Progress in the Development of the ADAPTS Dynamic Activity-Based Microsimulation Model

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ABSTRACT
This paper describes progress in the development of an activity-based microsimulation model, the ADAPTS (Agent-based Dynamic Activity Planning and Travel Scheduling) model, which dynamically simulates activity and travel planning and scheduling. The model consists of a dynamic activity planning framework within a larger activity-based microsimulation, which is a computational process model that attempts to replicate the decisions which comprise time-dependent activity scheduling. The microsimulation framework separates activity planning from activity generation and treats generation, planning and scheduling, as separate discrete but dynamic events within the overall simulation. This paper discusses briefly the motivations behind the model, the overall microsimulation framework and implementation, and the progress in the development of the individual models which comprise the system.

1. INTRODUCTION

The rule-based or Computational Process Model (CPM) formulation has been proposed as a type of activity-based model capable of simulating some of the underlying processes behind the development of the individual daily activity and travel pattern (Garling et al. 1994). Recent examples of implementations of these models include SCHEDULER (Golledge et al. 1994), ALBATROSS (Arentze et al. 2000) and TASHA (Roorda et al. 2005). These models all attempt, in some way, to specify and replicate the process of activity scheduling, and are therefore potentially more theoretically satisfying as well as more policy sensitive, since this type of model would represent the results of policy scenarios which actually cause changes in the scheduling process itself (Roorda et al 2005)

Operational activity-based scheduling process models necessarily make simplifying assumptions about the scheduling process. These include using an assumed priority order of activities to sequence the addition of new activities to the schedule as in TASHA (Roorda et al. 2005) and others, and using a fixed sequence for planning attributes as in most econometric models, the CEMDAP system (Bhat et al. 2004) and ALBATROSS (Arentze and Timmermans 2000) among many others. Ongoing data collection efforts including CHASE (Doherty et al. 2004), OPFAST (Lee-Gosselin 2005), UTRACS (Frignani et al 2010) have shown that priority assumptions tend to be violated frequently. The planning order assumptions also do not typically reflect the reality of activity scheduling. Analysis of planning time horizons from scheduling process data shows that many activities are opportunistically planned (Mohammadian and Doherty 2005) and that planning orders of the activity attributes vary significantly (Auld and Mohammadian 2009a). In addition, the dynamics of activity planning have rarely been represented in anything other than a theoretical manner, such as in Litwin and Miller (2005), although work is ongoing in this area (Arentze et al. 2006). For these reasons an activity-based modeling framework, the Agent-based Dynamic Activity Planning and Travel Scheduling (ADAPTS) model has been developed that simulates the underlying activity and travel planning and scheduling processes in a dynamic manner (Auld and Mohammadian 2009b).

2. MOTIVATION FOR MODEL DEVELOPMENT

The motivation for using a dynamic scheduling process with a non-fixed attribute planning order is best exemplified with a planning/scheduling example, as shown in Figure 1. Consider in Situation 1, a person is planning to meet two friends who live near the store for lunch at 1PM. She realizes she has some shopping to do, and decides to go shopping at nearby store beforehand. In this case, the previously planned activity of eating lunch constrains the choices regarding the planning of the shopping activity. Alternative, in Situation 2 a person is planning to do some shopping in a retail area and decides to call some friends to meet for lunch nearby after her completion of the shopping trip at 1PM. Here the already planned shopping trip constrains the eating out activity.

