation network. Highway and transit flows are assigned separately using methods appropriate for each.

A multi-class static user equilibrium highway assignment model is used to simulate the lowest cost path through the network for all travelers. This method is considered best practice, and is used in conjunction with both trip and activity-based models in North America. All classes of auto (single and multi-occupant) as well as all three classes of trucks (light, medium, and heavy) perceive the same travel times and link flows during the assignment process. Their path choices are dependent upon the generalized costs they perceive, which include vehicle operating costs, their value of time, and travel times and congestion on each link. The so-called BPR function, an aged but still widely used relationship, is used to calculate travel time as a function of the volume-to-capacity (V/C) ratio on each link.

The consistency check shown in Figure 2 compares the zone-to-zone travel times obtained from highway assignment with those used in trip distribution. The model is re-run if necessary to ensure internal consistency between the two estimates. The method of successive averaging (MSA) is used to steer the process towards convergence between the two estimates.

Transit assignment is carried out in a somewhat similar manner, where multiple transit modes and services can be combined in order to obtain a lowest cost trip. Walk and auto access on both ends of the transit trip are also considered. The TransCAD Pathfinder is used for transit assignment, which is widely used and considered standard practice in the industry. The generalized cost is a function of travel time, wait time, and fares. In its current implementation travelers can choose between local and express bus services. It was not clear whether the path-building parameters are internally consistent with those used in the mode choice model. It is understood that this issue will be addressed in the E6 model documentation.

Assignment models are validated by comparing the modeled flows on each link to observed counts where they are available. The RTCD includes over 100,000 counts from 25,000 locations within the region, gathered over the past decade. Despite this there is scant reporting of the highway assignment results. Daily comparisons by roadway functional type and totals by county are published, but detailed summaries of both (i.e., by functional type within each county), graphical summaries, comparisons across screenlines, and other widely used summaries are not. Overall the highway assignment results look acceptable, with errors by functional class ranging from -5 to 68 percent, and across counties from -24 to 36 percent. However, more detailed comparisons would allow reviewers to gain considerably more confidence in the results, and to detect suspect or erroneous patterns in specific places within the region. This would be greatly facilitated by using sub-county districts, as suggested earlier for other model components.

Transit assignment results are also published only for the entire region. The source and extent of the observed transit counts is not reported. The daily boardings by service provider range between -44 and 30 percent, with DDOT falling in the middle of that range and SMART defining the upper end. These are probably adequate for system-level long range planning, but would likely require refinement before being used for detailed transit studies. Comparisons of boardings by transit line and daily trips by service provider are also commonly reported in most MPOs. Their inclusion in the standard model reports at SEMCOG would facilitate a more informed assessment of their transit modeling capabilities. These issues will be resolved during the E6 model update, which will not only reconcile mode choice and transit path-building parameters, but also incorporate the newer 2009 transit on-board survey data. It is anticipated that much improved transit assignment results will be obtained from those efforts.

Analytical Requirements

George Box is credited with saying, "all models are wrong, but some are useful." His statement says a lot, including the reminder that models are abstractions of the reality they represent, not replicas. Perhaps the more compelling interpretation is that the accuracy and utility of a model must be defined by its intended uses. There are numerous ways that travel models might be crafted or enhanced, but SEMCOG's return on investment must be measured in terms of the intended uses of the model and supporting data systems over their lifetimes. Moreover, this discussion of goals and objectives, couched as intended uses of the model, must precede any discussion of the models themselves. This paper lays that foundation for the current modeling visioning process.

Many software designers employ a rigorous process of defining use cases for the systems they develop. These are formal definitions of how the end user expects to interact with a computer system, what results they expect to obtain, and in what form. The software developer can infer the most important features of the software by identifying common themes and requirements, which in turn become the earliest development priorities. The use case also becomes the criteria by which success is measured. In cases where the requirements are clear and immediate the original use case might be sufficient. In most cases, however, the use case is dynamic, allowing requirements to change as knowledge is gained and early adopters provide feedback on interim products.

SEMCOG has adopted the same approach in their model development to date. They completed an inventory of needs, resources, and existing models and data in the late 1990s. From that they laid out an aggressive decade-long plan for improving their models that became the "E series" of improvements. These requirements were re-examined as part of the preparation of this document. Their current and anticipated analytical needs are also shaped by federal requirements. This chapter summarizes the analytical needs implied or imposed from each of these sources.

Local requirements

SEMCOG uses their travel forecasting model to handle a variety of internal and external studies and programs. There are numerous ways that these uses can be categorized. One method is to broadly classify them as strategic versus tactical uses of the model. The former often includes efforts such as long-range transportation plans, transportation improvement plans, and analyses of region-wide impacts and opportunities. Tactical uses focus on specific projects or programs, whose effects are usually localized or concentrated in certain corridors or smaller study areas. These issues are summarized in Table 2 and discussed separately in the sections that follow. A discussion of performance measures, an area of growing emphasis, is also included.

Table 2: Current and anticipated SEMCOG modeling requirements

	Tactical	Strategic
Traditional	Subarea analyses Selected link analyses Transit corridor or project analyses Traffic impact studies (macro) Time & cost savings of projects	Update long and short-range transportation plans Project prioritization and planning Air quality conformity Assessment of regional strategies Trade-off analyses Improving regional mobility Demand management vs. capacity Transit-oriented design analyses Sustainable transportation options Evaluating new transport modes
Non-traditional	Construction & detour analyses Work zone staging & management Linkage with traffic operations models Signal timing optimization Traffic impact studies (meso/micro) Network reliability Equity analyses Environmental justice analyses Pricing studies	Capacity reduction strategies Market accessibility & competitiveness Economic impacts of transport Understanding freight & supply chains Impact of fuel price increases Equity analyses Environmental justice analyses Pricing studies

Strategic Uses

Travel demand models are ideally suited to the study of regional policies and investments, a role they are widely used for. The earliest models were developed to study the regional impacts of the Interstate highway system and major investments in large-scale urban transit systems. They also have a long history of use in the development of regional transportation plans and programs. In fact, Detroit was one of the first cities where such models were applied in North America, beginning with the pioneering work of John Hamburg in the 1950s. SEMCOG was formed in 1968, and has continually utilized travel demand models in their planning process since then. As noted earlier, their “E series” modeling improvement program is arguably its most ambitious update to date. When the ongoing E6 update is complete their Regional Travel Model will be a best practice implementation.

The E6 modeling suite was designed to accommodate a wide variety of uses through improvements in capabilities, spatial resolution, behavioral fidelity, and accuracy. Current and anticipated uses of the modeling system can be generally grouped into two categories, as summarized in Table 2. One might debate which category these applications fall into. Some might fall into both, differentiated only by the level of detail and range of options considered. Irrespective of the categorization it is readily apparent that contemporary travel demand models are being expected to address a much wider range of issues than explored when they were initially designed.

Many of these scenarios evaluated using contemporary models will have differential effects by time of day and location within the metropolitan area. The need to better understand university-related travel, a market segment not slated for separate treatment in the

E6 model, was noted several times in discussion with the SEMCOG staff and their planning partners. In addition, studying some of these options (e.g., equity analyses, 4D scenarios) will require the inclusion of non-motorized travel at the same level of resolution and fidelity as the currently included motorized modes of transport. 4D approaches are advocated by smart growth and sustainable community advocates, and includes the following elements:

- Residential and employment density
- Diversity of land use types
- Walkable design
- Access to regional destinations

Cervero & Ewing (2010) provide an excellent overview of the concepts and synthesis of the literature for readers interested in learning more about 4D design concepts.

