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The Human Activity-Travel Rescheduling Decision Process

Andrew F. Clark
Wilfrid Laurier University

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By

Andrew F. Clark

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Abstract

Over the past few decades the activity scheduling decision process has become an important topic for transportation researchers, including how people reschedule their daily activities and travel in reaction to change. Rescheduling decisions include modifications/updates to timing, location/route, involved persons, event/mode type, and other attributes of activities/trips, as well as addition and deletion of completely new events. Such decisions occur as part of an ongoing process over time, space and across individuals. This thesis developed and applied a new data collection methodology for exploring the rescheduling decision process. The methodology had four main stages: capturing preplanned schedules; Global Positioning System (GPS) tracking; an internet-based prompted recall diary; and a final open-ended in-depth interview to explore how and why rescheduling decisions were made. A total of 40 subjects participated in the study from the Kitchener/Waterloo area of Ontario, Canada. Results strongly suggest the development of a preplan is an on-going process, wherein tentative decisions on many attributes are often made (leaving them partially elaborated on the preplan), and that certain attributes (end times, involved persons) are more likely to evolve over a longer time period, whereas others (start time, activity/mode type, and location) are planned in advance and not likely to be elaborated upon. With regard to subsequent rescheduling decisions, the methodology was able to elicit a much greater number and variety of activity conflicts and modifications from subjects compared to previous studies. The causes of these rescheduling changes also varied substantially beyond the typical activity "conflicts" considered in existing models, particularly interpersonal and personal impetuses of change. Past time-geography concepts are supported by these results, although there are some aspects that are unique to these rescheduling decisions. Previous conceptualizations of the activity scheduling process can also be elaborated upon given these findings. Methodologically, the strengths of this study include the successful capturing of preplans (especially partial elaboration), utilization of GPS technologies to reduce the burden of capturing observed activity-travel patterns, and the ability to fully detail each rescheduling decisions through the open ended final interview.

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I am also very lucky to be supported by my family who have been there for me, supported me, and helped me get through all of the tough times. First to my parents, you thought I was crazy to continue in my Master's but once I started you were there for me every step of the way with your belief and encouragement. Most of all, thank you to my wife Cheryl, who has been there to help me in every conceivable way. She has been a listening ear, voice of reason, and anything else that I have needed during this process. Another thank you must go to Luke Cwik who lent his technical support to the project. There is nothing worse than getting a phone call at 8:00 in the morning, but he was always there willing and ready to lend his expertise. The data collection would not have been as successful without his help.

I cannot say enough about Eric Sadowski, who helped with all of the data input and transcribing of the interviews. He allowed me to focus on making sure equipment was functioning properly, analyzing data, and completing course work.

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I would like to dedicate this work to my wife Cheryl.

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CHAPTER 1: Introduction

1.1. Introduction

Rescheduling decisions are made by people every day in order to revise and update their plans in an effort accomplish their daily activities and travel. These rescheduling decisions include modifications/updates to timing, location/route, involved persons, event/mode type, and other attributes of activities/trips, as well as addition of new events and deletion of existing events. Such decisions occur as part of an ongoing process over time, space and across individuals. Travel behaviour researchers, policy makers, and modellers are particularly interested in *how* these decisions are made and the resulting impacts on observed activity-travel patterns/demand.

One of the challenges is designing data collection instruments that capture the rescheduling process, including how people think about their decisions and how they are made. Criticisms of past approaches often focus on the lack of detail and depth concerning the actual cognitive process involved, what is behind the decisions and how they come about. From a modelling perspective, understanding how these rescheduling decisions are made will assist in development of structural frameworks and choice of decision rules, and ultimately improve our ability to predict activity-travel behavioural changes in reaction to future policy, built environment, cultural or other changes.

As time progresses, the schedule is altered through additions, modifications, and deletions of activities until the moment the activity is executed. In order to fully understand rescheduling a brand new methodology was developed. The methodology uses open-ended interviews to collect information about the entire planning process – from initial planning to final execution of the activity schedule.

1.2. Objectives

The overall goal of this thesis is to gain a better understanding of rescheduling decisions and how they come about. In particular, the three main objectives are: (1) develop, execute, and critique a new method of collecting rescheduling data involving open-ended interviews; (2) determine how people go about expressing their preplanned schedules; and (3) explore the rescheduling process as it occurs in everyday life through a qualitative analysis.