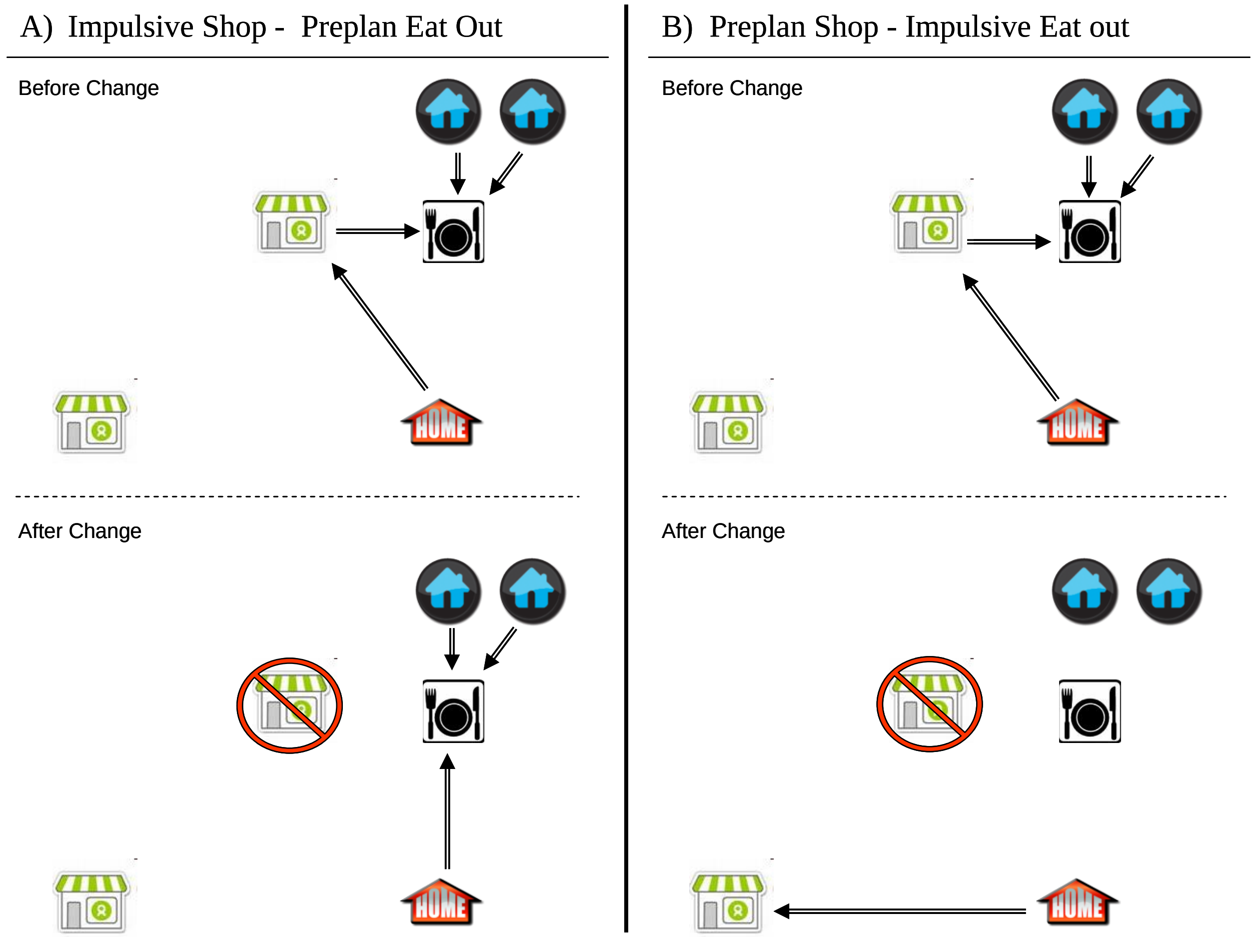

FIGURE 1. Example of a Choice Situation Depending on Planning Order

In both examples shown, the activity schedule looks identical: shopping, then a lunch with friends at a nearby restaurant. But in each case, how the schedule was determined was very different. Anything altering the planning process could result in an entirely different activity pattern. To relate this to potential travel demand management policies, imagine a policy was put in place which makes the original store unavailable. In this case in Situation 1 the person merely skips the impulsive shopping stop and continues on to lunch with friends, resulting in three total trips, instead of the original four. Meanwhile in Situation 2 since the shopping is preplanned the individual would react to the new policy by shopping at another available store therefore the lunch with friends is no longer undertaken, resulting in only one trip to the store. So a simple change of one store being unavailable can result in very different travel patterns depending on when each activity, and each activity attribute, was planned. It is critical to note that any model that does not explicitly take into account planning order can not represent the distinction between

Situation 1 and Situation 2, as the only difference lies in the order and degree of impulsiveness with which the activities are planned.

