The Travel Model Improvement Program

TMIP Email List Technical Synthesis Series

2007 - 2010

Helping Agencies Improve Their Planning Analysis Techniques

TMIP

Travel Model Improvement Program

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Defining Traffic Analysis Zones

Traffic analysis zones (TAZs) are the basic geographic unit for inventorying demographic data and land use within a study area. While the total number of TAZs dictates the size of trip matrices, the size and shape of TAZs can influence model results. Most notably, highway and transit trip loadings and the percent of intra-zonal trips are directly impacted by study area zonal detail and the size of the zones. Consequently, defining an appropriate zonal geography has long been a challenge to the travel demand model community.

Historically, the number of zones in a study area was limited by the capacity and processing power of computers. With the advent of geographic information system (GIS) integrated software and increased micro-computer power and capacity, the maximum number of zones in a study area is much less restricted. Generally, the more zones a study area has, the more useful the model may be for various planning related purposes (e.g. transit modeling, different land use alternatives, studying non-motorized activities, sub-area analysis). Increasing the number of zones in a study area does require additional investment of time and resources. As one contributor noted, "the greater level of zone detail should be balanced with the extra costs associated with the development of detailed input data, model development and maintenance, increased file storage space requirements and increased model run times." Ultimately, the number of zones in a study area is determined by the study area's size and planning needs. The following is a brief synopsis of the contributions to the email list regarding general guidelines for defining TAZs.

Defining TAZs
Generally, the number of zones should not simply be a function of the study area population. There are several factors that contribute to the determination of the number of zones in a travel model, including network detail, potential future alternatives to the network and land use, data requirements of the model (e.g. auto vs. non-motorized travel), and the anticipated growth in the study area. Contributors to the email list offered the following suggestions for determining an appropriate number of zones:

- The number of zones in a study area is typically a function of network geography,
- The number of zones in a study area generally increases as an urban area becomes denser,
- Zones tend to be smaller in denser areas (e.g. CBDs) and larger in areas of low density (e.g. rural areas),
- Larger zones tend to yield a higher percentage of intra-zonal trips.

Contributors also offered several observations regarding zonal structure:

- Where feasible, nesting census geographies (e.g. census blocks) within TAZ boundaries can improve the base year demographic inventory process,
- Additional zones may be required to study the impacts of non-traditional land development patterns, such as neo-traditional developments that encourage non-motorized activities and increase transit access,
- Zones with homogeneous land development can improve traffic assignment loadings to adjacent network,
- Additional zones may increase forecast accuracy and may also improve the modeling of non-motorized trips (e.g. walk and bicycle trips),
- A more refined zone structure improves compatibility for conducting micro-simulations and intersection analyses.

Based on the guidelines and observations noted above, zones are typically defined to be compatible with:

- Study scope and purpose(s),
- Land use homogeneity,
- Adjacent network geography,
- Other geographic features, such as rivers, lakes or railroads, and
- Census geographies.

TAZ Reasonableness Checks

Average zone sizes and ratios of zones per square mile provide useful insights about zone geography coarseness and may highlight potential trip assignment issues. Likewise, the average number of people per zone in a study area is a general indicator of regional density. A number of contributors noted additional metrics and statistics to assess network and land use compatibility with zone geographies. These included:

- Average TAZ size (expressed in square miles),
- Number of TAZs per square mile,
- Average population per zone,
- Number of network links per zone,
- Number of transit links/access nodes per zone,
- Number of zones by sub-area geography (e.g. rural vs. downtown, local-transit vs. all others),
- Trip densities per zone (a threshold value of trips per zone).

The density or size of zones can vary greatly depending on the amount of rural or less-developed areas in a study area. In addition, air quality requirements may require the study area to model outlying regions forcing the inclusion of more remote or developing areas, thereby influencing density ratios.

As one participant to the TAZ discussion noted, statistics regarding TAZ composition and size from a national survey sponsored by the Transportation Research Board (TRB) regarding travel demand model practices are available in the report entitled, “Determination of the State of the Practice in Metropolitan Area Travel Forecasting – Findings of the Surveys of Metropolitan Planning Organizations (Final Draft – June 2007).” The material is available at the following location: http://onlinepubs.trb.org/onlinepubs/reports/VHB-2007-Final.pdf on pages 22 and 23. The material is presented for small, medium and large size Metropolitan Planning Organizations.

Alternative Approach

Different zone structures for different steps of the model could be applied to make the number of zones more compatible with the particular travel model step. As one contributor added to the discussion, “transit and traffic assignments require more spatial detail than trip generation and trip distribution”. For example, mode choice and traffic assignment models could have more zones than the prior trip generation or distribution steps, which may not need the same level of detail. Concerns regarding consistency and forecasting accuracy however, lead others to suggest that the best approach is to have the same number of zones for each model step.

Conclusions

A standard for determining if a study area has an adequate number of zones does not exist. While increased computer power has essentially eliminated restrictions on the number of zones for all but the largest study areas, increasing the number of zones does lead to increased data collection and maintenance costs. Greater zonal detail can improve transit and trip assignment results and extends the potential usefulness of the model for other planning applications and studies (e.g. migrating data to a micro-simulation package). Smaller zones, as some contributors noted, may also discourage the practice of simply implementing special centroid connector capacities or volume delay equations in order to improve the adjacent network loadings.

November 2007

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Multi-Year Master Transportation Networks

A number of agencies consider the development and maintenance of a multi-year master network an efficient method for developing, storing, managing, updating and accessing the entirety of network related data. A multi-year master network file typically includes a base year network and all future year network alternatives.

Development and Maintenance of Multi-Year Master Networks

E-mail List respondents noted similar means of developing and maintaining multi-year master networks. The general basic steps employed by respondents to develop a master network are as follows:

- *Identify database* that will be used as initial starting point for developing a base year network. Conventional choices are either an existing rectified network or a GIS-based street centerline file that includes all roadway facilities (i.e. an all streets line layer).
- *Define base year network* by identifying relevant components. If the starting point is the all streets layer this may require omitting facilities such as local streets. In the case of an existing network it may require adding or deleting links to correspond to the base year transportation system. In either case, the goal is to identify and include all facilities that appropriately represent the base year network.
- *Add or modify centroid connectors* as needed to account for proper loading of trips.
- *Add new links* that represent future facilities that do not exist in the base year network. Modify or include additional centroid connectors as well for future year or alternative networks.
- *Code network attributes* for each network year. Two options were noted, either code all AB and BA link attributes by year on one link (e.g. lanes 2010 and lanes 2030) or code multiple versions of a link with one version for each year or alternative (e.g. one link with 2010 attributes and a separate link with 2030 attributes).
- *Use a selection flag or filter* to identify appropriate links for a specific year and/or alternative.

Application Procedures

The extraction of a single year network from the master network for model application purposes is accomplished through the use of a selection flag or filter to select the relevant links and attributes required for a specific model year application. One respondent noted that their process includes coding an initial year attribute to designate the year that the facility is operational. Likewise, a delete year attribute is used to disregard links that will no longer exist in a future year network. Upgrade and final year attributes account for network enhancements that occur in interim or final year networks.

One noteworthy observation was the importance of having a means of checking extracted networks for internal consistency. Once an alternative or year specific network has been extracted, it is important to have an automated process perform a sequence of tests to ascertain the integrity of the network.

Benefits

E-mail List respondents noted a number of benefits in maintaining a master multi-year network; these included the following:

- Improves network accuracy by affording effective comparisons between networks;
- Reduces amount of staff resources dedicated to network coding and network maintenance by eliminating the need to store duplicate information for each alternative;

- Provides means of eliminating network errors simultaneously in all networks;
- Ensures consistency and compatibility between network alternatives by automatically incorporating identical modifications for all affected years or alternatives, thereby eliminating unintended differences between network alternatives;
- Offers ability to rapidly develop alternative networks;
- Provides improved means of displaying model results;
- Affords straightforward development of historical records for lane configurations.

Conclusions

The task of creating and maintaining multiple networks appears to be more manageable within a multi-year master network process; a process that has been facilitated with the advent of GIS integrated modeling platforms. Individual year application is a straight forward process; year specific networks can be built by a simple query process. As noted, numerous benefits are derived from maintaining a master network, perhaps none more so than the reduction of network coding time, and the added accuracy and internal consistency among networks. This is especially relevant for large urban area networks that may include numerous alternatives and proposed improvements.

November 2007

Fuel Price Synthesis: Determining Current and Future Gas Prices

With the recent rise in gas prices, there is much debate over how to forecast future price changes. On the email list, this is a protracted issue with discussion going back as far as the inception of the Travel Model Improvement Program (TMIP) email list community. In November, 2001 an inquiry to the email list attempting to determine acceptable fuel cost ranges for a 2025 forecast scenario stimulated a discussion regarding changes to fuel prices and accounting for these changes within travel demand models (TDMs). Initially, many of the responses offered suggestions, methodologies and approaches for specifically forecasting fuel price and the subsequent influence on auto operating costs. The discussion has evolved through the years and has been expanded to include a number of considerations other than simply estimating future fuel costs. A significant amount of contributions have revolved around the potential changes, approaches and considerations that should be given to fuel price changes and the influences these may have on trip generation, trip distribution and mode choice models. A parallel discussion thread regarding model uncertainties, model sensitivities and elasticity's also surfaced.

The following synthesis represents discussions and contributions regarding potential methodologies and approaches to forecasting gas prices and represents a synthesis of all contributions to the email list community since it's inception regarding this particular subject matter. This technical synthesis will be presented in three main categories: methodologies and approaches (current and future gas prices), issues and comments, and conclusions based on the composite of all contributions to the email list.

Methodologies and Approaches

Three methods for determining the current price of gas as well as numerous approaches to forecasting the price of gas were made to the email list in response to the initial inquiry into forecasting gas prices and auto operating costs. Below are highlights from the contributions to the email list for determining a current base year value as well as approaches to forecasting the cost of fuel:

- *Current Year*:
  - Use the Bureau of Labor Statistics (BLS) to determine current average price data by region and for the country.
  - Determine the average price of gasoline over a period of time (e.g. 5, 10, 15, 20 years) to determine a current value.
  - Access information available on the internet to determine the current and/or historical price of gas for your region or the country. A number of contributors noted several sites that offer current information on the price of gasoline.
- *Future Year(s)*:
  - Apply the Delphi approach, which essentially relies on a panel of experts to prepare future year(s) estimates.
  - Adopt an approach that adjusts the price of gasoline faster or slower than the rate of inflation.
  - Apply linear regression (historical trend analysis) over a period of time to project future values.

