

FHWA Integrated Model Development Peer Review Meeting

Data: November 2, 2009

Location: Arizona State University, Tempe, Arizona

Integrated Model Design

In this agenda item, the integrated model design was presented in detail including the model structure and methodology. The presentation also included a discussion of the overall framework and model design, activity model design and operation, and the interface to the dynamic traffic assignment model.

The following aspects were brought up for discussion during the session:

a. Reaction of individual agents to congestion

In response to a question on the agents reaction to an instantaneous realization of the presence of congestion, the project team responded by saying that an individual agent does not change his/her destination in response to congestion. Within an open period, the agent makes an activity-travel decision based on expected travel times (from past experience) and the agent proceeds towards his or her destination. Since there is congestion on the network, the agent traverses the network under congested conditions and will reach the destination later than he/she should have based on expected travel times. However, the agent learns about the network conditions on the current day (current iteration) as he/she experiences the congested conditions and his/her expected travel times are updated. In the simulation for the subsequent day (next iteration), the agent makes activity-travel decisions for the same open period based on these updated expected travel times, and may choose a different location for the same activity, or cancel the activity all together if there are no opportunities that can be reached without violating the time-space prism constraints.

b. Day to day learning and experience of network conditions

The project team responded to a question on when agents start learning within the integrated model design by saying that the agents' knowledge of the network is updated at the end of every day (iteration). The expected travel times between origin-destination pairs are updated with travel times that were observed on the network on that particular day and these updated travel times are used to make activity-travel choices for the subsequent day. This day-to-day learning about the experienced network conditions is achieved by the outer loop presented in the integrated model

design. When does the learning process stop? In other words, when is the convergence achieved in the integrated model? (This is discussed in further detail in bullet point c.)

c. *Integrated model closure and convergence criteria*

The discussion during this session was primarily focused on the integrated model convergence and criteria to be used. The team presented the challenges they faced when defining specific closure criterion for the integrated model:

- Is convergence achieved in the integrated model when both demand and supply model converge?
- While the supply model has established convergence criteria, is there a concept of convergence on the demand modeling side?
- How do we define convergence criteria for the demand model where the output is just one of many possible stochastic realizations of the activity-travel patterns of individuals in a region?
- While there are specific criteria for convergence on the supply side, are there any convergence criteria for the demand side?
- What specific criteria, if any, should be used to monitor convergence in the demand model?

Ideas and Suggestions:

- The integrated model may be able to achieve convergence only when both the demand and supply models proceed towards convergence. The demand side should achieve some kind of stability across iterations; otherwise, there is a risk that the oscillation in the demand will cause the supply model to also not achieve convergence.
- Given the stochastic nature of the demand model, it is expected that there will be oscillations in travel demand between iterations. However, the magnitude of oscillations in the activity-travel patterns between successive iterations should reduce for the integrated model to achieve any kind of convergence.
- Measures for monitoring convergence:
 - Temporally and spatially aggregated O-D tables
 - Weighted temporally and spatially aggregated O-D tables across iterations to smooth out the oscillations between iterations
 - Time-space prism vertices

- Trip attributes distributions; perform validation-type exercises after every iteration by comparing the trip length distributions, the time of day distributions, etc. against known values and distributions. Once some form of convergence in these attributes is achieved, the stochasticity in an individual's activity-travel patterns may be acceptable.
- Strategies for reducing the magnitude of oscillations between iterations:
 - Instead of generating a new activity-travel pattern, modify/adjust certain episodes based on updated expected network conditions from the previous iteration.
 - Establish rules that limit the number of activities of the different activity-types that people engage in. The project team can establish some logic checks that keep tabs on the number of activities of different activity-types that individuals can pursue during a single day.
 - Include a function in the demand model that regulates how much information (about the network conditions from current day) individuals use to make activity-travel choices for the next day.
 - Establish rules which place restrictions on the sequencing and the timing of activities.
- Compare activity-travel patterns across iterations; if the day-to-day (iteration-to-iteration) variability is within reasonable limits then convergence is achieved. The limits can be established by using datasets like the Travel Choices Study from Seattle, Washington which collects activity-travel data about individuals including the routes chosen over a six month period. There are estimates of day-to-day variability in travel demand characteristics in the literature (for example, Eric Pas' work).
- The closure/convergence criteria and the measures to be used for monitoring convergence need to be established more precisely.