The first objective is quite important as it provides new opportunities to learn about the rescheduling process through a new approach to data collection. The second objective recognizes the importance of capturing the preplanning process, which forms a skeleton set of activities-travel that is the basis for subsequent rescheduling decisions. Past methodologies have most often adopted a highly structured calendar/planner format wherein subjects indicate all the activities they have planned on a time line; this thesis aims to leave the structure open to the subjects so as to allow discovery of alternative formats such as verbal or point-form formats. Such an approach should reduce potential instrument bias. The third and final objective is to learn more about the rescheduling process through a qualitative analysis of interview data that explores planning time horizons, impetuses for change, the impact of decisions on the schedule, and the process gone through to make a change.

1.3. Overview of thesis

This thesis is organized into six chapters. After the introduction, the second chapter is the literature review. This chapter provides an overview of theoretical frameworks, rescheduling modelling approaches, and data collection methodologies.

Chapter 3 presents the data collection *Methodology,* including strengths and weaknesses of the approach. Chapters 4 and 5 present results, starting with analysis of *Preplanned Schedules* and then a *Qualitative Analysis of Rescheduling Decisions* that explores when, why, and how rescheduling decision are made along with the impact the schedule. Chapter 6 presents a *Discussion and Conclusion* including an overview of what the results mean for the overall scheduling process, challenges and limitations of the data collection, and future work. Note that chapters 3, 4 and 5 are derived from papers that have been presented at conferences and are in various stages of publication as noted at the onset of each chapter.

CHAPTER 2: Literature Review

2.1. Travel Behaviour Research Foundations

One of the first modern attempts to study travel behaviour was initiated in 1956 when a group in Chicago started the Chicago Area Transportation Study (CATS). CATS was initially started to allow decision makers and transportation planners to determine the most beneficial transportation system. During this time, research focus was placed exclusively on the development of different models to predict demand so that an adequate supply of transport infrastructure could be provided; there tended to be little or no concern for explaining and understanding travel behaviour. Some researchers made quite restrictive assumptions or simplifications about behaviour, such as Howe (1960):

> *"Human beings may be considered to be electrons. Given the initial distribution of these unit negative charges, corresponding to centres of residence, and the distribution of centres of positive charge, representing places of employment, with magnitudes equalling the number of persons employed, the probability of movement between places of residence and places of employment can be predicted on the basis of electrostatic field theory".*

Another characteristic of early models were that they were aggregate "zonal-based" models that predict travel behaviour based on the characteristics of households and people in geographically defined areas. This is typically done in a four-stage process consisting of trip generation, trip distribution, modal split, and traffic assignment.

In the 1960's, there was a major shift in statistical approaches from an aggregate to disaggregate modelling approach. A disaggregate model examines the travel patterns and behaviour of individuals, households, or firms instead of groupings within zones. Disaggregate models allow for an "improved statistical efficiency, economy in data collection, and versatile policy application" (Kitamura, 1988). These improvements gave planners and decision makers a powerful tool to help them make policy and system

decisions. Some examples of recent disaggregate models include SMASH (Ettema et al., 1993, Ettema et al., 1996), ALBATROSS (Arentze and Timmermans, 2000), and STARCHILD (Recker et al., 1986a, Recker et al., 1986b).

Shortly after the movement to disaggregate models, a more significant change was made in the theoretical framework of travel behaviour research. Focus shifted from the spatial entities and patterns to people and activities that drive the demand for travel, which is a reflection of the disaggregate approach. This change initiated what Pas (1990) describes as the only true paradigm shift that has occurred in travel behaviour research. In broader terms the paradigm evolved from a desire to supply for travel demands to a desire to better understand and manage travel behaviour. Hägerstrand (1970) contributed to the paradigm shift through his belief that it is important to understand travel behaviour and its motivations instead of trying to strictly predict how travel patterns will change in response to limited transportation policy or system changes. If the behaviour is not understood, there is a great deal of difficulty in accurately predicting the impact of proposed policy or system change.

Hägerstrand (1970) proposed that an improved understanding of travel behaviour is possible by examining what constrains activities and trips. He described three spatio-temporal constraints that limit which activities can be executed: capability constraints, coupling constraints, and authority constraints. A capability constraint is when activities are limited because of biological construction and/or tools an individual can command. For example, an individual who is in a wheelchair is unable to ride a bike because the disability is a capability constraint to that individual. Coupling constraints are where, when, and for how long, an individual has to join other individuals, tools, and materials

to execute an activity or trip. One example of a coupling constraint is two people are meeting for lunch, so neither can eat lunch until the other has arrived at the restaurant. Finally, authority constraints are restrictions placed on activities and trips due to morals, laws, and other 'control' domains. For example, an individual cannot legally drive a car if he/she does not have a license because driving without a license is a punishable offence by the police (authority). These constraints manifest themselves in time and space, restricting the location and timing of activities.