- Employ sophisticated economic forecast methods, such as time-series models, single equations from multiple regressions, and multiple equation regression equations.
- Use the base year fuel cost and assume that the relative value remains the same in constant dollars.

Issues and Comments

Along with suggested methods or approaches, a number of contributors offered corresponding issues associated with determining the current and future price of gas. Some methods, such as using the internet or BLS data are self-explanatory. While other approaches, such as trending past gasoline prices to determine a current average price of gas as well as a future value(s), came with cautionary comments. Below are the highlights of the comments provided for certain approaches or methods:

- *Apply the Delphi approach*: As one contributor noted, the disadvantage with this approach is the estimate(s) may not be delivered in a timely enough fashion since a consensus needs to be achieved.
- *Forecast the price of gas either slower or faster than the inflationary rate*: Based on contributions to the email list, all costs in the base year are typically expressed in terms of constant dollars and it is assumed that the relative price of gasoline will remain the same in the forecast. Two contributors noted that any discussion regarding behavioral changes as a result of future year price increases should try to determine if the change is a result of the price increase exceeding the region's real-dollar wages or the Consumer Price Index (CPI). As one contributor to the discussion observed, the challenge is one of determining if auto operating costs as well as other costs (parking, transit fares, value of time) will be growing faster or slower than inflation, which is typically identified as the CPI. If the auto operating cost does not coincide with inflation, then an important element in maintaining consistency is to determine the potential impacts to the other costs as well.
- *Apply a linear regression*: A number of participants warned against using short-term trends to extrapolate or project future values. As noted by one contributor, trending fuel prices is difficult at best since the real price of gasoline trended downward until very recently (i.e. the past six years).
- *Employ sophisticated economic models*: One contributor felt that forecasting gas prices is essentially impossible by any available method because of the historical counter-trends between the real and nominal price of gas as well as the uncertain nature of world events. Similarly, another participant noted the difficulty associated with this endeavor because of all of the underlying factors that affect the price of gasoline, such as supply and demand, adoption of new technologies in the vehicle fleet, and government policies.
- *Use the base year value expressed in constant dollars*: Based on numerous postings, this appears to be the most widely adopted and accepted practice. As noted, this approach uses a base year value that is easily explained and defended. It was also noted that other methods may be too speculative when forecasting the price of gasoline because so many other events contribute to the actual price (world demand for oil, geo-political conflicts, and government policy).

Conclusions
A few of the email list comments conclude that it is generally recommended that each methodology and assumption be confirmed and agreed to during the planning process either through a technical working group or peer review committee. As one participant noted, developing a value based on the contributions of a technical working group or peer review committee doesn't necessarily contribute to better data but improves the understanding of the complexities involved in the issues being addressed and everyone understands how the value was generated. The general consensus is to assume the relative price of gas (as expressed in base year constant dollars) remains the same in the forecast. By doing so, the value can be defended, whereas forecasting the price of fuel is merely an exercise in speculation.

November 2007

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Fuel Price Synthesis: Travel Model Uncertainties

Travel models are developed to support informed decision-making regarding future transportation alternatives. Whether that is feasible in an environment of uncertainty when observed data and trends are not available was the focus of various discussions regarding the potential impact of prolonged higher fuel prices.

Six key questions posted to the email list during different periods capture the broad level of uncertainties associated with capturing the influence of higher fuel prices on overall travel:

- Lacking observed data to support behavioral responses it is unknown whether significant shifts in travel patterns, trip making characteristics and land use patterns may occur as a result of higher fuel prices so how does one forecast those effects?
- If the price of fuel becomes overly burdensome to all drivers, can we expect corresponding advances in vehicle technology to improve overall fuel economy (as seen in the 1970's) and how do you forecast vehicle fleet mix if this comes to fruition? Along with the uncertainty associated with the evolution of fleet technology, the switch to alternative fuels should also be considered.
- Could vehicle miles of travel (VMT) actually increase as a result of individuals reducing their driving costs by migrating to hybrid or fuel efficient vehicles?
- Is the discussion regarding fuel prices and out-of-pocket expenses even relevant in mode choice discussions except for the lowest income stratifications?
- What kind of economy will the United States have if the price of energy doubles or triples and the cost of transportation represents a greater share of economic input and what would be the corresponding effect on overall travel?
- Is it even a proper role for travel models to forecast gas prices when conformity determination and other planning applications require consistent planning assumptions to measure the scope of the changes?

Travel Model Uncertainties

As noted in previous syntheses on the topic, quantifying the potential impacts to travel behavior as a result of fuel price changes is not as straightforward as it initially appears since responses to these changes have evolved over time. A number of contributors were cautious about drawing direct relationships between gas price shifts and driver behavioral responses. Several contributors observed that while there is ample evidence that people do alter their travel behavior during previous (i.e. early 1970's) price spikes; nevertheless, more recent data is less conclusive. Moreover, consistent responses from which to draw conclusions to use as defensible travel model inputs do not yet exist. Consequently, the lack of consistent behavioral responses limits the certainty of how to address these underlying issues in current travel demand model practice.

For example, recent observations indicate that higher gas prices have had minimal impact on driver behavior. Economists have noted several probable explanations for these recent findings:

- *Increase of dual-income households* in America has created more disposable income and a greater ability to absorb increases to specific portions of the household budget (e.g. auto operating expenses);
- *Increasingly longer commute trips* make households more dependent on vehicles to get to and from work. This is especially true in regions where the automobile played a substantial role in determining land use patterns. Exacerbating the problem is the lack of viable alternative modes of transportation to support the longer commute trips;
- *America's love-affair with vehicles* has made people more willing to absorb out-of-pocket costs associated with higher gasoline prices by modifying expenses elsewhere in the household budget (e.g. eat out less, go to movie theaters less often or avoid unnecessary purchases). Another contributing factor is people simply switching to more fuel-efficient vehicles rather than choosing an alternative mode of travel.

This level of uncertainty led one respondent to hypothesize that a potential bias may exist to overstate probable shifts to alternative modes of travel if fuel price changes are incorporated in the model structure. Furthermore, the respondent cautioned that, "the challenge to the modeling community is to not overstate the changes in vehicle miles of travel (VMT) and mode share as a strict relationship between gas prices and travel behavior". In response it was recommended that larger macro-economic conditions need to be considered when interpreting past data regarding changes to VMT and mode share during periods of fuel price adjustments.

Further highlighting the difficulty in forecasting probable outcomes is the interdependence of the strength of the overall economy and transportation. As one contributor noted, transportation (the value added by goods and people delivered, and the mechanisms thereof) constitutes a quarter of our economy. Changes to that relationship could also impact overall travel.

Conclusions

Though ostensibly this synthesis has addressed the intricacy of properly forecasting behavioral responses to fuel price changes, the underlying issue has been one of adequately accounting for uncertainty in the modeling process. Imbedded also within the discussion is an understanding that addressing model uncertainty can be accomplished by acknowledging existing data limitations. Moreover, it appears that there is consensus in the modeling community to develop a process that provides modelers with the ability to communicate potential impacts while recognizing the difficulties of accurately quantifying the impacts.

Despite the level of uncertainty associated with a lack of observed data, it is also evident from the initial questions that considerable thought has nevertheless been given to potential outcomes. Indeed, the six questions themselves offer a framework for addressing the inherent uncertainty. For example, suggestions were offered for developing a forecast scenario given a set of known values (e.g. auto operating costs, tolls, transit fares, in constant dollars) and then determining a range of potential outcomes given different forecast variables (e.g. fuel price increases). Forecast scenarios could likewise be developed for other questions posed throughout the discussion. Thus acknowledging limitations (e.g. unknown behavioral response) while incorporating them into a range of potential outcomes (e.g. shifts in overall travel, trip lengths, and mode splits) appears to be a viable approach until there are greater levels of historical data to draw more specific conclusions.

November 2007

Fuel Price Synthesis: Potential Travel Model Considerations

Throughout the years a recurring discussion on the email list is the variety of travel model considerations to be addressed when accounting for fuel price changes. The ensuing diversity of comments (regarding potential behavioral responses to prolonged higher fuel prices) demonstrates the extent with which fuel price changes could eventually impact current modeling practice. Five key questions posted to the email list during different periods serve to define potential travel model considerations given higher fuel prices:

- If the cost of fuel (in terms of actual fuel price increases and/or corresponding gas tax increases) continues to a certain level (as yet to be determined), may it force general land use changes in the forecast scenario(s)?
- What are the potential consequences on household expenditure patterns given different auto operating cost scenarios?
- Is it reasonable to anticipate that people may choose to re-locate closer to jobs in denser settings that have greater alternative modes of travel to reduce trip lengths or retire certain trips altogether?
- What impact would these types of changes have on auto-dependant cities versus older/dense cities with greater transit service?
- What is the threshold value for the price of gasoline that will create basic changes in trip making characteristics and what are the potential outcomes?

Where there are few recommendations offering tangible solutions or practical examples to address the questions noted above, the discussion elicits a number of suppositions and observations on how select model input variables might require adjustment. Taken as a whole, these comments highlight the diversity of issues that eventually may need to be addressed in travel model development.

The following synthesis represents a compilation of all emails on the subject matter since the inception of the Travel Model Improvement Program (TMIP) email list.

Potential Travel Model Considerations

The synthesis describes six probable travel/land use related scenarios that may occur if fuel prices and auto operating expenses increase significantly for a sustained time period. These are:

- *Changes in land use patterns* may cause people to locate closer to jobs or shopping, thereby impacting densities and land use patterns.
- *Suppression of trips* is a reasonable expectation given higher auto-operating costs associated with increased gas prices.
- *Reduction in total trips* may be a possible outcome and will likely occur with weekend non-discretionary travel and long distance travel. One contributor noted changes will probably not occur with non-discretionary travel that occurs during the peak hours. Others thought that people would choose to combine trips to eliminate the need for non-discretionary travel during weekend travel.
- *Increased trip chaining* is possible.