Tactical Uses

SEMCOG receives between 60 and 100 requests each year to conduct project-level and operational analyses for other governmental agencies. Issues that SEMCOG and their clients are called upon to assess include:

- Construction analyses, which covers the gamut from predicting the location, extent, and duration of construction-related congestion to where changes can be made to the project or construction timeline to reduce congestion
- Work zone staging and traffic management, to include coordination between different construction projects
- Provision of data for traffic operations models, such as dynamic traffic assignment (DTA) and traffic microsimulation packages
- Traffic signal progression and timing optimization
- Selection of detours for construction or special event sites
- Detailed demand forecasting for subareas, which often includes selected link analyses and level of service determination
- Design of specific transit projects or corridors, to include transit-oriented developments
- Traffic impact studies
- Quantifying network reliability and predictability of travel times and congestion
- Time and cost savings associated with projects and corridor enhancements
- Assessment of equity and environmental justice impacts of projects and programs (i.e., how different social groups are affected by proposed projects and actions)

Unlike the contemplated strategic uses some of these applications are thought to be beyond the capabilities of most urban travel demand models to accurately portray. Some require an explicit representation of driver behavior, while others require coding of intersection geometry, vehicle detectors, and traffic control devices and timing. Other measures, such as network reliability, are not commonly obtained even from detailed operational models. Some of the desired functionality might be obtained through continued refinement of the E6 RTM, but others will require a separate but complementary modeling capability. This topic will be explored in depth in the update of SEMCOG's Travel Model Improvement Plan.

Performance Measures

It is widely anticipated that performance monitoring with be a major theme in the next federal transportation legislation is passed. This coincides with an expected increased emphasis upon the efficient operation and maintenance of existing infrastructure rather than continuing the recent historical emphasis on capacity and service expansion. Indeed, several MPOs and state departments of transportation are moving in that direction already. SEMCOG is one of them, having recently drafted measures as part of their "Creating Success in Southeast Michigan" initiative. The measures are organized into six thematic areas:

- Economic prosperity
- Desirable communities
- Fiscally sustainable public services
- Reliable, quality infrastructure
- Healthy, attractive environmental assets
- Access to services, jobs, markets, and amenities

The objective measures will be supplemented by a regional survey of public sentiments on all six themes. Many of the proposed measures will be quantified using information from other data systems, and for which the RTM is not a candidate source. However, the measures supporting desired outcomes in the infrastructure category will be gleaned from the RTM. This is especially true for forecasted values, where proposed projects, policies, and regulations will likely be judged by these desired outcomes. The transportation-related measures that the RTM and supporting data systems, to include stated and revealed preference surveys, will likely be called upon to inform about include:

- Infrastructure utilization rates
- Peak transportation infrastructure service, demand, and total consumption
- Transit ridership
- Percentage of time in compliance with air quality standards

While the exact definition of these measures has yet to be established the need to supply these measures are a key requirement for the modeling system. All three largely duplicate analytical requirements already summarized above, but underscore the need to have a robust peak period modeling capability. To the extent that most of the congestion occurs during the peak periods and the tactical needs above may dictate the use of more detailed network modeling these performance measures.

Federal Requirements

Metropolitan planning organizations (MPOs) are required by federal regulations to employ a federally certified process for transportation planning and programming. These plans are to be based in part on travel demand forecasts prepared by or on behalf of the MPO. Projects in the transportation improvement program in particular must be based upon forecasted levels of service and provision of mobility to target populations. The plans must also be financially constrained. A five-step sequential modeling paradigm – trip generation, distribution, mode choice, time-of-day allocation, and network assignment – has evolved over time as the standard practice for generating such forecasts.

The Federal Highway Administration has established a certification process and checklist for MPO models to ensure that they are capable of informing federally mandated air quality and transportation planning requirements (FHWA 2011). While the requirements are well defined by regulation and precedence, what constitutes an adequate travel demand model is not. Formal standards are published as part of the Transportation Conformity Rule (TCR) for regions in serious or worse non-attainment status for air quality. Southeast Michigan has never been classified as a serious or higher non-attainment area. The RTM is therefore not subject to the TCR modeling requirements. However, the region is presently designated as a maintenance area for ozone and carbon monoxide, and as a non-attainment area for both the annual and 24-hour fine particulate standards. A very small portion of Wayne County is also classified as a maintenance area for course particulate matter (PM10). Thus, the model is routinely used to generate inputs to mobile emissions and atmospheric dispersion models used for transportation conformity analysis and State Implementation Plan development.

The certification checklist is otherwise not definitive about the structure or capabilities of travel demand models. They acknowledge that analytical requirements vary from one MPO to another. However, the process is designed to ensure that the models that are in place are adequate for current and anticipated applications of the model. Moreover, they outline a series of questions to assess how well the modeling program addresses analytical risks, the agency's technical capabilities, and documentation. An external peer review of model development plans and activities is considered an important part of the agency's technical capabilities.

The documentation considered during certification includes, but is not necessarily limited to, three major areas (FHWA 2011):

- An inventory of the current state of transportation in the metropolitan area
- Key planning assumptions used in developing the forecasts
- Descriptions of the methods used to develop forecasts of future travel demand

The certification guidelines note the importance of multimodal analyses, but do not provide guidance about how such should be conducted. A robust travel demand model supported by recent transit ridership survey data is required for federally funded transit projects. Rigorous and consistent methods for calculating user benefits have been established as part of the Federal Transit Administration (FTA) New Start and Small Start programs. A well-defined set of modeling practices and forecasting conventions have been established against which candidate models are compared. The models are reviewed on an ad hoc basis as projects are submitted for FTA approval rather than on a set schedule, as certification is.

The Michigan DOT works closely with SEMCOG on modeling issues, but does not prescribe standards or requirements for travel demand modeling. They do have internal standards for the validation of travel demand models at the urban and statewide levels that are advisory in nature.

SEMCOG's E5 model generally exceeds the MDOT validation standards. MDOT also uses the SEMCOG model for the analysis and planning of projects within the SEMCOG region, to include recent efforts to develop a dynamic traffic assignment (DTA) model of the I-96 freeway corridor. MDOT intends to develop other subarea DTA models, and possibly such models for the entire freeway system within the Detroit region. Such applications will require accurate demand matrices by time of day, mode of travel, and trip purpose at the traffic analysis zone (TAZ) level.

TMIP Peer Reviews

A peer review panel was convened in December 2011 to examine progress to date and to advise SEMCOG on priorities for model improvement. It was a follow-up to a similar review conducted in the fall of 2004. Both panels were convened at SEMCOG's request, and funded under the USDOT's Travel Model Improvement Program (TMIP). There was no overlap in membership on the two panels, although both included widely acknowledged leaders in the field of travel demand modeling. The results of both peer review panels were formally documented and available from SEMCOG.

The 2004 panel made twenty specific recommendations for improvement of SEMCOG's travel models as they existed at that time. They are summarized in Table 3. The goal was to move the program towards the best practices in travel modeling, a goal that SEMCOG has largely delivered upon. When complete the E6 model will bring the total of implemented recommendations to 16 out of the original 20. Obtaining advice about how best to achieve the remaining goals, which largely revolve around the transition to advanced modeling methods, was an impetus for convening the 2011 review.

Having confidence that the E6 model will satisfy most of the previous recommendations, the second review focused upon how SEMCOG might meet their analytical requirements within the context of their existing model as well as shifting to activity-based models. A summary of their recommendations is shown in Table 4. They proceed from the premise that the E6 model provides an adequate basis for addressing most of the traditional topics posed to it. The topics listed in Table 4 will extend the capabilities of the agency to address analytical needs that cannot be handled with existing models. For each topic basic and advanced modeling capabilities were recommended. The basic recommendations can largely be accomplished through evolution of the E6 model and existing SEMCOG data programs. Most of the advanced recommendations can only be accomplished using an activity-based travel model. The exception is the economic and land use topic, which can be achieved through further implementation of the UrbanSim model.

The 2011 panelists did not establish a time frame for meeting their recommendations. It is assumed that the basic recommendations should be met within the next five years, although plans for their inclusion should begin immediately. The recommendations laid out in this document aim to fulfill all of their basic recommendations within the next two years. The timing of the advanced recommendations will depend upon when SEMCOG makes the transition to activity-based models.