The three constraints are embodied in the notion of a time-space prism. A time-space prism "not only has a geographical boundary; it has time-space walls on all sides" (Hägerstrand, 1970). The walls will continuously change from day to day but there will never be an activity during a day outside of the time-space prism. These prisms continue to evolve even throughout a day. For instance, if an individual decides to stay longer at an activity than he/she originally planned, the individual would not be able to travel as far; therefore the time-space prism shrinks. In contrast, if an activity is cut short, then the individual will be able to travel farther than the original prism indicated; therefore, the prism will increase in size.

A few years later, Chapin (1974) came at the problem of investigating travel behaviour from a different direction. His work was based on urban land-use patterns and understanding activity patterns, but differs from Hägerstrand's time geography by focusing on desire and opportunities. Chapin believed that activity participation is a direct result of basic desires coupled with an opportunity to execute activities. Having the opportunity to execute an activity include the availability of facilities and services.

For example, a man needs to exercise every day. However, if there are no safe walking paths near his house, he must start going to a local arena that has a walking path.

Cullen and Godson (1975) merged these two complementary approaches to create a new framework that incorporates desires, opportunities, and constraints. They proposed six key propositions that influence travel behaviour:

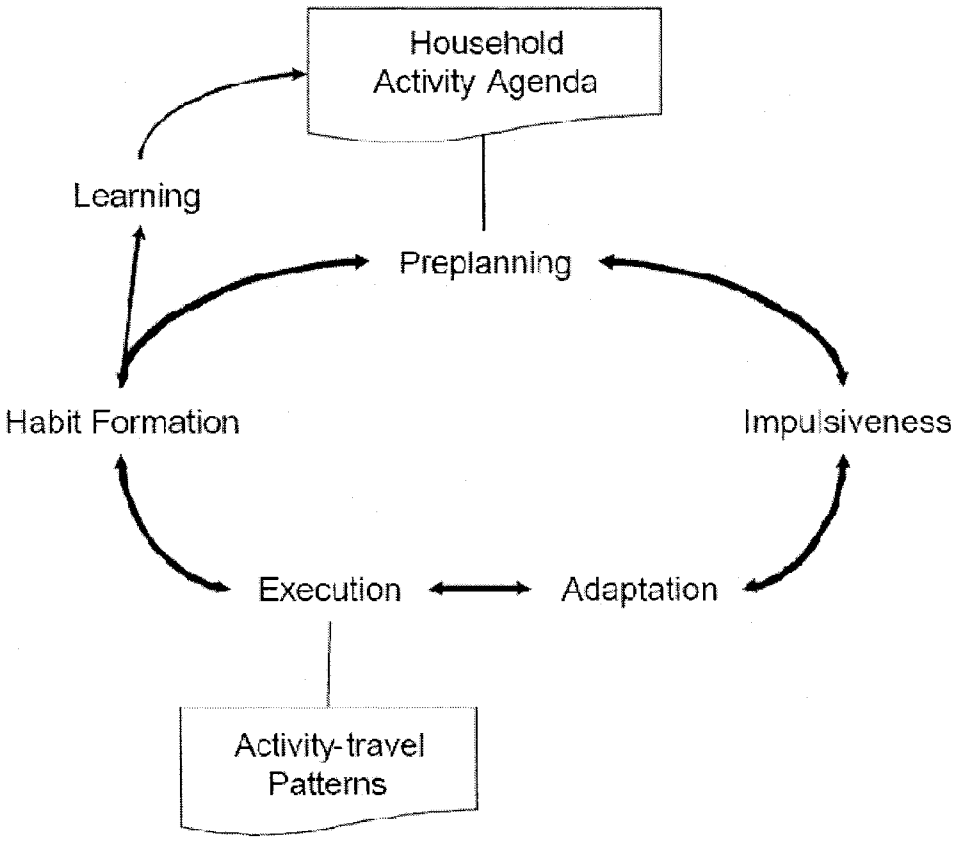
1) Organized Behaviour
2) The Action Space
3) Priorities
4) Constraints
5) Flexibility
6) Scheduling