3. ADAPTS MODEL MICROSIMULATION FRAMEWORK

The ADAPTS model simulates activity planning and scheduling over a specified timeframe, and integrates directly with a traffic simulator by outputting a list of trips to assign at each time step. As such, the ADAPTS model is dynamic, with planning and scheduling occurring in a time-dependent manner and impacted by the results of the time-dependent traffic network. In addition, the ADAPTS model is a learning based model, i.e. agents store the results of their actions in a long-term memory and these results are used to make future decisions. An overview of the ADAPTS simulation framework is shown in Figure 1. The simulation process includes three primary stages: initialization of the simulation environment, household and individual planning at each time step, and trip vector generation and traffic assignment at each time step.

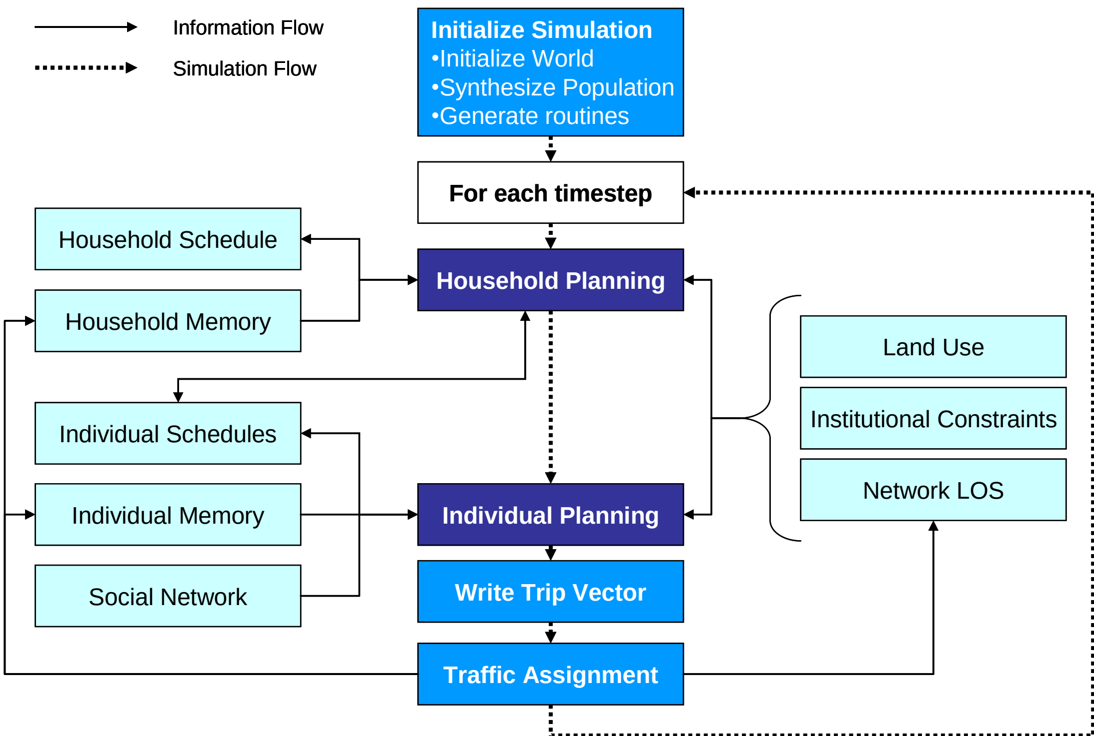

FIGURE 2. ADAPTS Simulation Framework

The ADAPTS model planning and scheduling framework is called at each timestep for both household and individual agents to update/plan their activity schedules, as shown in Figure 2 as "Household Planning" and "Individual Planning". The planning and scheduling model simulates the dynamic process of schedule formation and attempts to account for the varying interdependencies and potential differences in planning times, between the various attributes of the activity. This forms the core of the ADAPTS model. The detailed framework for the ADAPTS activity scheduling model is presented in Figure 3. This figure shows the process that an individual agent within the ADAPTS model would follow at each timestep, in building up and executing the activity-travel pattern. It presents activity scheduling as a dynamic process, completed over time with the final executed schedule resulting from a series of decisions. More detail about the overall ADAPTS framework, including details about activity generation, scheduling processes, etc. can be found in Auld and Mohammadian (2009a).