Table 3: 2004 TMIP peer review panel recommendations

Recommendations presently implemented:
Existing data inventory (1)
Vehicle classification counts (2)
Network coding and TAZ structure (3)
Land use modeling (4)
Trip generation and distribution review (6)
Traffic assignment (generalized cost)(10)
Air quality model integration (with MOVES)(11)
Validations (17)
Travel speed validations (18)
Travel model sharing (20)
Recommendations currently under development
Additional trip purpose (HBW market segmentation and home-based university)(5)
Transition from trip distribution to destination choice models (8)
Mode choice (parking cost model not included)(9)
Airport access modeling (12)
Enhanced freight modeling (13)
External trips (14)
Recommendations not yet implemented
Non-motorized modes (7)
Minor ("uncertain") improvements (area types, HOV, differential peaking, etc.)(15)
Activity-based modeling (16)
Traffic operations tools (19)

Table 4: Summary of 2011 TMIP peer review recommendations

Topic	Basic	Advanced
Data needs/methods	Continue data collection for performance measurements and validation	Explore new paradigms for effective data collection
Operations modeling	Expanded validation and post-processing of static assignment	Traffic microsimulation requires ABM integration
Freight/ commercial vehicles	Continue data collection for use with synthetic truck matrices, examine use of statewide model	Activity-based commercial vehicle model at comparable level to person-based ABM
Transit	Keep mode choice simple	Model fully model market segments within ABM context
Economic/land use	Use demand model accessibilities to identify future land use potentials	Dynamic economic and land use simulation sensitive to declines and shifts in economic relationships
Equity (fairness)	Develop broad range of metrics intended to communicate and educate audience on dimensions of the topic	Orient ABM development to rigorously track equity indicators at the person level

Multi-Year Model Improvement Plan

Travel demand models are widely used in practice and academia for a variety of applications. At SEMCOG the emphasis is upon informing policies and investments in transportation infrastructure and system operations. The issues and opportunities surrounding such actions have changed considerably over the past twenty years, and will evolve in the future in response to changes in social, economic, and political realms. As the analytical focus changes so must the data and models used to support such decisions. The discussion in the previous chapter summarized the changing issues and analytical requirements facing SEMCOG. Recommendations for continued evolution of the SEMCOG models in response to those trends are presented in this chapter.

The proposed evolution of the models and data follow five general tracks, as shown in Figure 4. The top two tracks are focused upon data needs, while the bottom three are oriented towards models. A progression from top to bottom is implied, in that each track shown is dependent upon successes with the ones above it. Moreover, all but the bottom two are extensions to current practice, and represent a continuation of existing programs and capabilities. SEMCOG's traditional modeling needs, shown in the upper right hand side of Table 2, can be met with the outcomes from the top three tracks. Moreover, these outcomes will meet the basic expectations of the 2011 TMIP peer review panel, as well as begin to address the operational analyses and subarea studies described in the previous chapter.

The bottom two tracks represent a recommended transition to advanced travel models, and will represent new investments for SEMCOG. They are designed to enable SEMCOG to meet anticipated new analytical requirements – those classified as non-traditional in the bottom row of Table 2 – as well as the advanced recommendations of the 2011 TMIP peer review panel, summarized in Table 4. The relatively near-term staging of these tracks reflects the fact that enough progress has been made with advanced models in other places to provide the insight necessary to import proven approaches quickly at SEMCOG.

Each of these tracks is further described in the sections that follow. The timeline covers the next decade, although the implementation can be shortened or lengthened to match agency requirements and resources. The estimated funding requirements for the major activities in each track are shown in Figure 4. The cost by year, broken down between data and modeling activities, is summarized in Figure 5. The average cost per year – approximately $250,000 – for the next ten years is very close to the average spent per year over the past decade. However, these recommendations do not reflect additional requirements that may be imposed by reauthorization of the federal transportation bill (e.g., MAP-21) or SEMCOG's Transportation Planning Certification report from FHWA and FTA.