Before Cullen and Godson, these propositions were discussed to different degrees but never formalized into a list of influences on travel behaviour. Organized behaviour and priorities originate from Chapin's work and the action space and constraints are from work by Hägerstrand. Cullen and Godson are the first researchers to connect flexibility and scheduling to travel behaviour. Flexibility refers to the degree of commitment an individual has to an activity and the ability of said individual to modify the time and/or location of the activity. As noted, flexibility is "directly related to whether or not the activity was arranged with others, planned alone, routine, or just passively allowed to happen" (Cullen and Godson, 1975). The flexibility of an activity then directly relates to the planning of a schedule. For instance, if an activity is non-flexible then a plan must be made around non-flexible activities to allow a schedule to be planned and executed without conflict.

By bringing attention to scheduling and the scheduling process Cullen and Godson moved the focus of research from travel patterns, as discussed by Hägerstrand

(1970), to how and why activity travel patterns are occurring. Despite this, research up until the 1990s largely continued to focus on observed/actual travel patterns using diary data. Researchers, such as Miller (2005), started looking back at literature to find potential methods and data that would allow new models to be created that better approximate scheduling and travel behaviour. As a result, the scheduling process started moving to the forefront.

Figure 1: Original scheduling process framework as described by Doherty (2002)



One example of the scheduling process framework proposed by Doherty (2002) and Doherty et al. (2002b) is shown in Figure 1. A scheduling process framework describes the process an individual implements before executing a schedule. From creating a preplan to rescheduling a preplan to executing activities, the schedule is continually evolving. As the schedule is first being developed, routine activities are placed on a preplan. Although routine activities are not necessarily fixed in time and space (see Roorda et al., 2007), they are initially placed on the preplanned schedule either fully elaborated or with some attributes unknown. For example, when an individual knows that they have golf lessons every Wednesday at 2:00, they will schedule this entire activity before anything else is scheduled. In contrast, if work is quite flexible but eight hours must be worked every day, an individual will place work on his/her schedule without including the start and end times.

After these routine activities are scheduled, the individual will continue to evolve his/her preplanned schedule by adding, deleting, and modifying activities. While the schedule is evolving, scheduling conflicts arise that lead to some planned activities needing to be further modified. To modify these activities rescheduling needs to occur in order to resolve all scheduling conflicts. In order to resolve the conflicts, activities already scheduled need to be deleted or modified. Rescheduling continues for the entire scheduling process until the final schedule is executed.

Before the preplanned schedule can be executed, there can be additional impulsive activities added. Impulsive activities are activities that are added to a schedule opportunistically without any planning. For example, while driving home from work there is a gas station that you decide to stop at because you realize you are running out of

gas. The key to this example is that the impulsive decision is made without thinking prior to the execution of the activity.

Each of the four different frameworks (Hägerstrand's time geography, Chapin, Cullen and Godson, and Doherty's scheduling process) has led to data collection and modelling advances. Initially all of the models developed focused on the work by either Chapin or Hägerstrand but as time moved forward, the scheduling process first described by Cullen and Godson started to come to the forefront. The modelling approaches were slightly modified as more of a rule-based approach and the data used to estimate the models became much more representative of how people actually plan their schedules.

2.2. Modelling Approaches

Disaggregate models, as previously discussed, have been the foundation of travel behaviour research for the last several decades. Most recently, modellers have been attempting to create a model that approximates the scheduling decision process. There are three basic modelling approaches that are used to estimate the scheduling process: constraints-based approach, utility-based approach, and rule-based approach. Each approach has different associated strengths and weaknesses and each have general assumptions that could cause bias and inaccuracies compared to the real world.

2.2.1. Constraints-Based Approaches

Constraints-based approach to modelling follows the time geography framework laid out by Hägerstrand. The purpose of a constraints-based approach is to examine "whether particular activity patterns can be realized within a certain time and space"

(Arentze and Timmermans, 2000). Arentze and Timmermans described the five steps that are generally used to create a constraint based model:

1) Generate a set of activities with a given duration, location, and other attributes
2) Travel time calculated between each pair of locations
3) Combinatorial algorithm used to generate all possible activity sequences
4) Determine feasibility of each sequence through answering a set of questions:
    a. Is the interval between end time and start time sufficient to perform activity and travel time?
    b. Can the activity start after earliest start time and before latest end time?
    c. Are the conditions about sequencing activities violated?
5) Select the sequence of activities that maximizes utility to an individual