- *Changes in trip length* may occur as a result of increased trip-chaining and changes in land development patterns.
- *Increased transit patronage* may occur as the price of owning and operating an automobile becomes extremely high (e.g. fuel, parking, tolls). Several contributors felt strongly about the relationship between higher fuel prices and transit patronage while others indicated a basic concern about making a direct relationship between the two by citing examples regarding sensitivities to travel time versus the cost of travel.

Additional travel model considerations were offered that might require a re-assessment of certain model input variables; these are listed below:

- *Changes in household expenditure patterns*: Several contributors provided examples of how households may redirect household expenditures in response to higher fuel costs but were unclear how this may influence trip making.
- *Increased auto-operating costs*: As one contributor noted, the historical cost for operating a vehicle has been relatively low on a per mile basis. Moreover, given a large increase in the cost of fuel, the per mile fuel cost and any anticipated changes brought about by higher fuel costs may still be relatively low.
- *Changes in fuel efficiency assumptions*: Similar to fuel costs, fleet fuel efficiency is typically assumed to be a constant over time to yield a value of X cost/per mile. Changes to vehicle technology in response to higher fuel costs may have dramatic effects on fleet fuel efficiency depending on how quickly the fleet migrates to this new technology.
- *Increased costs to transit*: A number of postings noted that the corresponding costs to transit should not be ignored when accounting for changes in fuel prices.
- *Changes in the value of time*: A question was posed regarding the justification for changing the value of time for different forecast years and whether it was possible to have a different value of time for transit costs and tolls costs. Since transit, toll, fuel, and parking costs are out-of-pocket costs, these should all have a consistent value; otherwise, comparing transit and toll alternatives in the same corridor would be difficult observed one contributor.
- *Changes to toll usage*: Preliminary evidence using recent traffic data indicates that volumes on toll roads have not changed in response to increased fuel prices, even during periods of extreme price spikes (e.g. Hurricane Katrina). One contributor felt that perhaps this is because the income characteristics of the toll road users are not influenced by changes in fuel price and the corresponding increase in basic operating costs per mile.
- *Changes in the departure/arrival times to avoid the most congested periods*: One particular response that may be anticipated with higher fuel prices is the modification of people’s departure and arrival times to avoid the most severe congestion. One recommendation was to increase the number of time periods being modeled in an attempt to capture this type of change.

Potential Travel Model Solution

One significant solution offered to the email community was to incorporate a feed-back between fuel costs and land use/demographics to account for the changes in travel related expenses, even though this is not a trivial endeavor. Understanding the underlying assumptions and correctly identifying the numerous land use-transportation dynamics associated with the cost of travel and determining the orders of magnitude and analytical approaches to interpreting the results are simply unknown at this point. Based on the contributions to the email list, it appears that beyond the realm of academia, these types of models have not been integrated into current mainstream travel model practice.

Conclusions

Each of the potential travel related outcomes and model considerations noted above are recommended for careful consideration; however, there are relatively few concrete suggestions on how to account for these issues in the current model practice with a high degree of certainty. Based on available observed data, the modeling community has a limited ability to model the potential consequences of higher fuel prices on overall travel. As one contributor offered, modeling the effects of the cost of driving hasn't really been adopted because large scale changes in response to fuel price changes have never occurred and therefore, the true effects are hard to establish. Moreover, it is simply too speculative to predict whether market constraints and innovations will drive up or down the relative costs of driving over time.

November 2007

Fuel Price Increases and Impact on Driver Behavior

Accounting for behavioral responses and modeling the impact of significant fuel price increases has prompted a discussion of fuel price increases and the impact on driver behavior. This summarizes discussions during the month of April, 2007.

Introduction

Discussion of fuel prices and their corresponding influences on travel behavior have occurred intermittently, along with the issue of how to account for price increases within the travel demand modeling process and how to account for fuel price elasticity. With recent nationwide gasoline price increases, the discussion of fuel prices and modeling approaches was once again initiated with a newspaper article regarding observed responses to recent fuel price increases. The article and several replies provided context for the discussion by highlighting previous behavioral responses to fuel price increases in the late 1970's compared to current driving habits. Further context was provided by discussion on the impact of significant gas price increases resulting from higher taxes. Based on information provided by the article as well as other contributions, there has been observed precedent associated with fuel price changes as well as driver responses to these changes. For example, fuel price increases in the late 1970's led to the following behavior shifts:

- Reduced driving, reduced fuel consumption (20 percent gas price increase yielded six percent less consumption);
- Purchasing more fuel efficient vehicles;
- Changing mode of travel; and,
- Changing residential location.

Whereas recent (2001 to 2006) fuel price increases and resulting driver behavior have not been consistent with behavior observed during the 1975 to 1980 timeframe:

- Recent data indicates drivers are not taking steps observed during the 1970's to conserve fuel (20 percent gas price increase yielded one percent less consumption),
- Minimal change in average vehicle fuel efficiency during the past five years; increased purchases of fuel efficient vehicles comparable to the 1970's have not occurred.

A presumption offered on the listserv indicated that market forces may increase gas prices to $4.00 per gallon or higher in the near future. It was also noted that higher gas prices could arise from increased federal or state taxes. Proponents that advocate higher gas taxes think this policy change would:

- Discourage consumption;
- Stimulate increased demand for fuel efficient vehicles;
- Provide funding for alternative energy sources; and
- Provide funding for additional public transportation.

Conversely, some economists argue that higher prices would not lead Americans to alter their travel behavior or influence consumption because people would make other household budget sacrifices before modifying current driving patterns or purchasing fuel efficient vehicles. One respondent noted that the nominal price of gasoline increased from $0.50 per gallon to $2.00 per gallon between the late 1970's and the late 1990's; yet, in real terms the price declined which resulted in further fuel consumption. Hence, a recommendation was made to verify that a fuel price increase exceeds regional wage increases or the Consumer Price Index (CPI) prior to drawing any conclusions regarding behavioral shifts in response to perceived fuel price increases. It was further noted that perceptions of whether price increases are temporary or long-term can also potentially influence behavioral responses.

Key Discussion Issues

Apart from the comments noted above, responses to the discussion on fuel price increases and their impact on driver behavior were varied. Three separate threads of discussion however accounted for the majority of comments. Though seemingly independent, the three topics listed below each offer relevant perspective on model development and application:

- Potential demand responses to fuel price increases;
- Viability of modeling long-term impacts; and,
- Modeling approaches.

Following is a brief synopsis of the comments provided within the three separate threads of discussion.

Potential Responses to Fuel Price Increases

Various behavioral responses to fuel price increases were provided throughout the discussion; however, when the discussion focused on significant fuel price increases, it was anticipated that potential responses could include changes in:

- Land use patterns;
- Trip/activity generation rates;
- Distribution of trip/activity locations;
- Mode of travel; and,
- Vehicle fuel efficiency.

Furthermore, significantly higher gas prices may decrease population and employment growth in auto dependent regions while encouraging additional growth in less auto-dependent regions. Similarly, sizeable increases in heating fuel costs could promote growth in milder climate regions.

Viability of Modeling Long-Term Impacts

An observation was made that potential means of modeling the impact of significant fuel price increases have not been forthcoming because:

- It has not yet occurred and consequently observed behavioral responses are not available;
- Predicting market constraints and technical innovations that will impact the cost of driving over a 30 year time frame is speculative.

A question arose as to whether existing modeling techniques can adequately address long-term changes in transportation costs. It was stated for example that model coefficients derived during model estimation are only valid for the range of variable values present in the estimation data set; consequently, there are limits to extrapolating elasticity curves for future conditions considerably different than existed during model estimation.

Modeling Approaches

One of the latter emails in the discussion concluded that potential modeling approaches to address fuel price change responses might include the following:

- Development of an integrated microsimulation-based land use/transportation model;
- Application of empirically based regional sketch-level models;
- Development of reasonably robust models and reliance on professional judgment; and,
- Defining a probable future by employing a multi-scenario analysis using the previous three approaches.

November 2007

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Land Use Models

For a number of metropolitan planning organizations (MPOs) and other planning agencies aspiring to advance their demographic forecasting process, the means of attaining and implementing enhanced demographic forecasting procedures is not readily apparent. As one e-mail list respondent noted, "…the migration path from DRAM/EMPAL (a widely used land use model) to state of the practice, if not art, is not clear to me". Other e-mail list respondents noted some trepidation in utilizing more advanced land use models even though it may be well documented and not overly complex. These concerns led to discussions on the merit of implementing advanced land use software packages and the investment of resources required to adequately implement land use models. The following is a brief synopsis of contributions to the e-mail list regarding the rationale for implementing advanced land use models, the means of doing so, and some concluding cautionary remarks.

Motivation for Implementing Advanced Models

E-mail list respondents offered several reasons and observations for wanting to implement more sophisticated land use models as well as the practicality of implementing newer models. These reasons included perceived limitations of traditional land use models and the potential benefits derived from implementing newer models.

Respondents cited the following limitations of traditional land use models:

- Inability to provide forecasted data at the traffic analysis zone (TAZ) level. Data is typically furnished at an aggregate level (e.g. county) and is generated by extrapolating current trends,
- Inability to evaluate policies required to achieve optimal land use patterns; these include policies such as smart growth, tax reductions, cost sharing, and land banking, and
- Inability to assess the regional impact of proposed local jurisdiction land use policies.

The following comments were offered as a potential motivation, or improvements that could be realized, by implementing advanced land use models:

- Employs finer geographic detail,
- Includes parcel level data and real estate pricing mechanisms in conjunction with geographic information system (GIS) integrated software,
- Includes feedback procedures between the transportation system and land use,
- Offers increased ability to account for human behavioral traits, and more realistic dynamics,
- Affords improved procedures to account for free market forces that shape new development, and
- Provides ability to incorporate actual land markets.

Means of Implementing Advanced Models

As noted by several contributors, transitioning from traditional land use models to more advanced models can be accomplished through incremental steps or stages. Moreover, the migration process need not merely represent a perfunctory change from one software platform to another platform. The following is a suggested approach for transitioning to a more robust land use model:

- Develop the necessary parcel database using a consistent land use classification to develop a region-wide parcel-based land use inventory,

- Inventory building types, dimensions, and age, if possible, to finalize the parcel database. As one respondent noted, “Many of these sorts of efforts focus too much on the land itself, ignoring the details of the buildings”,
- Use standard data sources,
- Develop a micro-data synthesis from aggregate data, and
- Automate the model calibration process.