d. Bootstrapping network level of service measures

In response to a question on the travel times that will be used in the first pass of the integrated model, the project team clarified that the travel times will be obtained by employing a bootstrapping procedure that applies the demand and supply models sequentially until convergence is achieved. The bootstrapped travel times are used in the first pass of the integrated model system.

Ideas and Suggestions:

- Do not use network level of service attributes from the four-step modeling approaches as the starting values for the integrated model system.
- Within the bootstrapping procedure, in addition to averaging O-D travel times across iterations, also average the O-D trip tables across iterations to achieve convergence faster. Use appropriate successive averaging techniques to bring the process to closure rapidly.

e. Network conditions and long term choices

The project team responded to a question on what happens when individuals experience congestion given their existing location choices and cannot engage in activities without violating the time-space prisms by saying that this gets reflected in the long term choice of the agent in the simulation for a subsequent year. After the simulation for one year is complete, the converged travel times are fed into the land use model for starting the simulation for the next year. At this time, in the land use model, households assess their accessibility issues and problems, and depending on the severity of the accessibility issue, they will either choose to stay or relocate home and/or work.

f. Travel times

The panel provided the following suggestions regarding the travel times and the choice processes they affect in the demand model.

Ideas and Suggestions:

- The network travel times will also impact the departure time choice, and possibly activity-type choice, in addition to the destination-mode choices, and arrival time.

g. Special events

This is in response to a question about handling special events in the integrated model design. In its current implementation of the integrated model system, there are no specific provisions for handling special events. It is currently planned that existing special events demand models will be used in conjunction with the integrated model framework to account for special events traffic.

MALTA and TrAM

In this session, the project team presented a detailed description of the dynamic traffic assignment principles. The presentation also included a discussion of MALTA (an implementation of dynamic traffic assignment model) which will be used in the integrated modeling project. Further, the project team also

presented a discussion on how transit will be incorporated in the integrated model design. In particular this piece focused on the simulation of the transit system including boarding and alighting of individuals, simulating transit vehicle movements, and so on.

The following aspects were brought up for discussion during this session:

a. Representation of non-motorized trips

The project team responded to the question about treatment of non-motorized trips (pedestrian and bicycle trips) by saying that MALTA currently does not simulate pedestrian and bicycle trips. However, in a parallel research effort by one of the project team members, the interaction between non-motorized trips with automobiles in downtown areas is being analyzed.

Ideas and Suggestions:

- Consider non-motorized trips in traffic simulation to accurately represent the traffic conditions. This is particularly important in downtown areas where the non-motorized and automobile conflicts are prevalent and these conflicts affect the traffic flow.

b. Capacity considerations in MALTA/TrAM

In response to a question on link capacities and their use in the traffic simulation, the project team clarified that the capacities are not used in the traffic simulation in the traditional sense of the word as defined in the Highway Capacity Manual. In the dynamic traffic assignment model, capacities are only an output from the traffic simulation and serve as a measure of the maximum flow rate that is observed on a link.

c. Consideration of on-street parking

The project team responded to a question on on-street parking and its consideration in the traffic simulation model by saying that parking is considered in MALTA. Parking affects the traffic flow parameters and in turn affects the speeds of vehicles on the link. In other words, the impact of on-street parking (lowering of speeds) is captured by the modified traffic flow parameters. Also, the lower speeds and increased travel times manifest themselves in the shortest path calculations involving the link.