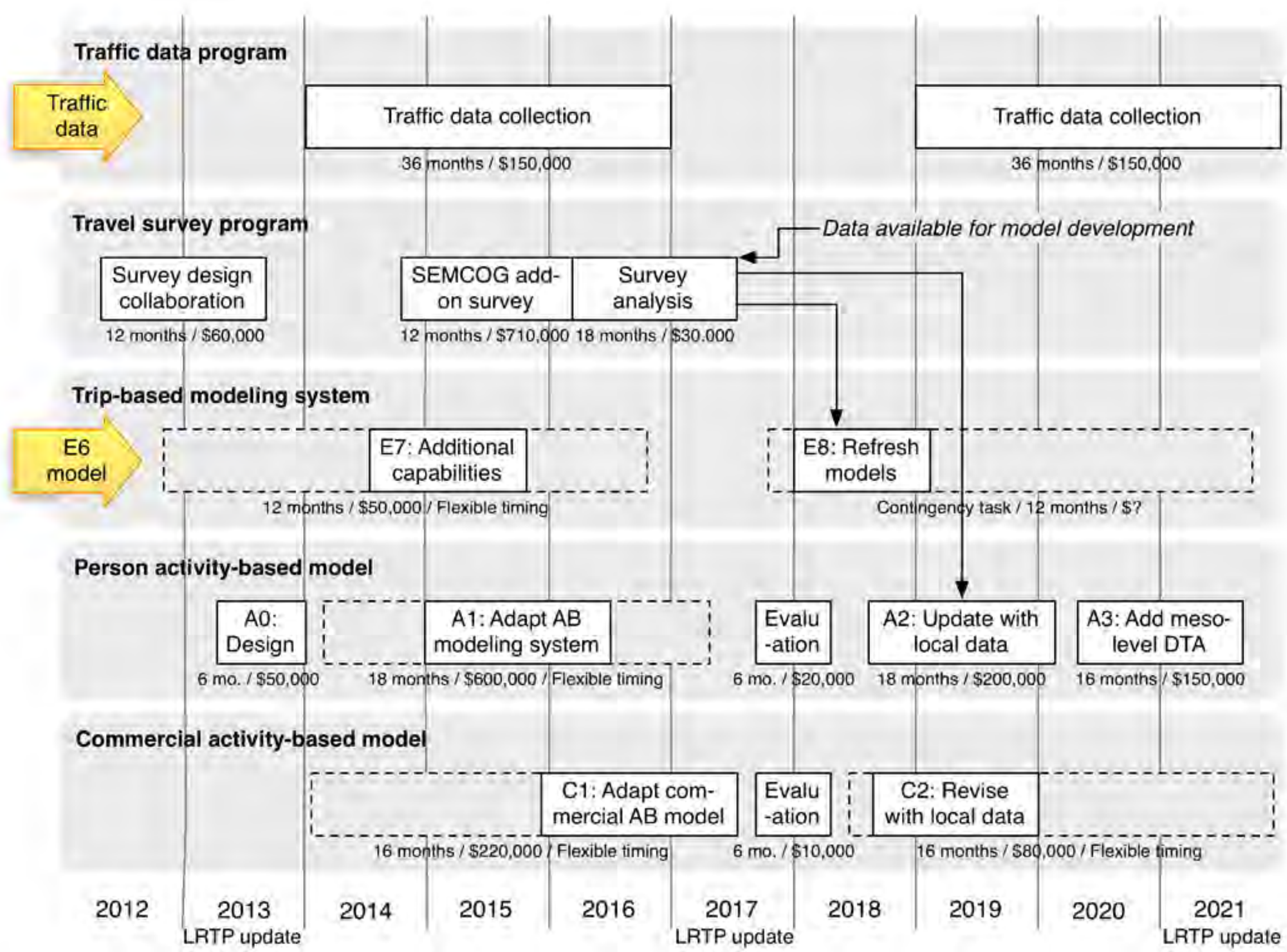


Figure 4: Proposed ten-year model improvement program

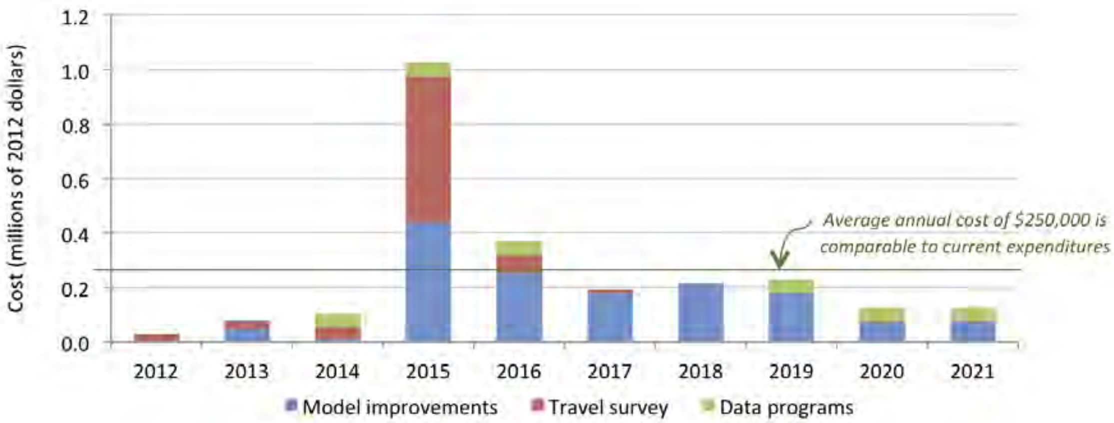


Figure 5: Estimated data and modeling funding requirements by year

Traffic Data Program

Current and historical data on traffic patterns in the region are essential model building blocks, and provide the target values required for model validation. Such data are also used elsewhere at SEMCOG, to include roadway performance monitoring and as important inputs to air quality analyses. SEMCOG has already developed the RTCD at an appropriate level of detail to support these missions. Small incremental changes to this highly important program will ensure that it remains capable of meeting the information and data needs of the other model improvement tracks shown in Figure 4.

The RTCD includes a commendable amount of traffic count data. However, most are total vehicle counts at each location. There are relatively few vehicle classification counts included. The latter are essential for differentiating between autos and several classes of truck. The commercial travel model generates many of the truck flows produced in the RTM. Robust truck counts are required to develop and validate such models. It appears that validation of the current commercial travel model was hindered by the small number of reliable vehicle classification available for the E5 model update. Expanding the coverage of vehicle classification counts has already been identified as one of SEMCOG's highest traffic data priorities over the next several years.

Because even the planning level DTA will likely report hourly flows the count data must be collected and recorded at least the same level of temporal detail. It appears that most of the recent data are already in this format, which should become the standard in the future.

Finally, the RTCD should be expanded to include travel time data, which will be required to develop and validate the time-of-day and DTA models used in conjunction with both trip-based and activity-based travel models. These data have been expensive to collect in the past, requiring formal travel time surveys. This situation is rapidly changing with the advent of cellular tracking data. Vendors such as AirSage are offering data from a large subset of the population that can be aggregated and geocoded to obtain highly accurate and time-varying estimates of zone-to-zone travel times for the entire region. Many of these data can be obtained quite inexpensively compared to travel time surveys. SEMCOG should monitor the progress of such data programs and be prepared to integrate such data into the RTCD as they become available.

Travel Survey Program

Timely data on household and traveler characteristics, preferences, and choices are also required to build, apply, and validate travel demand models. These data are derived mainly from travel diaries collected through household and establishment travel surveys. Because such surveys are very expensive they are undertaken only once per decade in most states and metropolitan areas, and in some cases only once every two decades. MDOT designed and executed an ambitious statewide travel survey in 2004-05. Dubbed MITravelCounts, the program employed a consistent approach and methodology across the state that resulted in data suitable for use with both trip-based and activity-based model development. SEMCOG conducted a supplemental survey to increase the number of observations needed within their region the following year.

MDOT is planning to repeat the travel survey in 2014 or 2015, subject to availability of funds. It is imperative that SEMCOG leverage this opportunity as they did in the past. The new data can be pooled with earlier data to expand the number of observations available for detailed market segmentation – a limitation encountered when attempting to segment trip purposes by income in the E6 model development – as well as revealing changes in travel behavior attributable to changing preferences and tastes. The effect of the on-going recession can be seen, providing a basis for better understanding how individuals and households have adjusted their behavior in light of higher unemployment and constrained household budgets.

While it is expected to generally follow the design and procedures developed in 2004-05 there are opportunities to modify the next survey as needed to meet newer analytical needs. An increased emphasis on information on departure time and the factors influencing it can be included, for example. As with travel time surveys the emerging techniques described in Appendix B can be expected to substantially alter how travel surveys are conducted. Such changes may not have a major effect on the design and execution of the 2015 MITravelCounts, but will almost certainly affect how travel surveys are conducted by the end of this decade.

SEMCOG should take as strong a role as MDOT will permit in the design and oversight of the next travel survey. Decisions about target sample sizes, especially within Southeast Michigan, are especially important to influence. Aspects of survey design that will permit the data to be used for both trip-based and activity-based models should be retained.

If the survey is conducted in 2015 the expanded and cleansed data should be available within 18 to 24 months afterwards. This will preclude their incorporation into the SEMCOG models in time for the 2017 update of the Long Range Transportation Plan (LRTP). Rather, these data will be used immediately thereafter to develop the next generation of models that will be operational in time to support the 2020 and subsequent updates. The data can also be used as soon as they become available for assessing the advanced travel models shown in Figure 4. The first such evaluations can occur in 2017-18, when the traditional trip-based models used to prepare the 2017 RTP update can be compared to the first generation of the advanced models.

An estimated budget of $715,000 has been programmed for this track. It includes $60,000 for coordination with MDOT on survey design and planning, as well as $30,000 for SEMCOG's role in the analysis, expansion, and quality assurance of the resulting travel survey data. The balance of $635,000 will be spent collecting additional survey data in Southeast Michigan. These additional observations will be required in order to ensure that sufficient observations for market segmentation within the SEMCOG model are obtained.

Trip-Based Modeling System

When implemented this year the E6 modeling system will include all of the elements commonly accepted as best practices within the realm of trip-based modeling. It will provide an excellent foundation upon which to begin adding the non-traditional uses of the model summarized in Table 2, as well as further increasing confidence in the performance and capabilities of the delivered modeling system.

In the near term SEMCOG should focus on finalizing its implementation and conducting the forecasts needed for the next LRTP, due in 2013. Such an approach appears to be what the TMIP peer review panel had in mind, where their basic recommendations emphasized adding selected capabilities to the current trip-based modeling system (see Table 3).

An E7 version of the model is recommended for adoption within the next two years that incorporates the following features:

- Validation of the traffic assignment process at the county level is recommended. Statistics on model fit by functional class by county can be used to demonstrate the utility of the model for many of the tactical applications. While previous validation work has focused at the daily level these efforts are expected to focus on model performance by time of day as well, a key requirement for success in linking the E6 modeling framework with a DTA package.
- The existing external trip model is based upon aged survey data. It should be revised with data from the recently updated MDOT statewide model. While the counts at external stations are current the travel patterns gleaned from the 1994 SEMCOG external travel survey most likely are not. Rather than conducting a new survey the same information can be synthesized from the statewide model.
- A planning-level DTA model can be used to augment the static user equilibrium (SUE) assignment model currently used. The former will be useful in studying the tactical issues identified in Table 2, as well as improving the time-of-day modeling of the E6 model. A planning-level DTA is considerably less demanding than simulation approaches, as described in Appendix A.