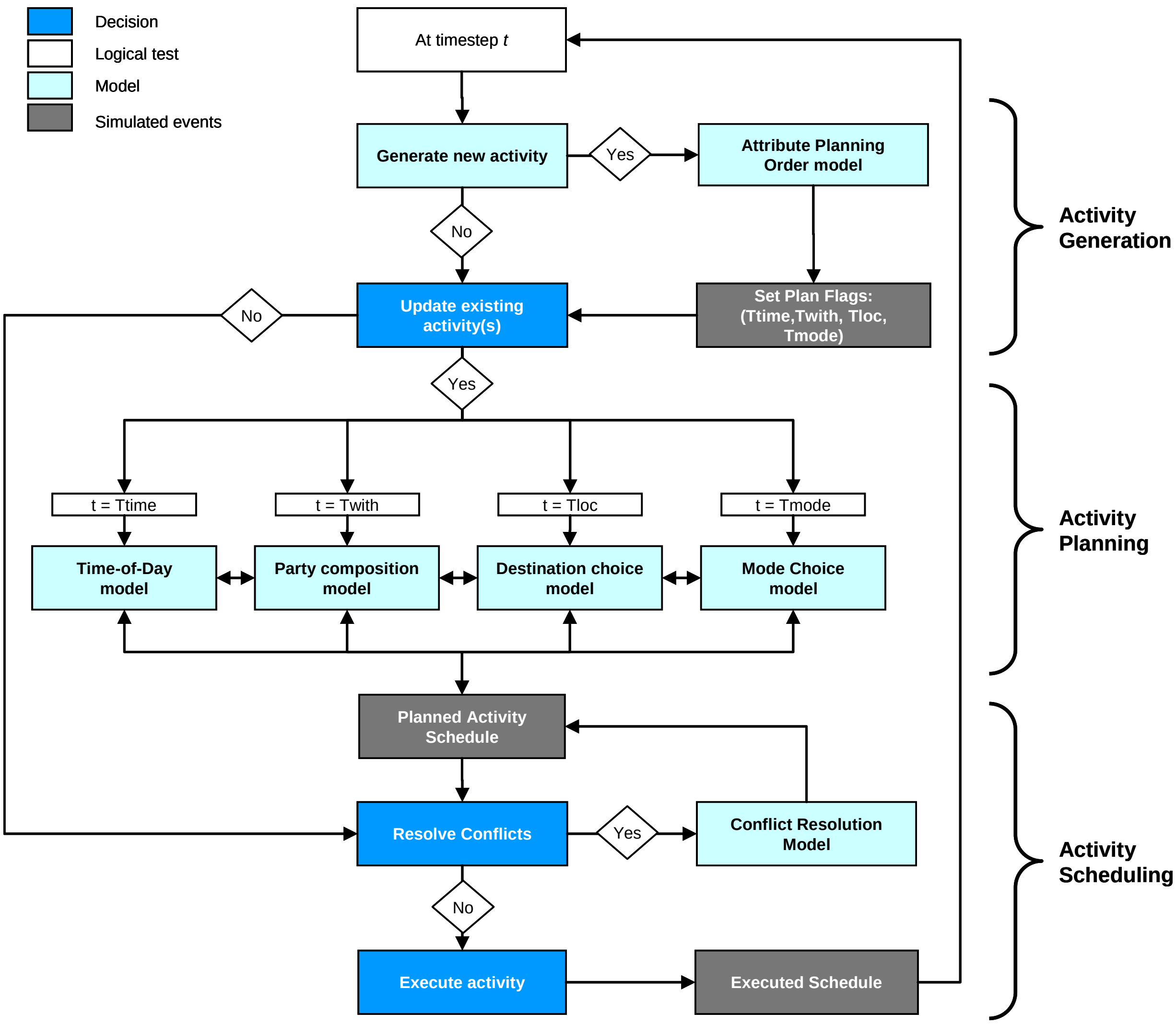

FIGURE 3 ADAPTS Activity Planning Framework (*Source: Auld and Mohammadian 2009a*)