d. *MALTA/TrAM features*

In response to questions about the features of MALTA/TrAM, the project team presented the following features of MALTA/TrAM:

- Auto and transit are simulated simultaneously and the interactions between autos and transit vehicles will be considered in the vehicle simulation.
- MALTA/TrAM can be used to implement hybrid (multi-resolution) simulations, i.e., the network in the subarea has a higher degree of detail than the rest of the study area.
- MALTA/TrAM can accommodate traffic signal controls.
- The vehicles are loaded onto individual links but the shortest paths are calculated at the zonal (or any spatially aggregated unit) level.
- If there is more than one stop close to an agent's home, the stop choice model within TrAM assigns the agent to a stop based on a utility maximizing criterion.

Ideas and Suggestions:

- Modeling transportation networks beyond a region may be a challenge especially when considering modeling transportation networks across states.
 - Stitching together networks will be a challenge because of varying spatial resolutions (city, region, metropolitan, state)
 - Very limited data and understanding of inter-state travel
- Consider time for access and egress in the simulation of transit trips since the boarding and alighting is occurring at transit stops.
- Need to devise a way to calculate the access and egress times to transit stops. (One of the project team member suggested using spatial queries.)
- Vehicles should be loaded all along the link to avoid lumpy loading. It may be helpful to have access links connecting parcels to roadways or have a group of parcels connected to a roadway by an access link in the network.
- If parcels are to be represented in a land use model then the network has to be very detailed as well. Therefore, for the initial prototype testing, the network and land use should be represented at a higher spatial resolution, and parcel level detail may be included in the land use microsimulation modeling process. In later applications of the integrated model, the land use and network systems may be represented in finer detail to enhance model fidelity and sensitivity.

- How does one reconcile the concepts of hyperpaths (used in TrAM) and multi-leg journeys (used in AMOS) and which one should be used in the integrated model design?
- If the concept of hyperpaths is to be used:
 - How does one deal with transit mode combinations (bus + rail; bus + ferry) in the demand model? Perhaps a nested representation of mode choices can account for access/egress connectivity?
 - How does one deal with O-D travel times for transit mode combinations? What particular transit related skims are passed back into the demand model - weighted travel times across different hyperpaths for a particular O-D pair or the actual simulated travel time for the O-D pair for a given transit mode combination?
 - How does one deal with the issue where, for a multi-leg journey involving multiple modes of transit, the model always suggests that the user will use a certain mode of transit (say, bus over rail), and as a result the model is failing to capture what happens in the real world?
- If the concept of hyperpaths is not used:
 - The entire decision making regarding the transit trip, i.e., the different modes for different legs, for example, would happen in the demand model.
 - How are transit mode combinations represented in the mode choice set in the demand model?
 - How are destinations accessible by transit mode combinations going to be identified in the demand model?
- How does one model individuals that switch return modes? This may be important to capture in the integrated model if the number of people that switch modes of transport on the return trip is significant. The demand model should be able to generate a mode choice set consistent with the possibility that individuals switch modes on the return trip.

Measures of Accessibility

The presentation focused on the measures of accessibility that can be defined and utilized in location choice models of various types.

The following aspects were brought up for discussion during this session:

a. Accessibility to school districts, parks, and open spaces

In response to a question on inclusion of accessibility to non-traditional land uses like school districts, parks, and open spaces in residential location choice models, the study team responded by saying that these non-traditional measures of accessibility can indeed be included. However, some care needs to be taken when defining these measures. For example, for land uses that are very big, is the accessibility measured as a distance to the entrance or distance to the centroid etc. The project team suggested an interesting alternative to incorporating school district related variables in the selection of residences by including test scores as a measure of the quality of the school district.

Software Architecture

In this session, the AMOS software architecture was presented followed by a discussion of alternatives for integrating the individual model systems.

The following aspects were brought up for discussion during this session:

a. Data exchange mechanisms

The project team indicated that the following data exchange mechanisms were being considered for the data exchange across the individual model systems in the integrated model system.