The use of local data sources and initially simplifying the land use model as much as possible was also viewed as a useful means of transitioning from traditional models to more advanced models. Having capable staff that thoroughly understand both the intricacies of the land use model as well as local real estate markets was seen by one respondent as being imperative in successfully transitioning to a more advanced land use model.

Similar to other efforts aimed at implementing advanced modeling methodologies, the land use modeling community does not have a standard model or process from which to draw upon. There are currently several different models and methodologies available for application. One e-mail list respondent noted that the modeling community should develop methods for providing, at a minimum, acceptable practice methodologies that are accessible and straightforward. An acceptable practice threshold was defined as a set of models that included feedback from transportation to land use and enough sensitivity to policies such that it made model application advantageous for MPOs. This was viewed as an inception point from which incremental improvements could be implemented over time with the ability to assess each enhancement from a cost benefit perspective. To achieve this however, it was noted that flexible and modular software platforms that allow incremental improvements first need to be developed.

Issues to Consider
One respondent stated that the implementation of advanced models will require a commitment to assemble the necessary data, as well as calibrating and properly applying the model. Other concerns regarding the implementation of advanced models included the following:

- The accuracy and magnitude of advanced model sensitivities,
- The availability of data to support model validation, and
- Whether it is possible to accurately model land use impacts.

Despite these concerns it appears that a number of agencies conclude that the regional planning process will benefit from an integrated land use and transportation model.

Conclusions
There is a strong interest within the modeling community to move forward and begin implementing more sophisticated land use models that may have the capability to more accurately depict the potential impacts of policy-level decisions. The current perception is traditional land use models have limited capabilities and are not sensitive to locally proposed policy initiatives. In response to concerns regarding the efficacy of transitioning to more advanced land use models, several respondents outlined a variety of steps that can facilitate the actual transition. Final considerations for those planning to implement more advanced land use models include the decision whether to use open source or commercial vendor software, the process for choosing appropriate software, whether to customize the software and to assess the trade-offs of being an early adopter of advanced methodologies.

January 2008

DISCLAIMER

The objective of the series is to provide technical syntheses of current discussion topics generating significant interest on the TMIP e-mail list. Each synthesis is drawn from e-mails posted to the TMIP email list regarding a specific topic. The syntheses are intended to capture and organize worthwhile thoughts and discussions into one concise document. They do not represent the opinions of FHWA and do not constitute an endorsement, recommendation or specification by FHWA. These syntheses do not determine or advocate a policy decision/directive or make specific recommendations regarding future research initiatives. The syntheses are based solely on comments posted to the e-mail list.

Employment Data

For a number of metropolitan planning organizations (MPOs) and other planning agencies charged with developing demographic data, accurate employment data can be an elusive and challenging aspect of inventorying and forecasting regional demographic data. Information not only needs to be accurate at the region-wide level but also at the traffic analysis zone (TAZ) and sector or district levels. Determining an accurate control total for the region is typically the first step in the process but may not represent the greatest challenge. Employment data must be stratified into employment categories (e.g. basic, retail, service and government), disaggregated to the zonal level and compared against population (e.g. employees per person) and household (e.g. employees per household) data at the regional, sector and zonal levels to ensure the information is representative of current trends and socio-economic patterns.

The following is a brief synopsis of contributions to the e-mail list regarding employment data/categories, including available employment data sources and the challenges associated with each database, potential long-term workforce participation trends that may impact travel, and some brief concluding statements from contributors to the e-mail list.

Employment Categories
As noted by one contributor, the number of employment categories needs to align with the needs of the travel demand model (TDM). Nationally, among different urban areas, there is a large variability of employment categories used in the models. Categories mentioned include industrial, commercial, service, education, FIRE (i.e. financial, insurance and real estate) and government. Identifying an appropriate number of employment categories, according to one contributor, may be a function of model complexity (e.g. gravity vs. destination choice). The North American Industry Classification System (NAICS) is typically referenced and customized locally to match local area employment category definitions. Prior to the NAICS, the Standard Industrial Classification (SIC) codes were used to categorize employment. Cross tabulations between the two systems have been developed to aid the migration between the two systems.

Data Sources
There are a number of public and private sources for determining regional employment control totals. Some states, such as Texas, make employment data available through a state employment or workforce agency. Other contributors to the e-mail list noted private vendors as potential sources. Primarily though, the e-mail discussion focused on three national sources – the Bureau of Labor Statistics (BLS), Bureau of Economic Analysis (BEA), and Census 2000/American Community Survey (ACS). There are a number of distinguishing features associated with each database. As noted by a contributor to the e-mail list, “no one data set captures all of the nuances of employment.” To assist with defining the differences between these prominent databases, a number of contributors to the subject provided overviews for each of the databases noted above. Below is a brief synopsis of those contributions by data source:

Bureau of Labor Statistics (BLS): BLS data is based on the ES-202 databases, which are monthly or quarterly census of employment and wages using payroll data (except for farm employment). The data represents a count of individuals who were issued paychecks during the reporting period. Because of this, the data does not distinguish between full or part-time workers or capture volunteer workers, contract labor, or business owners that do not pay themselves a salary. All part-time employment (no matter how short the time frame) that is salaried during the period is counted, including weekend jobs. The BLS, as noted by one key participant in the discussion, also includes other estimates of labor force and employed residents (place-of-residence) information that can be compared to Census 2000 and ACS data.

The labor force and employed residents data is available in the Local Area Unemployment Statistics (LAUS) program, which is based on three different databases – Current Population Survey (CPS), Current Employment Statistics (CES), and Unemployment Insurance (UI) data.

Bureau of Economic Analysis (BEA): The BEA "augments" the ES-202 data used by the BLS with data from the Internal Revenue Service (IRS) by including information on farm and non-farm proprietors. Since the data is payroll related, BEA data can be considered, "place-of-work," data. As one participant noted, BEA is, "a count of jobs rather than FTE (Full-Time Employee) numbers."

U.S. Census: The Census database is a survey of households conducted every ten years and respondents are asked to identify their primary job. A "primary" job can be either a part-time or full-time job. Consequently, the respondent is either employed, unemployed or not in the labor force. The data does not capture individuals with multiple jobs. Unlike the BLS data, the information does capture information about household employment and volunteer employment, but only because this is the persons "primary" job. Since the information is collected at the household, the employment data represents place-of-residence information.

Potential Long-Range Trends

As noted by several respondents, historical and existing economic and socio-economic conditions reveal that the national average of workers per household has remained relatively constant over time (e.g. approximately 1.22) and since 1960, the average household size has declined (although it has flattened more recently). Currently, there are a large number of single person households that keep the number of workers per household relatively low. However it may not be safe to assume that these trends will continue because of the aging population in the United States and the pending retirement of the "baby-boom" generation, which could impact participation rates in the economy and workforce. As noted by one contributor, it might be, "relevant to create scenarios with different numbers," to address the pending generational issues.

Another trend noted by contributors is a concept referred to as the centralization of employment. As regions mature and develop diversified bases of employment, the number of employees per person generally increases, which is most evident in older urban areas. Within small geographic areas in an urban area, "the number of people that work in an area can exceed the number of workers who live in the area."

Conclusions

There are a number of employment data sources but there isn't consistency among the potential resources. Confusion sometimes arises in how these different databases define a worker. Labor force includes unemployed individuals while a worker is defined as someone having a job. As one contributor summarized, the decennial census, ACS and information from the LAUS program are sources of labor force and employed residents. The CES data from the BLS and BEA data can be used to gather specific employment figures for an urban area. Another contributor suggested that a potential benchmark of jobs and workers in the region might be, "the region-wide expansion of a really-good household survey," assuming the expansion isn't set to a pre-determined target value.

As the current generation of "baby-boomers" retires, planners may have to re-consider the impacts that this generation may have on the underlying employment figures if these people choose to work longer in years, become self-employed, and hold part-time and/or volunteer positions long into retirement. As noted by e-mail list contributors, the self-employed, part-time and volunteer positions may not be accurately inventoried or evident in the available databases. The corresponding impacts on trip lengths and vehicle usage, however, could be quite profound.

February 2008

DISCLAIMER

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The Derivation of Initial Speeds in Travel Demand Models

Travel model network speeds are a significant and influential attribute of the travel demand model (TDM) development process. Network link speeds are one of the two attributes (i.e. speed and distance) for determining network travel times that are traditionally utilized in three steps of the TDM development process: trip distribution, mode choice and traffic assignment. Some models also utilize accessibility measures in trip generation. Accurate speed data are essential for:

- Models that utilize a feed-back process in the model structure to derive congested weighted speeds,
- Models that use time-of-day traffic assignments,
- Models that attempt to matched observed speeds at different volume conditions,
- MPOs that develop congestion management plans,
- Urban areas that conduct mobile source emissions modeling, and
- Studies that analyze network alternatives for corridor analysis studies.

The following is a synopsis of the contributions made on the topic of speeds, with a specific focus on determining initial speeds and the collection of speed data that supports the derivation of initial network speeds.

Determining Initial Speeds

Specific speed data that is inventoried to support the derivation of initial network link speeds as noted by contributors to the e-mail list include:

- Observed speed data by time-of-day (based on speed and travel time studies),
- Posted speed limit data, and
- Uncongested free-flow speeds representing off-peak travel speeds.

Based on contributions to the e-mail list, the speed values noted above are then used in one of three ways:

- The speed value may serve as the actual network speed that is subsequently utilized throughout the model without modification to the original value,
- A relationship between the inventoried speed data and an initial network speed value is formulated to derive the input network speed value, or
- The data serves as the initial speed for deriving a congested weighted speed through a sequential feed-back loop procedure.

Apart from forming the basis of deriving initial link speeds, it should also be noted that the inventoried speed data is also used to develop speed-flow relationships that are used to create specific volume-delay equations (e.g. by facility type for different time periods) for the traffic assignment step.