In order to implement the microsimulation framework shown in Figure 2, including the planning processes described in Figure 3, a set of object-oriented classes and routines have been developed in the C# programming language. The structure of classes used in the microsimulation framework code is shown in Figure 4. This figure shows that the ADAPTS model is constructed as a series of classes which contain references to other classes and a set of statically implemented classes for general planning and scheduling functions. The basic structure is that there is a World class which contains items which are accessible to all objects, such as the current simulation time and the list of the zones with the simulated region. The world class also contains the list of Sub-problems in the microsimulation. The Subproblem class is simply used to hold a randomly assigned collection of households within the region. This is done to make the simulation more manageable by only holding a certain amount of households in memory at one time. As such the simulation is run for each subproblem independent of the rest of the subproblems which will also ease later transition to parallel processing of the simulation. Each subproblem contains a list of households, which in turn each contain a list of individuals in the household. Both the Household and Individual classes are derived from an abstract Entity class, which contains much of the code for scheduling, contains the actual executed, planned and queued (unfinished planning) activity schedules, and contains all of the housekeeping functions such as serialization for the classes. The household and person classes are then derived from the Entity class (passing on all entity class methods and properties) with additional household or person data attributes. At the lowest level is the Activity class, which is used to define instances of activities which are then stored in either the household or person schedules.