These general steps have been used as the foundation for many early models including PESAP (Lenntorp, 1976), CARLA (Jones et al., 1983), and BSP (Huigen, 1986). The goal of these models was to evaluate the feasibility of activity patterns and sequences based on Hägerstrand's constraints. There are two general assumptions that the developers of these models have stated: individuals place activities in a specific sequence to avoid wasting time and; everyone has the same basic constraints (i.e. coupling, capability, and authority). In some instances, efficiency may not be the only motive in the scheduling process. By assuming individuals always avoid wasting time in their schedule there is a possibly of ignoring other more relevant scheduling motives. There are also some constraints that play a part in which activity sequences are and are not possible across the population. Therefore, there may be some bias in assuming that these constraints are the same. In most cases, constraint based models are developed through deduction instead of observation and empirical data. The value of a constraint based model is the ability to investigate policies that affects the space-time of activity patterns,

such as investigating the consequences of a bus route being changed on the travel time and patterns (Arentze and Timmermans, 2000).

Other researchers have used Geographic Information Systems (GIS) to develop constraints-based models. Miller (Miller, 1991, Miller, 1998, Miller, 1999, Miller, 2006, Miller and Wu, 2000) has taken a lead in developing space-time accessibility. Kwan (Kwan, 1998, Kwan and Hong, 1998) have used travel diary data to develop space-time accessibility measures based on a "prism-constrained feasible opportunity sets" (Kwan, 1998). Finally, Scott (2005) developed a shortest path algorithm that can be implemented in a model to establish the potential path area or space-time prism where an individual can execute his/her schedule. The weaknesses and assumptions first discussed in the original models still apply in the newer GIS integrated models but there is some hope that better data sets for creating these models will improve matters, especially with respect to the constraints of an individual, an individual's abilities to travel and the motive for sequencing activities.

2.2.2. Utility-based Approaches

Utility-based approaches started to be used in the late 1970s based on econometric principles and have since grown to be the most commonly used approaches in transportation modelling. The fundamental assumption of these models is that individuals make choices that maximize their total "utility". According to Dictionary.com, utility is defined as "the capacity of a commodity or a service to satisfy some human want" (2008). In other words, utility is the desire of an individual to participate in an activity and the resulting satisfaction gained by completing the activity, which is inspired by Chapin's approach of examining travel behaviour.

With respect to activity scheduling models, the approach often adopted is to generate a set of possible activity schedules for a given time period (e.g. day) and determine the one that has the greatest utility. four basic steps include (Arentze and Timmermans, 2000):

1) Define a choice set
2) Collect attribute information for each choice set
3) Relate attribute values to observed choice frequencies
4) The resulting set of activities that has the highest utility is chosen for an individual.

There are many examples of models that adopt utility maximization, including STARCHILD (Recker et al., 1986a, Recker et al., 1986b), a model developed by Kawakami & Isobe (1990), The Daily Activity Schedule Model (Ben-Akiva et al., 1996), PETRA (Fosgerau, 1998), COBRA (Wang and Timmermans, 1999), HAPP (Recker, 1995), PCATS & PCATS-RUM (Kitamura and Fujii, 1998) among others (Doherty and Mohammadian, 2007, Adler and Ben-Akiva, 1979, Cirillo and Axhausen, 2006, Ettema et al., 2007, He and Scott, 2007, Bhat and Misra, 1999, Mohammadian and Doherty, 2005).

As stated above, the most common assumption when developing these models is that individuals make their choices to maximize utility. However, a common critique is that utility does not provide a complete explanation for all scheduling decisions (Gärling et al., 1998b). Instead a wide range of alternative heuristics rules could be added to allow for a kind of hybrid approach at modelling scheduling decisions. Another general assumption that is often made is that accessibility to destinations and modes influence how activities are chained. A third general assumption concerns how utility is derived.

For example, in STARCHILD (Recker et al., 1986a, Recker et al., 1986b) utility is derived from wait time and in a model by Kawakami & Isobe (1990) destination determines utility, which is a function of the other attributes.