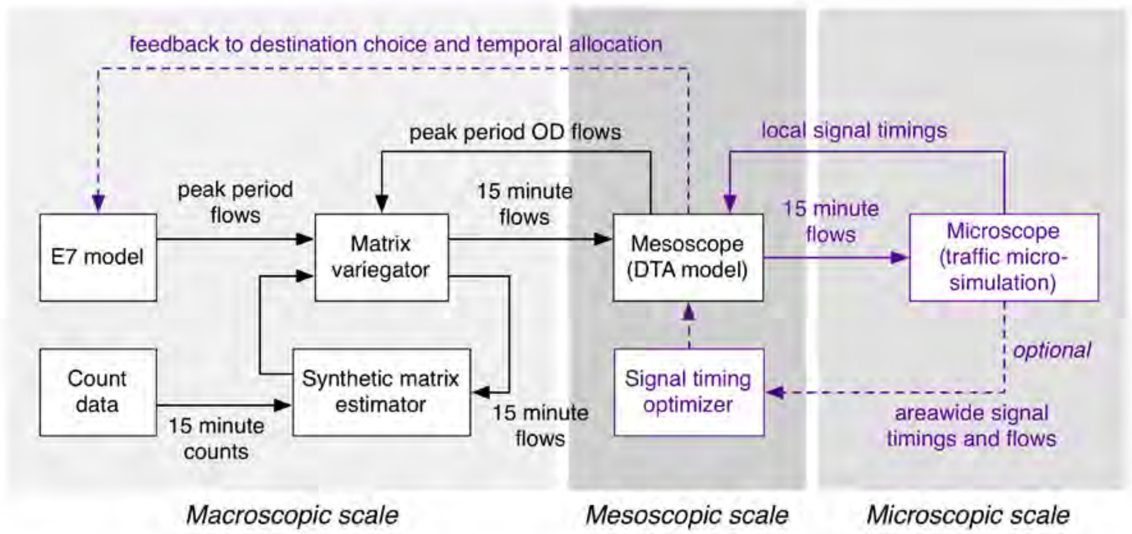
The first two features can be accommodated within the current modeling framework, with little or no changes to model structure or implementation. The introduction of a DTA component to the model will increase the level of accuracy required for the E series models. The model is currently calibrated and validated for the region as a whole. It is possible for a model to perform well in testing at that level, where highly aggregated measures mask trip distribution or destination choice patterns that cannot be reconciled with observed data. Testing the model at the sub-county level can provide additional insight into differences in travel patterns across the region and additional constraints on trip distribution patterns. This further validation is beyond what is expected in the E6 model development, and is therefore identified as an E7 model in Figure 4. This work should be completed prior to or in parallel with the implementation of the DTA components.

Several extensions to the E7 model will be required to implement a DTA model, as shown in Figure 6. The components include:

- A matrix variegator is used to convert the flows by period (typically the three-hour AM peak period and four-hour PM peak period) into the finer time intervals required by DTA models. Such models typically required demand sliced into 15 to 60-minute intervals. The allocation process typically uses departure and arrival time data from travel diaries, traffic count patterns, and vehicular and traveler tracking data.
- Synthetic matrix estimation (SME) can optionally be used to help refine the demand estimates, both in terms of origin-destination patterns and the allocation of trips to the short time intervals required by DTA. SME should be used as a diagnostic tool to help illuminate inconsistencies in traffic count data and socioeconomic data in traffic analysis zones with the largest adjustments. The output of SME can help inform the matrix variegation process.
- An optional feedback loop can be implemented that will enable the destination choice model and temporal allocation procedures in the E7 model to respond to the time-dependent travel times or costs generated by the DTA model. It is expected this is capability will be added after experience is gained with the combined E7+DTA model.

The TransCAD package includes SME and planning level DTA modules, reducing the amount of work required to implement these components. The matrix variegator, as well as the scripting necessary to connect these components, can be implemented within TransCAD as well. Doing so will protect SEMCOG’s investment in the platform, compatibility with modeling efforts at the Michigan DOT, and reduce the training required to implement the E7 and DTA models.

While dynamic traffic assignments will eventually become the norm for advanced travel models it is expected that at least for the near term that they will be an adjunct to the model, not a replacement for the SUE assignment methods commonly used for long-range transportation plans and studies, where modeling time-dependent travel patterns is not required. The simpler methodology and faster testing of the SUE will make it easier to implement in such cases, resulting in faster model turnaround times. As experience and confidence is gained with DTA it will likely completely replace the SUE methods over time.



The elements in black are the components required to implement planning-level DTA in the SEMCOG model. The components in purple are optional extensions that would add value. The signal timing optimizer is likely not required until intersection simulation is undertaken (part of the long-term recommendations). The elements at the microscopic scale are extensions that local governments and consultants would need to most effectively use the SEMCOG model in conjunction with traffic simulation tools, but are not required to implement recommendations outlined in this document.

Figure 6: Coupling planning-level DTA with the E7 model

Person Activity-Based Model

Achievement of the advanced recommendations of the peer review panel (Table 4) will require the implementation of activity-based person and commercial travel models, which in turn will be significantly facilitated by more closely coupling both with expected continued investments in the UrbanSim system. It is anticipated that a large number of such models will be perfected over the next few years. Considerable experience will be gained in the transfer of such models, a better understanding of how to couple them with advanced DTA models, and widespread experience using them to inform policy analyses and long range planning. SEMCOG will be in an excellent position to benefit from the pioneering efforts of others by implementing modeling systems developed elsewhere. They will be able to tailor the resulting systems to Southeast Michigan at a much lower cost than developing the models themselves.

The evidence to date suggests that activity-based (AB) models are, in and of themselves, not more accurate at replicating observed traffic counts than traditional trip-based models. Thus, replacing the latter with the former is not likely to help overcome unresolved data limitations, specification errors, or poor model fit. While most AB models operate on a microsimulated population of synthetic households doing so does not ensure closer correspondence between modeled and observed flows. One comparison of AB versus trip-based models used for evaluating small and medium projects in Ohio found that the former offered no substantial benefit when modeling such projects (Ferdous et al., 2011), a conclusion we do not dispute. However, AB models do confer a number of benefits that cannot be obtained using trip-based models:

- The need for a matrix variegator is obviated because travel is generated at a much finer (or continuous) time scale than traditional models. Designing the AB and DTA models to use the same time interval durations should be simple.
- Equity analyses commonly use different segmentations of the population than the travel-based market segmentation used in travel models. Redefining the latter in terms of the former would be very costly and disruptive. Microsimulation, on the other hand, permits highly flexible data mining using any combination of household or traveler characteristics desired.
- AB models enforce a consistency in travel choices for travelers and their households. A classical problem of using transit for commuting and then separately selecting an auto to drive to lunch with is avoided.
- Non-home-based trips, the purpose we know the least about in traditional models and have the least confidence in, are eliminated in their entirety. Such trips are segments of tours, ensuring consistency with other travel choices made by persons and households.
- Inter-household interactions and choices are explicitly modeled, which in turn shapes tour patterns to accommodate the travel needs of non-drivers in the households.

Other advantages have been cited in the literature, but these appear most germane to SEMCOG. Of those listed the first two appear to be most important in light of the desired capabilities summarized earlier. The ability to carry out operational analyses and the likely need to consider equity in making hard choices about reduced public investment in infrastructure are key analytical requirements.

Almost all of the AB models developed to date have been original or significantly modified works, where the pioneers have built and tested both the models themselves and their software implementations. Significant new data collection has often accompanied such efforts. As a consequence, most of this research and development work was costly and proceeded at a slow pace, and not a possibility for MPOs that lacked the staff or significant funding for consultants to complete such work. The remainders have adopted a “wait and see” attitude, wanting to take advantage of the investments made by the pioneers and seeing a compelling case for adoption before moving to AB models.

Work is finally underway to transfer AB models from one metropolitan area to another. The SHRP 2 C10 project aims to create a set of generic AB models coupled with dynamic network models that can be widely implemented at low cost. The San Diego AB model is also being transferred to the Miami-Dade County region, with the intention of implementing the model with local data, calibrating it to observed conditions, and testing it through local applications. It is anticipated that some parts of the model may need to be overhauled or estimated using local data, but such decisions will be made based upon experience using it locally. Addition model transfers may occur that can further inform SEMCOG’s efforts.