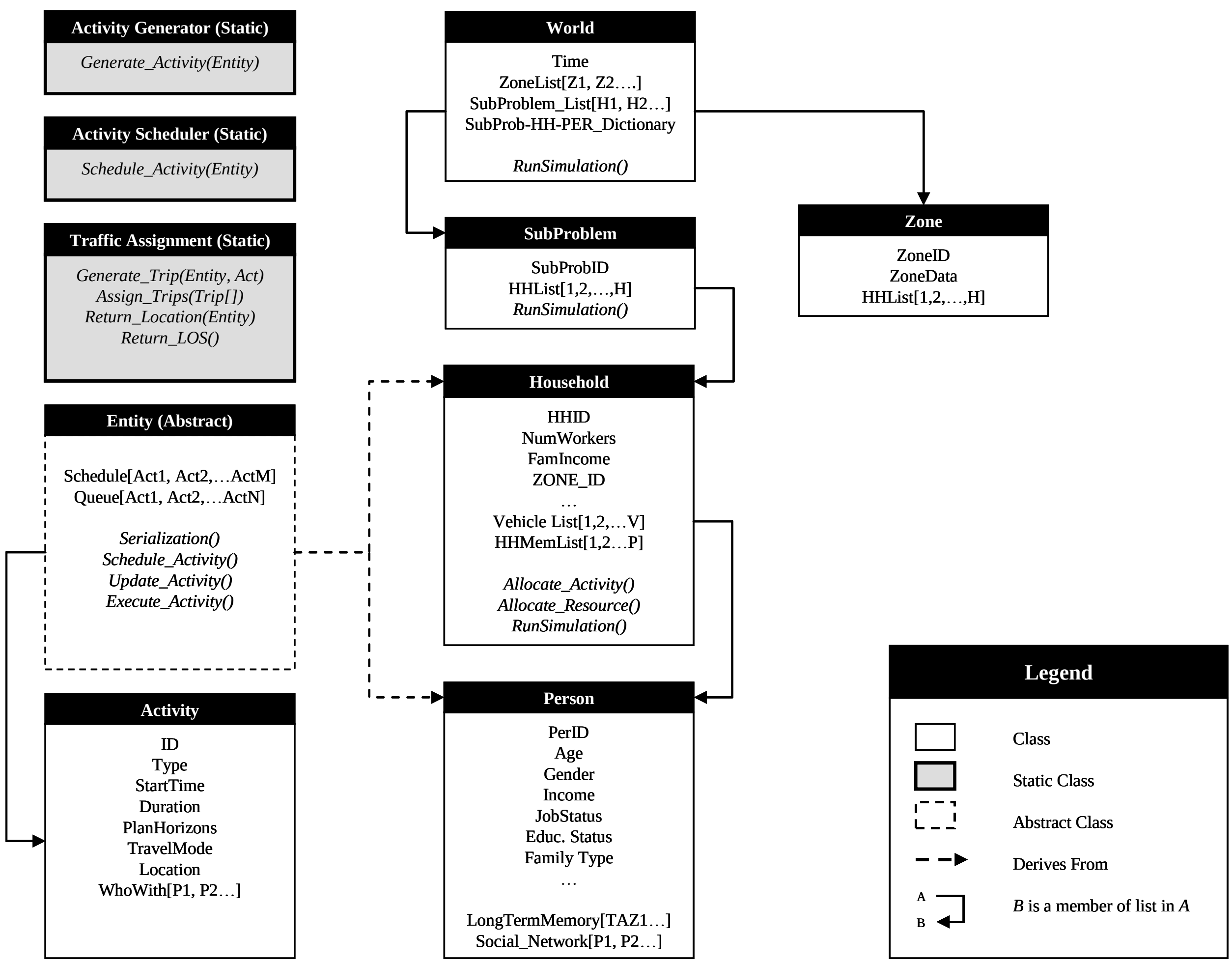

FIGURE 4. Class Design in ADAPTS Microsimulation Model

There are also a number of static classes which help to implement the planning framework and are callable by any of the entity-derived classes. These include the Activity Generator, which generates new instances of activities, the Activity Scheduler which performs scheduling, conflict resolution, etc. and the Traffic Assignment class, which builds the input trip vectors used in the Traffic Simulator and gets LOS measures and individual locations from the simulator. The simulation is run by first creating an instance of the World class, then filling it with the zonal, household and person data obtained from the input files and population synthesizer. After the world is instantiated, the Run Simulation method is called from the World class, which in term calls the Run Simulation method for each Subproblem at each timestep. Finally the Run Simulation method in the Household class is called, which implements the process shown in Figures 2 and 3.

4. COMPLETED AND FUTURE WORK

In addition to having the basic microsimulation class structure programmed, numerous other aspects of the ADAPTS model have been developed. The population synthesizer which is used to initialize the simulation, which is capable of generating both households and the individuals in the households accurately and efficiently, has been created (Auld and Mohammadian 2010a). Next, an activity generation routine has been developed which determines individual activity generation rates according to a series of probability distributions for each activity type according to individual socio-demographic status (Auld and Mohammadian 2010b). The activity generation model has been calibrated and validated for the Chicago Metropolitan Area. A planning order model which assigns attribute plan horizons to the newly generated activities has also been recently developed (Auld and Mohammadian 2009a). This model forms the core of the ADAPTS planning framework as it allows for variable attribute planning orders and determines when each decision is made within the simulation. Finally, the system of scheduling and conflict resolution rules used to actually schedule the planned activities has also been developed through the use of various planning process data sources (Auld et al 2009). Currently, much of the model development is still being finalized, most importantly the development of all of the actual attribute models, i.e. mode choice, destination choice, etc., as well as the development of a household activity and resource allocation model, and a social networking model used for joint social/discretionary activities. Finally, the integration of the model with a Traffic Simulator remains to be completed. The completion of the ADAPTS planning framework will allow the simulation of planning, scheduling and execution of activity patterns in an integrated dynamic framework.

REFERENCES

Arentze, T. and H. Timmemans (2000). *ALBATROSS – A Learning Based Transportation Oriented Simulation System*. European Institute of Retailing and Services Studies (EIRASS), Technical University of Eindhoven.

Arentze, T., H. Timmermans, D. Janssens, and G. Wets (2006). Modeling Short-term Dynamics in Activity-Travel Patterns: From Aurora to Feathers. Paper presented at the Innovations in Travel Modeling Conference Austin, TX, May 2006.

Auld, J. A and A. Mohammadian (2009a). Activity Planning Processes in the ADAPTS Activity-Based Modeling Framework. Paper presented at the *12th International Association of Travel Behavior Research Conference*, Jaipur, India, December 13-18, 2009.