Speed Data Collection Methodologies

The derivation of initial network speeds is reliant on the inventory and collection of observed speed data which can be a considerable data collection effort. Based on contributions to the e-mail list, relatively few study areas have collected or are actively collecting comprehensive speed and/or travel time data. Only the Atlanta, Georgia and

Portland, Oregon study areas provided detailed information regarding their speed and travel time data collection efforts. For the Atlanta region, these efforts include:

- Collecting speeds at specific locations for different time periods and days of the week for different facility types (and area types), and
- Collecting point-to-point travel times using a “floating car” method for different time periods (e.g. morning peak, evening peak, and mid-day time periods).

Additional data collection methods noted by contributors include:

- Utilizing loop detector data on freeways to determine speed-flow relationships as well as travel times,
- Utilizing toll transponders to automatically collect travel times,
- Acquiring speed and travel time data from vehicles installed with GPS devices (e.g. private vehicles, taxis, or municipal vehicles), and the potential application of,
- Utilizing video technology to collect speed-flow relationships, volumes and travel times.

Each of the methods noted above incur associated costs and challenges. The floating car method and GPS data can be expensive to implement and retrieve. Speed data from loop detectors can contribute spot speed data that may not have any correlation to the length of the segment. Video technology to either distinguish and follow individual cars or read license plates is expensive to implement and may not be completely reliable. Additional information regarding the floating car methodology, speed-flow surveys and data inventories that have been documented in the e-mail list discussion follows.

Floating Car Methodology:
In a floating car procedure, a driver attempts to mimic the same speed as a majority of drivers in the corridor. The travel times from the Atlanta study were obtained using specialized GPS equipment with specific checkpoint locations. As noted by a contributor, prior to the deployment of GPS technology, travel time (and subsequently speed) was collected with pen and paper using a stop watch.

Speed-Flow Surveys:
Speed-flow surveys are also conducted by some study areas to quantify the relationship between speeds and traffic volumes by facility type (and area type) for different time periods. This data is used to calibrate a set of locally developed volume-delay equations. For freeways, information from loop detectors has been utilized by two study areas in the e-mail contributions.

Arterials, though, offer greater challenges associated with acquiring the average segment speed. The use of loop detectors for speed and flow information is highly dependant on the juxtaposition of the loop detector with respect to the intersection. The speed collected at a mid-block detector will be (in most cases) very different from speed or travel time data collected from intersection to intersection. For arterials, Portland Metro also noted the use of the “average car method with GPS transponders attached to probe vehicles measuring mid-block speeds, upstream from intersections" (e.g. floating car procedure). Traffic counters were used to obtain the necessary count data for those segments studied.

Some contributors indicated that observed speed/travel time data need to be augmented with additional data on delay at intersections. This is especially evident in the discussion regarding the calibration of volume-delay equations. Collecting delay data at intersections, though, was acknowledged to be an enormous and probably unrealistic option. The potential use of video technology to collect this information was noted by two separate contributors. The North Texas Tollway Authority (NTTA) indicated that fixed cameras along with specifically developed software has been deployed to detect speeds that are used to provide continuous updates to the speed/LOS/flow maps on the NTTA website.

Inventorying Posted Speed Limit Data and Free-Flow Speed Data:
The Atlanta region also noted that the posted speed limit by segment is inventoried and used as one of the five variables applied to a scoring system to determine the facility type, capacity and free-flow speed of the facility. Free-flow speeds represent the typical operating speeds on a facility during low demand or the speed that would be encountered by a driver during periods with little or no congestion.

The derivation of free-flow speeds is typically based on known information such as the posted speed or observed speed data. Typically, the free-flow speed for access controlled facilities such as interstates, freeways, and directional ramps is higher than the posted speed limit for these facilities. Whereas, "… for signalized urban streets, the free flow speed is normally much less than the speed limit due to the influence of traffic signal delays, driveway disruptions, etc." as one contributor noted. Four other large study areas indicated the use of previously observed speed data or are actively collecting speed data to quantify free flows speeds by facility type or develop speed-flow relationships by facility type (e.g. freeway and arterial).

Conclusions
Based on contributions to the e-mail list, it appears that the desire to acquire reliable speed data is one that resonates throughout the travel model community. However, it does not appear that a consensus exists on which speed data to include in the highway networks as the initial speed; rather, it appears to be highly dependant on available data and the level of familiarity the local area has with the data. With the broader adoption of feed-back loops in model structures, free-flow speeds appear to be increasingly utilized to derive congested weighted time-of-day speed results from the equilibrium assignment process.

July 2008

DISCLAIMER

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Timing of Household Travel Surveys

The following is a synopsis of the contributions and responses regarding the appropriate nature and timing of travel survey programs during periods of local or national change. Potential solutions and alternative survey approaches such as, panel surveys are also reviewed. The synthesis represents contributions made to the e-mail list during October 2008. The discussion is augmented with select contributions made during two separate seminars on the Virtual Mentoring Technical Service Center (VMTSC) in late October and early November.

Introduction

One of the more important foundations for the development of any travel demand model is obtaining a basic understanding of the dynamics of urban area residential travel that can be collected through household travel surveys. Additional critical data worth obtaining includes information on urban goods movement or commercial vehicle travel as well as the impact of external trip travel patterns which are acquired via other travel survey instruments. Travel surveys provide a substantial amount of information regarding travel behavior, including but not limited to, why travel occurs, the activity, the frequency, cost, mode, and trip length in addition to person and household characteristics of the traveler. Thus, the resulting travel survey data comprises key inputs and calibration benchmarks in the development of travel models.

More importantly the timing of a regional data collection program can be critical with respect to future demand forecasts. As noted by a participant, *when* the survey is conducted can potentially raise credibility concerns regarding the defensibility of the data and the model. Given the unstable economy and changing fuel prices, what can be done to reduce concerns about moving forward with household and other travel surveys? And, what should agencies consider in developing their regional data collection programs? These two questions are the foundation of the e-mail discussion synthesized below.

Key Discussion Issues

Participants overwhelming conclude that given the uncertain nature of socio-economic conditions, there never really is a truly “opportune” time to conduct travel surveys. According to one contributor, “there is no time when travel is stabilized,” given the influence of external forces. Several contributors noted the lack of accurate anticipation associated with recent events such as the financial turmoil, housing problems, and elevated gas prices as evidence of anyone’s ability to accurately predict future conditions when budgeting and constructing a travel survey program. As noted by a contributor to the discussion, a survey that is conducted every 10 years may “miss the boat” on unique events; or, conversely, the survey may unduly capture a unique occurrence which may have unintended consequences with respect to model results.

As noted, cross-sectional household surveys offer a "snap-shot" of participant's travel at the time the data was collected. Several contributors felt that traditional cross-sectional household survey's may not be able to capture temporary or permanent changes due to external forces or changes in the region's transportation infrastructure because of the infrequent nature of these data collection efforts. Consequently, several questions and concerns were raised regarding traditional survey programs. These include:

- Data collected episodically (e.g. periods of 5, 10 and 15 years can exist between regional data collection efforts),
- Insufficient data to conduct meaningful analysis of responses to socio-economic change (e.g. external factors may be ignored or undocumented),
- Large "one-time" budgetary cost,
- Privacy issues and the intrusive nature of surveys that may lead to reliability concerns associated with the information obtained from travel surveys (e.g. this may influence bad transportation planning decisions),
- Proliferation of cell-phone only households (e.g. call-back interview issues).

Potential Solutions and Considerations

At issue is creating a dataset that represents an event either before or after it has occurred and whether the event represents a true temporal alteration of long term trends or simply represents a one-time event (short or relatively protracted). Therefore and as recommended by more than one contributor, travel surveys should be collected when the data need is apparent and the money is available in the budget to move forward. Relevant knowledge of existing models, past data collection efforts, and reasonable judgments regarding future model expectations should help form the basis of how frequent and how large the data collection efforts should be according to one contributor. As suggested by another contributor, documenting average fuel prices, local and national unemployment rates, and average housing prices at the time of the survey can offer relevant and timely information regarding exogenous events that occurred at the time of the data collection effort.

The timing of regional data collection programs is obviously critical and not only in the context of large scale socio-economic cycles. Several contributors highlighted local events as examples of occurrences that could influence travel survey results. Regional transportation events, such as the opening of a significant toll road or transit fare changes, may warrant delaying the onset of travel survey collection programs. By delaying the survey, the planning agency could, in theory, have datasets that represent the before and after conditions associated with the implementation of the regional transportation projects.

For small-to-medium sized study areas continual or episodic data collection efforts may not be very realistic given budgetary constraints and timelines. One pragmatic solution offered was to conduct frequent model validations and updates to track model results as a means to address and monitor influences on travel and therefore comparative model results. Interim year forecasts could be used to verify baseline conditions or determine that the base year events were a one-time aberration or trend. As one contributor added, “a near-term ‘model verification’ exercise could offer insights about the uncertainty of a longer-range forecast.”

For instances when the travel survey program has been interrupted or postponed due to a unique event, one suggestion offered was that trip rates or portions of the model structure from other regions could be borrowed and the agency could, “focus on other areas to collect data needed to validate a model rather than estimate a new model set.”

Potential Opportunities
A panel survey, unlike the traditional cross-sectional sample surveys, is not a one-time data collection effort. Panel survey participants agree to be surveyed over many years. Information is collected in “waves” with the period in-between waves measured in months or years. Therefore, panel surveys have the potential to accurately capture the changes that occur as a result of socio-economic changes.

The concept of implementing panel surveys for non-marketing purposes, such as capturing behavior associated with transportation decisions, is relatively new to the United States. There are limited examples in the United States. The Puget Sound Transportation Panel (PSTP), which began in 1989, is the most frequently cited example in the United States. Several contributors noted the planned panel survey in the state of Ohio as a long anticipated event in the survey and transportation communities. The Ohio panel survey will be augmented with a supplemental and concurrent global positioning satellite (GPS) data collection effort. As one contributor specifically noted about this example, “this allows for the collection of multi-day data, which could further illuminate the effects of short-run perturbations in society and the economy.”

Conversely, the international community has greater experience with the practice of panel surveys. Examples noted by contributors to the discussion included the German Mobility Panel, which uses a 3-year rotational design to reduce attrition concerns, and the Sydney Continuous Household Travel Survey. The cited benefits of the rotational design in Germany include:

- Reduces conditioning effects in panel members, and
- Enhances the sustainability of the panel.