The gradual evolution to AB models at SEMCOG, shown as the bottom two tracks in Figure 4, can take place in the near-term. The models and their software platforms will have matured considerably by then, and at least some will take advantage of parallel and cloud computing to reduce their computational burden. The work in this track has been organized around five discrete work elements:

- *A0: Design* will be an intensive effort to evaluate currently transferable AB models and agency experiences with the process. A detailed work plan for transferring the chosen platform will be created. This effort can begin in 2013 and is expected to take six months to complete, at a cost of $50,000.
- *A1: Adaptation* will be devoted to implementing the chosen AB platform at SEMCOG. A fully operational model using currently available data will be produced and tested. The emphasis will be on adjusting and calibrating the model to locally observed conditions rather than estimating model components from travel survey data. Staff training will be an important task in this element. The work can be completed any time between 2014 and 2017, although spreading the effort over that entire time is not recommended. Rather, the implementation should be targeted within 12-18 months during that period. The cost of this work is expected to be $600,000.
- A *comparative evaluation* of the AB platform should be conducted in the second half of 2017, when results of the 2017 LRTP update are available. These will be generated using the E7 modeling system, permitting both models to be compared to validation targets as well as one another. The goal of this element will be to identify which parts of the AB framework meet acceptance criteria, and which will benefit from being re-estimated or updated based on local travel survey data. It is anticipated that this work can largely by accomplished by SEMCOG staff with minimal consultant assistance. A budget of $20,000 and duration of six months is assumed for this work element.
- *A2: Update* will incorporate key travel patterns gleaned from the analysis of the 2015 travel survey into the AB modeling framework. Some modules will perform acceptably, while others are expected to benefit from being overhauled using local data. The results of the previous step will inform priorities for model update. It is anticipated that the A2 model will be the primary tool used to conduct the 2020 LRTP update. This work can be accomplished over an 18-month timeframe at an expected cost of $200,000.
- *A3: Mesoscopic simulation* will be added at the end of the decade, replacing the planning-level DTA with a simulation-based platform capable of explicitly modeling the delay at intersections. The resulting travel times will be more accurate, especially in congested conditions. Moreover, a simulation-based approach can incorporate some aspects of intelligent transportation systems and the effect of improved traveler information, which will play increasingly more important roles as the USA moves from building infrastructure to operating and maintaining it more efficiently. It is widely anticipated that AB models will routinely be more tightly coupled with DTA models by that time. This element is expected to last 16 months, with a budget of $150,000.

While the choice of AB modeling platforms can be deferred until completion of the A0 work element, it should be emphasized that SEMCOG's investment in UrbanSim is seen as the foundation when it does occur. Although it has seen limited use to date at SEMCOG the UrbanSim model already contains the necessary socioeconomic and land use inputs, and is loosely coupled with the E5 model to obtain travel time and cost information used in UrbanSim. The synthetic population of households and firms will be directly usable within an AB modeling framework. If the latter requires additional household and person attributes it is likely they can be added to UrbanSim, adding value to both modeling systems. Alternatively, the output of other population synthesizers can be used with UrbanSim. It is anticipated that over time the linkage between land use and transportation models will become as important as the nexus of AB and DTA models. SEMCOG should keep both planes of integration in mind as both models evolve.

Commercial Activity-Based Model

While there is considerable experience to date with activity-based person travel models there has been little parallel progress with comparable models of commercial travel. In fact, progress overall in commercial vehicle modeling has lagged far behind person travel modeling over the past several decades. The trip-based commercial vehicle presently in use at SEMCOG is innovative, and exceeds the level of practice commonly found in most MPOs. However, it probably represents the limit of trip-based modeling of such flows in practice. Important dynamics such as trip chaining, distribution centers, supply chain logistics, and other factors influencing freight in particular are difficult to capture in trip-based approaches. Moreover, the cost of updating the survey data with enough observations to enable the market segmentation specified for the current model will be prohibitively expensive.

The aforementioned increased emphasis on vehicle classification counts will yield a larger sample of truck counts that can be used to better evaluate the performance of the current model. The current model can continue to be used as presently structured and implemented if found to be operating acceptably. However, there are a few options on the horizon that will offer greater capabilities and reflect current and emerging commercial travel trends. Two in particular have adopted elements of activity-based travel modeling. Both are still research efforts, but appear to be moving in promising directions:

- The Chicago Metropolitan Agency for Planning (CMAP) is investing in an innovative three-level freight modeling approach. When complete it will be capable of analyses ranging from delineating markets Chicago trades with (long-distance travel to, from, and through Chicago) down to the impacts of specific facilities and local policies. This modeling framework will take years to develop, test, and perfect. When complete it will likely be an excellent candidate for transfer to Southeast Michigan.
- The SHRP 2 C20 program (Freight Demand Modeling and Data Improvement Strategic Plan) will likely spawn one or more demonstration or implementation projects of advanced freight models that will be expressly designed for widespread adoption. While the structure and capabilities of such models can only be speculated upon at this time there is a strong likelihood that the results will be an

improvement over models currently available, to include the current SEMCOG commercial trip model.

Unlike the person AB models these efforts are not expected to produce mature and transferable products until later in this decade. Thus, action in this track has been deferred until 2016-17 in Figure 4, in part to offset this track from the person AB model implementation to avoid resource contention and level out funding requirements. Assuming that an approach different than the current one is adopted three work elements are recommended within this track:

- *C1: Adaptation* will focus upon implementing the selected commercial travel model at SEMCOG. A fully operational model will be implemented, but the degree to which it can accommodate local data will depend upon the particular model chosen and the type of data required for model application. Validation targets will be developed using truck count data from the RTCD. As with the person AB model implementation training will be an important aspect of this work element. Work on this can begin any time before 2016, but should be completed within 16 months rather than spreading it over several years so that momentum is maintained. This work element is expected to cost $220,000.
- The *comparative evaluation* of the commercial travel model should begin during the fall of 2017, when results of the LRTP update completed earlier that year become available. These will be generated using the commercial vehicle component of the E7 modeling system. The results can be compared to one another, as well as to the validation targets. The goal of this exercise will be to determine what parts of the model are candidates for re-estimation or revision in order to better replicated locally observed flows. It is expected that this work can be largely accomplished by SEMCOG staff with minimal outside assistance. A budget of $20,000 and duration of six months is assumed for this work element.
- *C2: Update* will seek to update the model using a combination of local data, to the extent available, as well as data synthesized from other regions and the literature. Approaches such as synthetic matrix estimation may be applied to diagnose anomalies and identify suspect or inconsistent data. The results of the evaluation step will be used to prioritize the activities accomplished in this work element. It is assumed that the updated model will be completed in time for use in the 2020 LRTP update. This work element is expected to cost $80,000 and be completed within 16 months.

The geographic scope of the commercial travel model will be larger than the person AB model. Most travel by urban residents is between locations within their community. Some commercial travel also travels a relatively short distance. But a substantial amount of freight moves through supply chains that stretch across regions and continents. Thus, many will have one or both trip ends outside of Southeast Michigan. This increases the importance of closely integrating the commercial vehicle model with its counterpart in the Michigan statewide model, as well as reliance on the FHWA Freight Analysis Framework (FAF) for a complete picture of freight connections with other regions.

Appendix A: Overview of Dynamic Network Models

Dynamic traffic assignment (DTA) is referred to several times in this report. There is no singular definition or reference implementation of DTA. Rather, a number of approaches fall under the banner and can be confusing to the uninitiated. In this brief discussion we provide a quick overview of the concepts. Chiu et al (2011) have produced a reader aimed primarily at practitioners, while Peeta & Ziliaskopoulos (2001) go into considerable technical details about both static and dynamic traffic assignments.

Network models can be broadly classified in at least two different ways. One refers to the fidelity and resolution of the flows being modeled:

- *Macroscopic* models operate at the coarsest level of resolution, where flows are represented as large groups of flows on routes between origins and destinations. The flows are broken into coarse periods of time (typically several hours each) if they are differentiated by time at all.
- There is no clear definition of *mesoscopic* models, which are a hybrid of macroscopic and microscopic scales.
- *Microscopic* models typically model individual vehicles and their interactions with one another and traffic controls as they traverse a detailed representation of the network. These models step through time in half-second to several second intervals.

A second classification scheme divides such models into static and dynamic types. The former have invariant network definitions and demand that affect all modeled travelers identically. This gives rise to the useful construct of an equilibrium solution, which is both repeatable and mathematically stable. Dynamic models, on the other hand, can reflect many different states as a function of the demand and congestion, and those states can vary over time. They represent the time and flow-dependent impact on travel much better than static models, and typically at a higher level of spatial and temporal resolution. Some dynamic models obtain equilibrium solutions, but because they incorporate some stochastic elements most dynamic models reach disequilibrium solutions.