Auld, J. A. and A. Mohammadian (2009b). Framework for the development of the Agent-based Dynamic Activity Planning and Travel Scheduling (ADAPTS) model. *Transportation Letters: The International Journal of Transportation Research*, 1 (3), 243-253.

Auld, J.A. and A. Mohammadian (2010a). An Efficient Methodology for Generating Synthetic Populations with Multiple Control Levels. Paper submitted for presentation at *89th Annual Meeting of the Transportation Research Board*, January 2010.

Auld, J.A. and A. Mohammadian (2010b). Calibration and Validation of Activity Generation in the ADAPTS Scheduling Process Model. Paper submitted for presentation at *89th Annual Meeting of the Transportation Research Board*, January 2010.

Auld, J. A., A. Mohammadian and M. Roorda (2009). Implementation of a Scheduling Conflict Resolution Model in an Activity Scheduling System. Forthcoming in *Transportation Research Record: Journal of the Transportation Research Board*.

Bhat, C.R., J.Y. Guo, S. Srinivasan and A. Sivakumar (2004). Comprehensive Econometric Microsimulator for Daily Activity-Travel Patterns. *Transportation Research Record: Journal of the Transportation Research Board*, 1894, 57-66.

Doherty, S. T. (2005). How far in advance are activities planned? Measurement challenges and analysis. *Transportation Research Record: Journal of the Transportation Research Board, 1926*, 41-49.

Doherty, S. T., E. Nemeth, M. Roorda and E. J. Miller (2004). Design and Assessment of the Toronto Area Computerized Household Activity Scheduling Survey. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1894, 140-149.

Frignani, M. J.A. Auld, K. Mohammadian, C. Williams and P. Nelson (2010). Urban Travel Route and Activity Choice Survey (UTRACS): An Internet-Based Prompted Recall Activity Travel Survey using GPS Data. Paper submitted for presentation at the 89th Annual Meeting of the Transportation Research Board, January 2010.

Garling, T., M.-P. Kwan and R.G. Golledge (1994). Computational-process modeling of household travel activity scheduling. *Transportation Research B*. 25, 355-364.

Lee-Gosselin, M.E.H. (2005). A data collection strategy for perceived and observed flexibility in the spatio-temporal organisation of household activities and associated travel. *Progress in activity-based analysis*. Timmermans, H. (ed.) Elsevier, The Netherlands.

Litwin, M. and E.J. Miller (2005). Event-Driven Time-Series Based Dynamic Model of Decision Making Processes: Philosophical Background and Conceptual Framework. *Proceedings of the 83th Annual Meeting of the Transportation Research Board*, January 2004.

Miller, E.J. (2005), Propositions for Modelling Household Decision-Making. *Integrated Land-use and Transportation Models: Behavioural Foundations*, M. Lee-Gosselin and S.T. Doherty (eds), Oxford: Elsevier, pp. 21-60.

Mohammadian, A. and S.T. Doherty (2005), Mixed Logit Model of Activity Scheduling Time Horizon Incorporating Spatial-Temporal Flexibility Variables, *Transportation Research Record : Journal of the Transportation Research Board*, No. 1926, 33-40.

Roorda, M.J., S.T. Doherty and E.J. Miller (2005a). Operationalising Household Activity Scheduling Models: Addressing Assumptions and the Use of New Sources of Behavioral Data. *Integrated Land-use and Transportation Models: Behavioural Foundations*, M. Lee-Gosselin and S.T. Doherty (eds), Oxford: Elsevier, pp. 61-85.

Roorda, M.J., M. Lee-Gosselin, S.T. Doherty, E.J. Miller, P. Rondier (2005b). Travel/Activity Panel Surveys in the Toronto and Quebec City Regions: Comparison of Methods and Preliminary Results. *Proceedings of the PROCESSUS Second International Colloquium on the Behavioural Foundations of Integrated Land-Use and Transportation Models: Frameworks, Models and Applications*, Toronto, June 12-15, 2005.