Another advantage of continuous surveys, according to one participant, is it obviates the need to periodically, “request a one-off substantial budget survey.”

The largest drawback to panel surveys is attrition, which is realized through participation disinterest, panel members moving out of the study area, and panel households changing and eventually contact is lost with that household. A few contributors noted that obtaining and sustaining the proper sample size raises several statistical and sampling concerns.

Conclusions
As noted by one contributor, traditional surveys may not be perfect, just like traffic counters and other data sources. However, there are many years of research and implementation practice that lends credence to these types of survey instruments. The data is also available in a

relatively short time period, upon the completion of the survey, whereas complete longitudinal
survey data requires a number of additional years of data collection.

There are many salient benefits to capturing time sensitive information with respect to travel demand modeling. Currently, there is very limited experience in the United States as to what to do with information generated by longitudinal panel surveys and how to incorporate this information into travel demand models. Based on these discussions, the debate still exists as to whether it is more efficient and practical to periodically survey or to develop continual surveys that may provide a wide sample of the variability of decisions and influences to travel.

As one key contributor noted, “even if we could quantify the economic and social factors that impact travel behavior, how could we predict economic and social change?” Developing a sound survey design approach and increasing the frequency of data collection and model validation efforts appears to be the common solution for overcoming unpredictable local and national socio-economic episodes.

December 2008

Feedback Loops

The following is a synopsis of the contributions and responses regarding feedback loops for travel demand models. Approaches noted by contributors as well as potential considerations and criteria for measuring convergence are also reviewed. This synthesis represents contributions made to the e-mail list that were initially made in 2005, briefly revisited in 2006 and addressed again in February, 2009 when the subject of convergence criteria for large urban area models was discussed. Additional contributions were augmented by the discussion of determining Braess' paradox.

Introduction
Traditional four-step models apply trip generation, trip distribution, mode choice, and trip assignment model components in a sequential, linear and independent fashion. In general, outputs from an individual model component are used as input to the next model component without any further adjustment or refinement. The individual treatment of model components isolates decisions regarding origin-destination, mode and route. Immediately evident with this approach is the discrepancy between the input travel times used for trip distribution and mode choice, with the resulting congested weighted inter-zonal travel times from trip assignment.

In contrast by creating a nexus between the different model components in the TDM hierarchy through an iterative process, the outputs from one level of the model hierarchy become consistent with the inputs to a proceeding step in the model structure rather than exist as autonomous activities in the model chain. This sequential iterative approach to travel demand modeling is called a feedback loop process where the demand or representation of regional travel patterns by trip purpose is no longer estimated independently and irrespective of network supply as a result of having link costs (e.g. time/speed) updated for each iteration of the feedback process. As a result, the travel times used to determine trip patterns during the trip distribution process and the resulting congested travel times from assignment become increasingly consistent with each iteration of the feedback loop process. The most common feedback structure is to link trip distribution, mode choice and traffic assignment.

Approaches
There are a number of approaches associated with implementing a heuristic model structure. The two most common approaches discussed are the naïve feedback and the method of successive averages (MSA). Three other approaches were also mentioned in the listserv but did not receive as much attention. The basic descriptions of the approaches follow:

Naïve: The naïve or direct feedback approach uses the demand from an initial model cycle to update travel times for the next successive iteration of the model chain. New estimates of demand are determined by updating travel times during each iteration. The resulting travel times are used directly and are not altered between iterations based on previous results. As one contributor noted, "the demand normally oscillates from one cycle to the next cycle" and convergence may be difficult. A pre-determined optimization function or fixed number of iterations is used to determine the converged solution set.

MSA: The MSA approach uses the weighted link flows or travel times from the current and previously weighted trip assignment results to compute updated links costs (e.g. time) that are reintroduced to the next iteration. Convergence is tested prior to the next iteration to determine if the difference in values being tested have diminished enough to achieve a pre-specified threshold level between iterations (e.g. travel time, link flow, or trip table stability). If convergence is not achieved, another loop is performed; otherwise, the pre-determined optimization function is satisfied or a fixed number of iterations is encountered (typically to limit computation times).

Fictive Costs (2.5 Cycles): A third approach briefly mentioned is the fictive costs approach. The initial congested weighted travel times are fed back directly for the second iteration. The results of the second iteration are averaged with the resulting times of the first iteration to obtain the final travel times.

Constant Weights: An alternative approach to the MSA application briefly mentioned in the discussion is the use of constant weights (sometimes referred to as fixed weights). Proponents of this approach feel that a predetermined weighting scheme can be identified to reduce potential oscillations between iterations and to arrive at consistent travel times. Within the general discussion, various weighting schemes (sometimes referred to as step sizes) were discussed, such as applying equal weighting or determining an optimal weighting scheme between the current and previous iteration (e.g. 70% new/30% old). Several contributors noted success with fixed Lambda values while another contributor noted success with decaying the Lambda variable with each iteration.

A fifth less discussed approach is the Evans MSA approach. Some contributors find the combined model scheme more compelling than others.

The MSA approach appears to be the most widely adopted feedback methodology implemented in the United States.

Convergence Criteria and Considerations

According to some contributors, determining the appropriate metric of convergence can be elusive given the array of options available to measure system-level and link level performance. It was noted by one contributor that a single parameter may not be adequate to, "sufficiently define the solution" while others emphasized that measures of system-wide convergence may be achieved without actually arriving at acceptable link level performance criteria (e.g. volumes v. count comparisons). Methods of achieving feedback convergence and the measure used to achieve convergence include:

- Compare travel time skims from one iteration to the next (i.e. "stationary highway skims"), which can be measured by root mean square error (RMSE).
- Compare OD trip tables from one iteration to the next (i.e. "stable trip tables"), which can be measured as total misplaced flow (TMF) or RMSE. A contributor considered trip tables to be, "a less sensitive measure", of convergence.
- Compare link volumes to determine the percent change in vehicle miles of travel (VMT) and vehicle hours of travel (VHT)

Additional convergence measures include the GEH statistic and relative gap (traffic assignment).

The Atlanta MPO provided the following convergence criteria:

- Criteria One: Less than 5 percent of the O-D pairs have peak hour travel times that change by more than 5 percent.
- Criteria Two: The average change in peak hour volumes is less than 5 percent.

Portland Metro provided the following guidance:

- Prepare histograms of travel times (i.e. skim matrix) weighted by trips. The target statistics for the histogram is to have the standard deviation within 0.5 minutes and the mean difference within 0.25 minutes.

Based on contributions to the e-mail list, there does not appear to be consensus regarding any one parameter or set of parameters that should be used in the averaging process to determine closure for the MSA approach. As noted above, three different approaches (i.e. travel time, trip tables, and link volumes) have been used individually or in combination (e.g. measuring convergence using trip matrices as well as link flows). Some contributors indicated experience with trip matrices converging faster than link flows. Several others felt using time was not adequate because this variable may not be stable in terms of oscillation from one iteration to the next and the resulting travel times may not be consistent with the resulting link flows.

Issue of Uniqueness

Because the feedback process represents a holistic approach to modeling, the interaction and specifications within each individual model step may influence model results from one application to another (i.e. comparing different network alternatives). Within each loop, the traffic assignment model must be applied, which in and of itself is an iterative feedback process. Some contributors noted that the stability associated with the equilibrium assignment model may improve overall convergence (and reduce computation time) for the iterative process. Several contributors indicated that a traffic assignment stopping criteria of 0.001 or tighter (i.e. relative gap) is necessary to improve overall model convergence in a feedback mechanism.

Another variable associated with uniqueness is the input data itself. As noted, quite different solutions may be achieved, if a different set of initial conditions are utilized (e.g. input travel times – free flow times versus congested weighted times). A specific contribution concluded that no matter how beneficial feedback mechanisms may be in resolving input and output data in the sequential modeling process, the implementation of a feedback approach does not correct or overcome short-comings with model input data (e.g. demographics).

Implementation Considerations

As evident in the discussion, the type and sophistication of feedback process is highly dependent on urban area size and level of congestion. As noted by some contributors, models for smaller study areas (e.g. urban areas with 50,000 in population) probably don't merit a feedback mechanism given the level of congestion typically associated with these urban areas. Conversely, the implementation of a robust feedback process was considered critical for large, heavily congested urbanized areas. Achieving tightly controlled feedback convergence also comes at an expense though. Each individual loop may take several hours, depending on the complexity of the models. It is for this reason, that some contributors noted applying a fixed number of loops. MPOs need to weigh the practical benefits of achieving improved solutions sets against the computational time and effort required to apply the models.

Integrity of the Results

A few contributors posed strategic questions regarding the validity of the results. As noted by one contributor, "are the sensitivities implied in the feedback observed in the real world?" Stated another way, the optimized results may not actually reflect real-world travel behavior associated with a congested system. Several contributors noted that sensitivity tests should be implemented when comparing model results between different alternatives.

Conclusions

Based on the variety of e-mails on the topic, wide-spread adoption beyond very large metropolitan areas has probably been limited by the rigorous knowledge base it requires to implement a feedback mechanism. It is evident in the discussion that some contributors have significant breadth and understanding regarding the mathematics and theory behind feedback loops. As such, a number of approaches have been adopted in the modeling community. The approaches probably reflect the level of understanding of the problem, available software and the desired solution set. Conversely, some MPO staff may not have the same level of familiarity with these concepts to implement a successful feedback mechanism. As one contributor noted, "there are a lot of very poor implementations of feedback sitting on MPO computers".

Because of the array of approaches and practices associated with measuring convergence, formulating meaningfully conclusions based on the e-mail list regarding approaches, convergence parameters and measures of convergence is difficult. This does not suggest that ambiguity exists. A number of erudite contributions for each methodology and approach were made in the discussion. Clearly, each approach yielded *a* solution set but as one contributor noted, there are also multiple solution sets to the same problem.

August 2009

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Model Uncertainty

The following is a synopsis of the contributions and responses regarding travel demand model (TDM) uncertainty. Approaches noted by contributors as well as potential considerations and criteria for measuring model uncertainty are also reviewed. This synthesis represents contributions to the e-mail list that were initially made in 2005, revisited again in 2008 and briefly addressed in June, 2009. Additional contributions were augmented with discussions regarding assessing reasonable forecast year model results, forecasting error, and predicted versus actual — validation checks of travel patterns. These topics were raised in 2005, 2007 and 2009 respectively.