Two broad classes of transportation network models have evolved over the past 50 years. Traffic assignment models have typically been used in conjunction with travel demand forecasting models, and route packets of vehicles on a highly abstract representation of a transportation network. The emphasis has usually been on correctly representing interzonal travel times and selection of least cost paths through those networks. Link flows emerge from the process. Until recently almost all traffic assignment models were static equilibrium formulations operating at the macroscopic level. Almost all travel demand models use assignment models of this type.

Traffic simulation models have evolved separately over roughly the same time frame. Their heavy computational and data requirements have traditionally restricted them to relatively small problem sizes, and except for occasional research activities have not been applied at the same scale as urban travel demand models. The emphasis of such models has typically been on the interactions between vehicles and accumulation of highly detailed network performance data. Thus, almost all such models are dynamic disequilibrium formulations operating at the microscopic level. Traffic engineers typically use such models to study design and operational issues at the subarea or corridor level. However, in recent years large-scale traffic models have been attempted with varying degrees of success. The TRANSIMS model is arguably the best-known model of this class in the USA, although several vendors presently offer packages capable of modeling large areas (e.g., MATSim, TransModeler, AIMSUN).

Perhaps nothing distinguishes the difference between traffic assignment and simulation models better than how intersections are represented. Traffic assignment models have traditionally used node-abstract representations of networks, where the Cartesian coordinates of the node are its only attributes. Links are defined by the nodes at either end of them. The effects of traffic signs or signals are included in mathematical functions that relate flow levels to travel times for all vehicles on each link in the network. Traffic simulation models, on the other hand, have detailed representations of lane geometry and connections, as well as traffic signal timing and phasing. Delay is calculated separately for each vehicle in the simulation as a function of its ability to move along its desired path through the network.

DTA models operate in the space between static macroscopic and dynamic microscopic models, retaining certain elements of each. They attempt to strike a practical compromise between the two, combining the relatively small and tractable data and computational footprint of the static models with the time-dependent network states and more accurate representation of time and delay afforded by dynamic models.

While theoretical papers and research models have existed for well over 30 years the use of DTA models in practice is relatively recent. Their widespread use and broad acceptance of their eventual widespread adoption have only occurred in the past several years. There are two broad classes of DTA models in use today. The older analytical models, also known as planning level DTA, have been primarily used in academic research. They are very similar to existing static equilibrium models, except that the shortest (least cost) paths are built through time as well as space. Such models are typically macroscopic. Ironically, they are more compatible with travel demand models and similar to static equilibrium models than other dynamic formulations.

The other class of DTA models uses simulation instead of a deterministic link capacity functions to calculate delay and travel times. This requires the explicit coding of traffic signal parameters, and in some instances the same level of lane connectivity required in microscopic traffic simulation models. Simulation-based models more accurately represent the non-linear effects of congestion, but at the expense of larger data and computational footprints. A choice between them is best made based upon the needs of the agency.

Appendix B: Emerging Technologies in Travel Surveying

Travel surveys are expensive, time-consuming, and disruptive undertakings. Initially conducted in person with the respondents, most over the past few decades have utilized recruitment and collection of self-enumerated diaries by telephone. Computer-assisted telephone interviewing (CATI) is widely used, which has enabled error and consistency checking in real-time. This has greatly improved data quality while reducing the cost of conducting the survey. These practices are fairly standardized, although lingering problems of under-reporting of certain trips, difficulties in recruiting certain segments of the population, geocoding accuracy, and other issues remain. If these shortcomings are not sufficient enough to motivate change it is likely that continued budgetary shortfalls will prompt the long overdue revolution in the way we collect data about personal and business travel.

Some changes to established practice have already extended the utility of the traditional diary-based travel survey. The use of Global Positioning System (GPS) receivers has been widely promoted as a means of overcoming the problem of under-reporting certain types of trips. However, their use has done nothing to reduce to cost of data collection or analysis. Stopher & Greaves (2007) advocate replacing the randomly drawn households with a paid, rotating panel of households. Such a program would get past the survey fatigue and resistance to follow-up questioning; such respondents are simply dropped (not paid) from the program.

The biggest looming advance, however, revolves around passive data collection techniques with automated retrieval systems. The majority of the population, to include the notoriously difficult-to-capture dual professional couples and younger technology workers, own cellular phones. Estimates of the number of households who exclusively use such phones varies, but is thought to range from 15 to 25 percent of the overall population, and up to 50 percent of young college-educated professionals in some urban markets (Kempf & Remington 2007, Blumberg & Luke 2009). With the widespread adoption of these devices the infrastructure for handling the voice and data traffic has mushroomed, and even with continual capacity additions many carriers have a difficult time keeping up with growing demand. One implication of this growth is that most urban areas now have very dense cellular networks, enabling them to triangulate user locations at ever-increasing levels of accuracy.

While data privacy issues, unwillingness on the part of carriers to share such data, and the cost of such data when available are all formidable barriers the likelihood that they will be overcome within this decade appears high. If trusted third parties emerge that can mine the data without revealing individual users or creating a burden for carriers the possibilities are endless. While marketing firms are eager to exploit such data for commercial purposes they will have equal value for developing and testing theories and models of travel behavior with sampling coverage, duration, and diversity never achieved before. While communication with the owner of the device may not be possible pattern-matching and spatial inference engines will be able to associate activities with locations to synthesize likely trip purposes, mode of travel, time sensitivities, and other travel characteristics.

However, it is the convergence of these possibilities – passive data collection and the paid respondents envisaged by Stopher & Greaves – that will revolutionize the collection of travel survey data. Paid respondents can install apps that will enable them to mark up recorded travel paths with information about trip purpose, factors influencing route and mode choice, number of people traveling with them, etc. Collecting the data will be as simple as syncing the device when connected to the cellular network. Moreover, the sampling period can extend from weeks to months, providing valuable insight into the known but barely measured day-to-day variability in travel patterns and choices. The cost of developing such mobile apps is small. Once a breakthrough is made in recruiting the move to this model of data collection for personal travel will occur very quickly. SEMCOG should closely monitor such trends, for it will fundamentally change the data collection paradigm and enable them to build an entirely new generation of models.

How quickly the process can evolve so that it can be used in a commercial environment is an open question, for the pairing of vehicles and drivers – to say nothing of the service or goods being moved – is far more ambiguous. Thus, if an update to the commercial establishment survey is contemplated during the next decade it will likely need to follow current practices. However, opportunities to use web-based reporting and respondent markup of GPS tracks on interactive maps should be sought from survey vendors. It is in this environment, where the tracking device must remain installed in a vehicle with several drivers (especially over a week or longer collection period), that GPS tracking will be a superior solution than trying to associate mobile phones with particular vehicles.

The point in contemplating these looming advances in travel data collection is to underscore the difficulty in recommending a definitive data plan for the next decade. The data needs can be well anticipated given SEMCOG's analytical needs and the general direction of research and development in activity-based travel modeling and dynamic traffic assignments. The profession has arguably been in the transition to these advanced models for the past 15 years, and the possibilities and direction of this work is generally well known. However, advances in mobile computing and telecommunications have proceeded at a much faster pace and are driven by market forces quite different than public policy planning needs. The potential of this technology to dramatically reduce the cost of acquiring travel data while at the same time greatly expanding the sampling frame will fundamentally change these practices in a much shorter time frame than travel models will develop. Thus, SEMCOG and other transportation agencies will need to revisit their data collection strategies on a biannual basis. It also underscores the need for SEMCOG modeling staff to actively participate in the TRB travel survey committees in order to remain abreast of the rapid changes in this field.

Appendix C: Staff Development

The potential utility of a model is largely defined by the capabilities of the user. They must be able to creatively and competently apply it, as well as glean useful knowledge from it, in order for the model to fulfill its potential. Unfortunately, this aspect of modeling capability is largely ignored when defining work programs and consulting agreements. We believe that it must be a high priority for SEMCOG, and given equal consideration as the data development and methodological advances being undertaken. Thus, the holistic specification of a model, shown in Figure 1, both begins and ends with the user in mind. The latter, which is highly correlated with staff development, is considered in this chapter.

Changing Skills

Most graduate programs in transportation engineering or planning include a review of traditional practices in travel demand forecasting and its role in strategic planning. The five-step sequential trip-based modeling paradigm is well established, and there is an abundance of literature and practical experience with it. It is reasonable to expect that current and future staff will have at least some familiarity with the process. It is likely that they can gain the skills required to use such models through a combination of refresher reading, review of documentation on the SEMCOG model, and coaching by experienced staff members.