- Message Passing Interface (MPI)
- Database Flags

b. Data storage standards

The project team realizes the importance of advanced data formats to store, access, and query efficiently across all the individual model systems. The following data formats will be considered for storing and accessing data in addition to standard database management systems

- netCDF
- HDF5

c. Distributed processing

The project team understands that computational tractability and performance are going to be major challenges. It is envisioned that all three individual model systems will be implemented to take advantage of parallel and/or distributed processing.

Calibration and Validation

The project team presented calibration and validation criteria for three model systems: Urbansim, AMOS, and MALTA/TrAM in this session.

The following aspects were brought up for discussion during this session:

a. Population synthesis at parcel level

The project team provided a clarification to a question about synthesizing population at the parcel level that synthetic population can indeed be generated at the parcel level. However, the fit of the person attributes may be poor if there is a lot of variability in the person structure of the households belonging to a particular household type. However it is advisable to synthesize population at a higher spatial resolution like blockgroups or TAZ's and then assign households that are synthesized to parcels using location choice models.

b. Model Calibration

In response to a question about the 80/20 split that was proposed to estimate and calibrate the models, the project team likes the idea of splitting the sample into one-half and estimating models on both halves of the sample. Then, compare estimates and specifications to make sure that the models are robust across random samples.

Ideas and Suggestions:

- Instead of using a 80/20 split of the sample for estimation and calibration respectively, divide the sample into two and then estimate the parameters using the two random halves and compare the model estimates and specifications.

c. Land use model validation

In response to a question about land use model validation on the employment side, the project team acknowledges that it would indeed be a good validation exercise. However, in the absence of employment data at a fine spatial resolution of blockgroups/TAZ's, the validation exercise may be difficult to carry out.

Ideas and Suggestions:

- Use employment numbers from the department of labor to conduct validation exercises.

d. Error characterization

The project team responded to a comment about error characterization by saying that it would indeed be helpful to document sources of error beginning with the sub-models so as to be able to differentiate the variability in outputs caused by error and that caused by changes in input factors.

Ideas and Suggestions:

- Document the source of error starting with sub-models within the three individual model systems.
- Characterize error distribution by running the model a number of times.
- Then consider any change in outputs beyond that depicted by the stochastic variability of the model system to represent a true change brought about by changes in input system conditions.

e. Policy Evaluation

The project team responded to the question about the expectations for results obtained from the integrated model in response to policy scenarios by saying that detailed examinations will be conducted to make sure that the changes/variations follow expectations and conform to observations from other studies that have evaluated similar policies.

Overall Recommendations

The peer review panel made the following overall suggestions at the meeting:

- The project team should prioritize efforts aimed at integrating the model systems and develop and implement the integrated model prototype first, and can leave other individual model enhancements (for example, the population evolution model for the land use microsimulation model) as a lower priority. It is absolutely critical to start the testing of the interfaces and integrated model prototype as soon as possible, even if it means using synthesized activity-travel demand patterns for testing interfaces.
- The project team should consider a phased rollout of the sub-models/modules of the individual model systems and not just do one grand release of the entire prototype integrated model. The phased rollout will keep the user community including the panel actively engaged during various stages of the prototype development and provide valuable feedback and advice on individual sub-models/modules.

- The panel suggested that more effort be directed towards model sensitivity analysis than on model validation to ground counts. Model validation is dependent on the quality of the data and the panel did not think the team would be well served to spend significant amount of time cleaning the data. Instead they want the project team to spend considerable amount of time conducting sensitivity analysis of the integrated model system and in ensuring that the integrated model system provides plausible answers to policy questions under consideration.
- The project team should reconsider testing the integrated model on multiple test sites given resource limitations and constraints. They also suggested that the prototype testing and development may be done using data from the two test sites; however, the extensive sensitivity analysis that the project team wishes to pursue may eventually be done using one test site.