Introduction

Model uncertainty exists at many levels including model inputs, model application, model structure, and model results. Consequently, measuring, managing, and planning appropriately while acknowledging model uncertainty are specific challenges facing the modeling community. Indeed, addressing or clearly articulating the extent of uncertainty surrounding model results may initially appear incongruent given the amount of time and money invested to arrive at a forecast. As noted by one contributor, there really isn't any incentive to do so and any analysis that includes rigorous testing of the model results may, "provide advocacy groups (e.g. transit, highway, and bicycle) with ammunition to criticize a forecast". While acknowledging model uncertainty can be misconstrued as diminishing model credibility, many contributors to the contrary felt that incorporating uncertainty analysis may offer greater insight into potential outcomes and the interpretation of alternative model results.

Significant attention is given to interpreting model results on numerous occasions in the e-mail list. As noted by several contributors, the use of a single statistic to communicate model results (e.g. vehicle miles traveled, ridership) is unrealistic since it conveys more precision than is warranted for a discrete answer. Given the range of sources of uncertainty that may influence outcomes, arriving at a "reasonable" answer may be purely random considering the extent of uncertainties and assumptions that support a forecast development.

Sources of Error and Uncertainty

Based on contributions to the e-mail list, two significant sources of error contribute to uncertainty in the model results:

- Model estimation (e.g. mode choice model estimation) and supporting data sources (e.g. travel survey instruments, geo-coding of survey results)
- Model inputs (e.g. socioeconomic data, networks, cost data, trip generation rates)

Other items noted as sources of error included:

- Introduction of a new mode (and subsequent model parameters)
- Behavioral responses to new modes, facilities and policies
- Dynamic nature of specific projects (e.g. alignments, operational characteristics)

And considerable emphasis was given to the uncertainty associated with land use models.

Propagation of Error and Uncertainty

Specific mention was given to the fact that most Metropolitan Planning Organizations (MPOs) will calibrate to a base year and make the leap forward to a single forecast scenario year without the insights obtained from interim year forecasts. This may exacerbate the amount of error propagation associated with inputs and uncertainty in the outer forecast year. As noted, even minor base year anomalies can have potentially significant consequences when factoring the temporal distance between the base and forecast year. As one contributor stated, "we forecast something for which data is scarce and follows the ever changing laws of human behavior/preferences and changes in technology".

Propagation of errors and uncertainty can also occur as a result of zealous base year model validation efforts. Several contributors offered cogent warnings about manipulating variables or superimposing synthetic functions without any justification except to merely improve base year comparisons to count since these ramifications are carried forward in forecast applications. As noted by several contributors, a model may compare favorably to existing conditions but may not necessarily represent a good forecasting tool.

Identifying Model Uncertainty

The most common approaches from the e-mail list contributions for identifying, testing and possibly vetting uncertainty in the model forecast are as follows:

- Implement rigorous alternative scenario testing for a range of possible forecast conditions. As one contributor noted, "The more dependant implementation is on the veracity of the forecast, the more likely they are to be wrong".
- Implement risk and sensitivity analysis through the use of controlled testing of the models (e.g. rapid increase in fuel prices might constitute a real negative income effect).
- Verify that the trip patterns predicted by the models are actually occurring by comparing the predicted versus actual outcomes – presumably either through short term forecast comparisons (when updated counts are available) or reviewing previous model results. Interpreting these results can also raise several perplexing issues. As one contributor noted, "should counter-intuitive results be interpreted as a poorly performing model or are these results indicative of unrealistic inputs"?

Based on contributions to the e-mail list, most types of sensitivity tests (with the possible exception of toll projections) are rarely conducted because of time and budget constraints.

Communicating Model Uncertainties

As noted above, there are a number of potential factors that can influence the predictive capabilities of the models. Specific recommendations for communicating model uncertainty tended to focus on the results rather than those issues associated with inputs and other variables. In addition to individual contributions, specific guidance and recommendations were given by two sources: the Federal Transit Administration (FTA) and the United Kingdom's Transportation Analysis Group (TAG)). These include:

- Document upper/lower bounds, best estimate, standard estimate (FTA). FTA policy guidance specifically requires an analysis and documentation associated with capital-cost and ridership uncertainties to improve the portrayal of the alternative(s).
- Assign probabilities to different scenarios/assumptions to introduce confidence intervals and other statistical criteria for assessing project risk
- Determine the plausibility and implication of different scenarios
- Define the dependent and independent variables as well as their relationships (e.g. land use – transport and vice versa) that would affect the likelihood of certain scenarios (TAG). This may include a range of possible inputs for each variable.

In addition to the solutions noted above, it was recommended that corresponding documentation be developed that accurately conveys and describes the consequences and implications of different scenarios and alternatives. Documentation regarding the basis for the decisions (e.g. explicit assumptions that this scenario will occur) was another recommendation.

Implementation Considerations

As noted in the supplemental information provided by TAG, the incorporation of uncertainty analysis should avoid introducing optimism bias when reviewing the plausibility of schemes or alternatives. This also applies to approaches that incorporate the quantification of dependent and independent variables that may influence the schemes (e.g. the likelihood of a land use scenario or network alternative). As one contributor noted, “It’s also not clear as to whether the original developers of a model can objectively present the test results – so the question comes up as to who should perform the tests”. Moreover, as with any future alternative, there are variables that are beyond the scope of capture, such as random events, or unforeseen national economic issues which can unduly influence forecast results.

Determining Reasonableness

It appears from the contributions that introspective examination of the models rarely occurs and if it does, it is difficult to quantify. As one contributor noted regarding a specific modeling example, “I have not attempted to determine what is and what is not “reasonable”, merely what converges”. Uncertainty analysis recognizes that there is more than one probable scenario outcome given different parameters since the plausibility of achieving a certain outcome is dependent on events that may or may not occur. Yet, communicating forecasts as reasonable, likely or plausible is challenging in and of itself. The issue then becomes what is the definition of reasonable. As one contributor added -- Is it something other than correct?

Defining the orders of magnitude of error or uncertainty associated with the results is another significant issue. As one contributor noted, “While it is fairly easy to define a series of sensitivity tests, it is not so simple to determine whether the test versus base difference are of the right magnitude – or, in some cases, it’s not clear what the right DIRECTION for a change should really be”. Specific guidance is absent in most of the contributions.

The Transportation Analysis Group in the UK provided the following four input classification schemes for future input values:

- Near certain,
- More than likely
- Reasonably foreseeable, and
- Hypothetical.

Each of the categories noted above is then used to establish the scenario plan against which to judge the core appraisal.

Model Complexity versus Complexity of Assessing Uncertainty

As more MPOs move to more complex and perceivably more robust platforms (e.g. tour and activity-based), analyzing the results may be a legitimate consideration. As one contributor posed, “does a complex model limit uncertainty analysis”? A few contributors noted suspicion as to whether a more complex model (e.g. activity-based) could even be measured for uncertainty. The perception being that complex models are more concerned with precision rather than accuracy. Other contributors disagreed with the premise since, “additional features should result in a more accurate model system”.

Conclusions

Debate exists regarding concrete measures to quantify uncertainty and risk in the forecast. Relatively few contributions provided anything beyond simplified approaches despite a number of contributors endorsing the idea of documenting model results variance coupled with some level of uncertainty acknowledgement and analysis. As one contributor noted, “It appears there is enough concern and knowledge about model uncertainty, that its consideration could be much more rigorously addressed in our model process”. Beyond toll and major transit investments studies however, there haven’t been compelling reasons to invest in such activities to date (e.g. air quality determination essentially requires adherence to a single solution set in a fixed point in time). Thus, the challenge appears to be identifying an effective means of communicating model uncertainty without compromising or diminishing the value of the models. Without properly documenting model assumptions and associated uncertainties, the results may be narrowly interpreted when in reality there are a number of dynamic influences that could affect the likelihood of the forecast. Not acknowledging these uncertainties contributes unintended additional veracity to conjectural forecast results.

November 2009

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Speed Adjustments Using Volume-Delay Functions

Volume-delay functions (VDFs) describe the speed-flow relationships in a travel demand model network based on the available link capacity. As traffic increases on the network, the resulting travel time and delay increase. In an effort to better represent delay due to congestion, some study areas estimate alternative volume-delay functions or construct speed-flow relationships based on observed data to achieve reasonable congested weighted speeds from the trip assignment model.

The following is a synopsis of the contributions made on the topic of adjusting travel model speeds (and resulting delay) using the volume delay function. Beyond the basic issues of which coefficients or alternative function(s) to apply, questions also arose regarding the degree at which speeds are controlled by the various functions.

Approaches
Based on contributions to the e-mail list, one of three approaches is typically applied with respect to VDF curves:

- Apply a single volume-delay formulation for all facility types,
- Apply unique user specified VDF functions developed for each facility type (e.g. freeway, expressway, arterials) and possibly area type in the network, and
- Develop unique user specified VDF functions to account for delay at signalized intersections.

The first approach applies a single volume-delay function for all facility types regardless of operating characteristics. In this instance, the Bureau of Public Roads (BPR) may be the most often applied speed-flow formula. The standard BPR coefficient values for alpha and beta are 0.15 and 4.00 respectively. Some study areas apply an alternative value for alpha and/or beta but these values remain constant across all facility types.

The derivation of alternate BPR functions using the second approach is typically based on comprehensive speed and travel time studies. As noted in an earlier technical synthesis on speed initialization practices, relatively few study areas have the resources to continually update and collect travel time and speed data. For those study areas that do collect speed and travel time data, the data could be used to “calibrate” network speeds and travel times with respect to observed volumes along the curve of the user specified VDF functions. Some contributors felt that any match between VDF-generated travel times and field-measured times in the base year, “will only be by coincidence, and won’t hold for the future or for analyzing alternatives”.