The knowledge and skills required to develop, apply, and interpret the advanced models recommended in this report are unfortunately not as widespread. While there is an abundance of published academic works there are considerably fewer well-documented models in practice, and there is little consensus on the best form or implementation of these models. There is even less published about experiences in their development, implementation, testing, and validation that can usefully inform practitioners, although considerable progress is emerging in that vein.

In addition to a solid foundation in microeconomics, statistical methods, and mathematics, users of advanced models will require competencies in several non-traditional areas. If SEMCOG couples activity-based travel demand and dynamic traffic assignment models their staff will require a strong foundation in several areas:

- Activity-based travel demand modeling
- Discrete choice models
- Microsimulation and stochastic processes
- Sample enumeration
- Traffic flow theory and dynamics
- Traffic signal optimization

- Data mining and visualization techniques

Few universities offer such courses, but current graduates generally lack a strong foundation in these skills. Thus, SEMCOG will need to take an active role in equipping their employees with such skills. There are several courses available on the first two topics available through the National Highway Institute, National Transit Institute, and Travel Model Improvement Program. All are underwritten by the U.S. Department of Transportation. However, non-university training opportunities in the other topics are rare.

The skills required for land use modelers are also demanding. While they do not require the same depth of knowledge about activity-based travel models or traffic science they do require some. They must be equally well versed in discrete choice models, and have several unique knowledge requirements to effectively use a system such as UrbanSim. This includes a solid background in location choice theory and economic input-output modeling.

It should be noted that package-specific training courses, such as those provided by vendors of specific software platforms, as not adequate vehicles for gaining such knowledge. While they by necessity infuse some of the underlying concepts they are designed to impart knowledge about how to use a specific software platform. This type of training is essential, but it is not interchangeable with or substitutes for formal focused training in the topics described above.

Skills Infusion

Most metropolitan planning organizations cannot afford to underwrite a graduate education in the topics above for their modelers, even if such programs existed and were accessible though distance education. SEMCOG is no exception. While some of the aforementioned federal agencies offer short courses or workshops on these concepts they are designed only to impart basic concepts and terminology. None provide a deep enough foundation for students to go out and implement such models. In short, they motivate further study – self-guided or formal – by those willing to pursue the topics further.

Lacking distance-based university or federally sponsored training programs SEMCOG has little choice but to promote them. At least two ways of infusing this knowledge – contracted training and incremental skills development – are discussed in the following sections.

Contracted Formal Training

SEMCOG can fund contracts solely aimed at providing training for their current and future staff. A series of three to five-day training sessions on each of the topics described earlier could be arranged over the period of one to two years, reducing the workload and budgetary impacts of the program. Each training session should include the following components:

- Advance reading to familiarize the staff with the concepts to be presented. Such reading should not cover the topic at the same depth as the subsequent lectures, but rather lay the foundation necessary to successfully absorb the material presented.

- Lectures should be structured to present the salient concepts and to give the staff an opportunity to interact with the instructor(s).
- One or more exercises or case studies can be used to solidify the concepts conveyed in the lecture(s). Some of these can be done in real time, but others that involve full runs of the model may need to be completed in advance by the instructors, with the staff "walking through" the results with them.

Variants on this traditional approach should be carefully considered. One twist might be to use video-based lectures in lieu of classroom instruction. This would enable the staff to view them when convenient, as well as providing a resource for future employees or current ones wanting to refresh or gain new skills. Video-based instruction will require an active blog or similar portal where students can pose questions and comments to the instructor. Such dialogue should be accessible to all staff in the course.

In some cases textbooks or published reports may serve as suitable course reference materials. In other cases the contractor will be required to assemble the course materials. To the extent possible such materials should be provided in searchable digital format.

Incremental Skills Development

Many agencies have included training as a standard part of consulting contracts. This usually occurs at the end of the project, when the finished product(s) can be demonstrated through several applications. This has the advantage of closely coupling the work submitted by the consultant with knowledge of how to use it. The downsides include the fact that such training is usually focused only upon the contracted work rather than broader picture. As with training provided by vendors of transportation modeling packages, it is often tailored to their specific product and presented by specialists in that product rather than recognized leaders in the profession.

Despite these limitations this type of training is highly recommended as standard elements of all contracts. This will often be resisted by consultants and academics, who will argue that the associated costs will distract from an already lean budget for model and data development and documentation. Some will argue that the documentation and weekly interaction between the developer and SEMCOG will suffice. This may be true for smaller endeavors, and those that involve overhauling or enhancing current functionality. Such training should be required for all other development projects, even if it requires spreading out the development over a longer period of time in order to attain a triple win: better data, better models, and better employees.

Skills retention

Staff development is a process, not an outcome. They provide a necessary foundation for success in implementing and applying the practices recommended in this document. The models can evolve only as quickly and fully as the modelers are capable of accomplishing. Some of the constraints have less to do with staff capabilities than other issues, such as manpower levels, organizational priorities, or project assignments. However, the majority will be dictated by the capabilities and creativity of the modeling staff. The training activities described above provide a necessary first step towards so equipping them. SEMCOG should institute practices that will ensure that once instilled these skills are continually exercised and enhanced. Much of that will occur as part of their daily assignments. However, our experience with other agencies suggests that complimentary activities will increase the return on investment:

- Active participation in MDOT training and modeling user groups is essential for keeping abreast of developments elsewhere in the state, development and implementation of the statewide model and urban models from other MPOs, and development of modeling standards for Michigan.
- Active participation in the TRB annual meeting and specialty modeling conferences will enable the staff to continually expand their knowledge about current advances in the profession, ability to share what SEMCOG is doing, and learn from experience of others. Similar benefits will accrue from participating in Association of Metropolitan Planning Organizations (AMPO) meetings and committees.
- A willingness to serve on TMIP peer review panels will enable senior staff members to learn from success stories elsewhere and build their network of professionals.

It is tempting in times of budget constraints to reduce or eliminate investments in staff development. Many agencies are willing to sacrifice this activity in order to gain additional data or more sophisticated models. We strongly recommend against this approach, for the most comprehensive data and elegant models cannot overcome the lack of staff that are well equipped and motivated to use them to their full potential.

Appendix D: Suggested Further Reading

Several readily accessible reports and recorded webinars can provide additional information for interested readers:

TRB Special Report 288: Metropolitan Travel Forecasting: Current Practice and Future Direction

This report provides a high-level, non-technical examination of travel forecasting models that provide public officials with information to inform decisions on major transportation system investments and policies. The report explores what improvements may be needed to the models and how federal, state, and local agencies can achieve them. According to the committee that produced the report, travel forecasting models in current use are not adequate for many of today's necessary planning and regulatory uses. The findings of the surveys of metropolitan planning organizations used to help develop this report are available online.

Available online at http://onlinepubs.trb.org/onlinepubs/sr/sr288.pdf

Activity-Based Modeling Executive Session 1

The Executive Session is intended to provide directors and non-technical managers with a high-level overview of how models are used in policy analysis and planning, why current models cannot answer certain policy questions, the benefits and limitations of activity-based models, and the time and resources needed to implement an activity-based modeling system. It is a recorded webinar developed by the USDOT's Travel Model Improvement Program, and can be viewed online. This session lasts just over two hours.

Available online at http://tmiponline.org/Clearinghouse/Items/20120202_-_Activity-Based_Modeling_Executive_Session_1.aspx

NCHRP Synthesis 406: Advanced Practices in Travel Forecasting

This report evaluates the benefits advanced models might offer, summarizes implementation and institutional issues that may form barriers to change, and distills lessons learned from those agencies that have invested in advanced modeling practices to date. The findings are based on narrative interviews with more than 30 agencies that have pioneered these models, literature reviews, and practical experience gained by leaders in tour and activity-based models, land use models, freight and commercial movement models, statewide models, and dynamic network models. Most of these advanced models have been successfully used to address policy and investment options at urban and statewide levels.

Available online at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_406.pdf

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