Variations of the BPR VDF (i.e. modifying the alpha and beta coefficients), conical functions, and applying alternative formulae, such as Akçelik’s formula, attempt to progressively decay speeds faster with increasing V/C ratios to achieve desired speed-flow relationships in the base year condition. A number of contributors felt that the standard BPR curve overestimates speeds for volume-to-capacity (V/C) ratios greater than or equal to 1.0. One specific alternative approach noted by a contributor is to develop VDFs that produce different curves for V/C conditions above 1.0 and for conditions below 1.0. By varying the slope of the BPR curve, several contributors felt that resulting forecast speeds would be more accurate when congestion levels invariably increase in the forecast scenario. One contributor noted having a unique set of volume-delay curves for each time period as well.

Based on contributions to the e-mail list, it appears that the use of alternative VDF coefficients and alternative functions are commonly utilized in larger metropolitan areas. Denver, Los Angeles County, Atlanta, and Portland all indicated applications of locally derived speed-flow curves. Conclusions could not be formulated regarding practices at small to medium sized urban areas.

With the third approach, it was noted that the slope of the curve can be modified to better reflect the different speed-flow characteristics between access controlled facilities, such as freeways, and facilities with signalized controlled intersections (e.g. arterials) by varying the alpha and beta parameters for each facility type. One contributor also indicated that in addition to user specified VDF functions for each facility type the data can be augmented with estimates of delay for facilities with signalized intersections if that data is available.

Minimum Allowable Speed Degradation

Because of the asymptotic nature of volume-delay curves, also described as “monotonically increasing functions” with respect to travel times, speed adjustment factors are allowed to continue infinitely until speeds reach, “unrealistically low,” values. Based on contributions to the e-mail list, there are considerable variations in national practice with respect to defining a minimum speed with which to allow resulting travel speeds to degrade during the trip assignment process. Indeed, a debate exists among contributors as to whether implementing such a criteria is even justifiable.

The motivation for implementing minimum speed thresholds or “floors” (as they are sometimes referred to) is to match observed base year network speeds and/or observed travel times (if these are available). By doing so, some contributors felt that the traffic assignment results may be more practical for planning purposes and useful (e.g. “realistic” congested speeds needed for mobile source emission modeling). Several contributors recommended a range of 8 to 17 mph as the minimum allowable congested speed, while others noted the use of minimum speed ratios (i.e. the ratio of congested to free-flow speed for different facility types).

With respect to speed floors, concerns included:

- Model assignment process becomes less sensitive to volume changes (may be seen as a benefit in an equilibrium assignment process since it may converge more quickly).
- Model feedback process becomes less sensitive for links with unrealistically high congestion levels (e.g. links exceeding a V/C ratio of two).
- Model may produce results where higher V/C ratios yield higher speeds than links with lower V/C ratios. As one contributor questioned, “Doesn’t it make sense within equilibrium assignment to have a lower speed for V/C = 2.63 than V/C = 1.2”?
- Model results may be rendered impractical for future year analysis between scenarios or competing alternatives.

Other’s noted that unrealistically low speeds may be a result of faulty underlying assumptions, such as the capacity used and the peak-hour factors used to derive peak period or daily capacity. Extremely low resulting link speeds may also highlight problems in the time-of-day trip tables as one contributor noted.

Utilizing Processed Speeds

Alternative volume-delay functions are also utilized to post-process speeds for the purpose of mobile source emissions modeling. Since models are calibrated to match regional or cordon line traffic counts, the resulting speeds may be inconsistent with observed speeds at the corresponding V/C ratio. Therefore, the speeds that are produced by the travel models need to be post-processed and refined to produce more realistic network link specific values for use in mobile source emission modeling. The speeds (based on the resulting assigned V/C ratios) are processed using alternative volume-delay equations that are typically independent from the VDFs used in the travel model.

A question arose as to whether it was valid to use the post-processed speeds as part of the feed-back process to derive the final congested weighted speeds. According to contributions to the e-mail list, the accepted national practice is to apply the unadjusted or non-processed speeds back through trip distribution and mode choice. Thus, the base year model is, "calibrated with the link specific speeds and not a post-processed speed". Speeds are only post-processed once the appropriate model assignment results have been achieved.

Conclusions

Based on contributions to the e-mail list, only a relatively few study areas have conducted current and comprehensive speed and travel time studies to support the development of locally derived volume-delay functions. Despite this, the application of user specified volume-delay function curves to control resulting assigned speeds (and therefore the congested impedance in an equilibrium assignment application) appears to be common practice among many large urban areas. With the exception of a very few large urban areas, models are typically not calibrated to match observed speeds.

Several contributors weighed in with sound reasoning and justification for modifying the volume-delay functions locally. Others expressed reservations as to the viability of such tight base year constraints with respect to speeds, delay and diversion. One contributor opined whether it is possible to produce a model that can calibrate to observed speed conditions (and observed flow conditions) and yet remain viable for forecast scenarios where those conditions will most likely be different. Interim year verification may offer a resolution to this question.

Furthermore, the travel demand modeling community does not appear to have reached a consensus as to whether VDF constructs such as preventing speeds from decaying to unrealistically low values during the trip assignment process should be implemented. Convincing arguments for and against VDF constructs were made by contributors to the discussion.

December 2009

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Transit Oriented Developments

The following is a synopsis of the contributions and responses regarding the subject of transit oriented development (TOD). The primary motivation for the discussion was identifying the industry practice for forecasting transit ridership increases associated with TODs. The inquiry and discussion occurred in November, 2010 and expanded to include a debate regarding the potential influence transit oriented developments may have on reducing automobile vehicle miles of travel (VMT).

Transit Oriented Development Overview

Based on contributions to the listserv, a transit oriented development could be defined as a compact and diverse development located in close proximity to transit that offers attractive environments and conditions for non-auto travel. If implemented properly, TODs offer a compelling link between land use diversity and density with increased transit utilization. Contributors noted that the benefits of TODs extend beyond increased transit ridership.

Potential by-products include social and environmental benefits as well as improved investment productivity. Indeed, it is the linkage between density and diversity that makes TODs attractive planning strategies for reducing or at the very least off-setting automobile VMT growth. This is in stark contrast to conventional development which is characterized by its auto-centric low- density development that is evident in most urbanized areas.

Forecasting Transit Oriented Developments

Travel demand models were recognized as the most effective tool available for forecasting TODs. When a demand model is not available, there appears to be several potential project level resources available. One contributor noted that there are, "a number of "sketch models" or "planning support tools"" available. The tools are generally geographic information system (GIS) based and/or graphically based spreadsheets that are designed to operate at the tax lot and real estate project scale, according to the same contributor. Another contributor noted two specific published documents as potential resources: Transit Cooperative Research Program (TCRP) #95 (*Travel Response to Transportation System Changes*) and a 2010 Journal of American Planning Association (JAPA) article (*Travel and the Built Environment: A Meta- Analysis*).

Forecasting Considerations

Based on relatively few responses, it appears that the two primary variables that need to be captured in any analysis are the land use characteristics in proximity to the new transit station as well as the service characteristics of the particular station under study. One contributor promoted a tool that has been utilized to examine transit ridership. The specific input variables associated with this tool highlight the scope of issues that could be given consideration during any analysis. These are aimed at quantifying transit station characteristics, which include the following inventory of variables:

- o Land uses within walking distance of the station,
- o Feeder transit network service,
- o Station parking characteristics, and
- o Pedestrian and bike access characteristics.

Forecasting Challenges

One contributor noted that a comprehensive tool that analyzes all of the potential variables does not exist. Others noted the following issues associated with off-model tools:

- Availability of off-model software (i.e. proprietary versus open-source),
- Scalability of results (e.g. sketch/project level that is not transferrable to the region),
- Insensitive nature of these tools to accommodate macro-level issues (e.g. changes in fuel price, economy).

In contrast, a noted advantage of utilizing off-model systems is the apparent simplicity that may be afforded by these tools and the relative confidence associated with the results (if the results are based on existing case studies).

Given these challenges, one contributor recommended that the process of forecasting ridership numbers should be de-emphasized and, "more emphasis should be placed on risk management and enterprise, and market design and management," of the TOD. The City of Portland was specifically mentioned as an example of having strong TOD/pedestrian oriented development (POD) guidelines in greenfield settings that apparently have succeeded in increasing transit use and walk access.

TODs and Auto VMT Reduction

The nexus between TODs and auto VMT reduction is simply a fiat according to some contributors. The success of these specific types of developments relies on the ability to provide diverse access to and from the development, including auto access. Consequently, some of the new trips associated with the development are made by automobiles. As noted, any new development will increase auto VMT (e.g. existing auto VMT plus additional VMT created by the new development).

As noted by contributors to the discussion, transit oriented developments do not completely eliminate auto trips (or the need for auto trips) because these types of developments are not exclusively served by transit or other forms of non-vehicular access. TODs simply provide the mechanism to pursue other forms of mobility. According to one contributor, "TODs should not be generally seen as an auto trip reduction strategy".

Other contributors felt that local traffic (e.g. pedestrian and transit) generated by the development is more than enough to off-set the new auto trips to the development. As far as forecasting the amount of new transit trips to the development, one contributor offered that, "the fraction of new or added trips generated by the TOD that are transit satisfied goes up relative to background levels that were previously exclusively satisfied by auto."

Reinforcing the discussion regarding auto VMT, a specific contributor noted examples of development that occurs in Texas independent of significant transit access (i.e. rail) which mimics key concepts associated with TODs, such as providing mixed-use development in a pedestrian-friendly atmosphere (e.g. high-rise residences juxtaposed in close proximity to retail shops). The contributor noted that these developments can be successful irrespective of any transit presence because high-density, mixed-use developments offer an alternative experience for specific end users (i.e. high-end retail shoppers). The contributor conceded that these developments are solely successful because nearby parking (e.g. parking garages) provides convenient access for high-end retail shoppers. Without this type of auto access, it is highly questionable whether these mixed-use retail/resident patterns could succeed.

Conclusions

In the absence of having a travel forecasting model, there are a number of documented resources and sketch planning tools available for project level analysis. As noted by contributors, these sketch planning methods are limited in scope and context to be considered useful for region-wide analysis. Consequently, travel demand models are recognized as the most effective tool for forecasting transit ridership estimates associated with the implementation of transit oriented developments.

Based on the limited contributions, most of the contributors to the discussion believe that a properly designed TOD with pedestrian friendly access will increase transit ridership. Debate exists as to how effective TODs are at reducing or off-setting VMT associated with automobiles.

November 2010

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