2.2.3. Rule-based Approaches

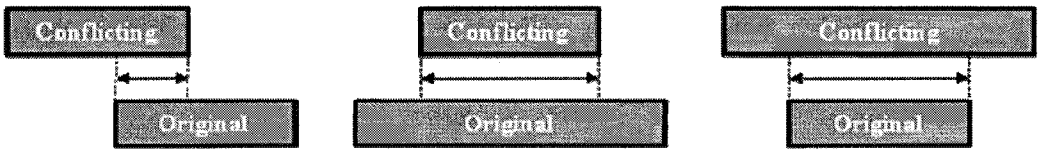
Emerging approaches to modelling travel decisions and the scheduling process utilize a heuristic rules, borrowing mostly from the field of psychology. This approach recognizes that people do not always make decisions that *maximize* their utility within a set of constraints, but instead are more likely to make a decision based on a more limited/simple set of heuristic rules that allow people to arrive at a solution that is satisfactory to their own travel behaviour. Tversk and Kahneman's (1981) prospect theory further proposes that "various kinds of contexts influence the heuristics used and hence the outcome of decision processes". Operationalizing this approach normally involves specification of a set of "IF...THEN" rules that are placed within a decision tree to determine which choices/activities are executed in which contexts. Some rule-based models that have been developed include ALBATROSS (Arentze and Timmermans, 2000), AMOS (Pendyala et al., 1998, Pendyala et al., 1995), SMASH (Ettema et al., 1996, Ettema et al., 1994), and TASHA (Miller and Roorda, 2003, Roorda et al., 2006) among many others (Gärling et al., 1998a, Arentze and Timmermans, 2005, Doherty and Axhausen, 1999, Gärling et al., 1994, Vause, 1997). In lieu of explicit empirical observations of the actual if-the rules used to make scheduling decisions, most rule-based models either assume a given if-then structure, or adopt utility-based approaches for operationalization in the short term (e.g. (Ettema et al., 1993, Ettema et al., 1996, Kwan, 1997), (Gärling et al., 1998a).

2.2.4. Rescheduling Models

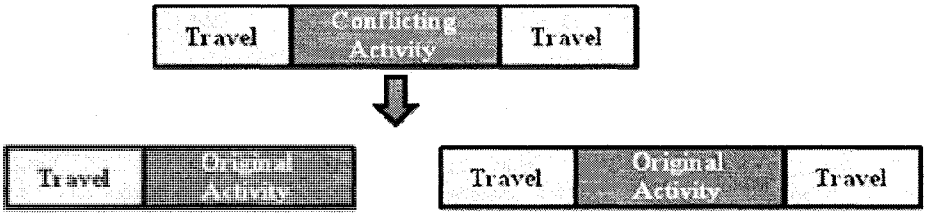
More recently, there have been focused attempts to develop models of rescheduling decisions and/or conflict resolution strategies (Doherty et al., 2002a, Joh et al., 2002, Joh et al., 2004, Gärling et al., 1999, Auld et al., 2008, Joh et al., 2005a, Joh et al., 2005b, Nijland et al., 2007, Roorda and Andre, 2007, Roorda and Miller, 2005, Ruiz et al., 2005, Ruiz and Timmermans, 2006, Sun et al., 2005). These models have allowed researchers to break the seemingly multi-faceted scheduling process modelling development process into smaller portions that can be tackled efficiently.

Rescheduling and/or conflict resolution models are particularly key as they allow models to predict how people may adjust their daily lives during the planning of their schedule in reaction to policy changes, conflicts or other stimuli. Figure 2 illustrates graphically an example of conflict scenarios. The different models attempt to explicitly predict the choice of how an individual will resolve these conflicts. Most models predict that individuals will either modify the start/end time to the original activity, conflicting activity, or both activities or delete the original activity or conflicting activity. Modelling methods used to resolve scheduling conflicts include decision trees (Auld et al., 2008, Sun et al., 2005, Joh et al., 2002, Roorda and Miller, 2005), discrete choice models (Roorda and Andre, 2007, Nijland et al., 2007), and a hazard model (Ruiz and Timmermans, 2006).

Figure 2: Examples of conflict scenarios used in past rescheduling models
a) Auld et al. (2008) and Roorda & Miller (2005)



b) Ruiz et al. (2005) and Ruiz & Timmermans (2006)



2.2.4.1. *Rescheduling Using Decision Trees*

Decision trees "represent a set of mutually exclusive and exhaustive rules" (Auld et al., 2008) which can be used to approximate the rescheduling process. Roorda and Miller (2005) describe the rescheduling aspect of their TASHA model as a rule-based model that has two unique rules to evaluate rescheduling decisions: activity precedence and rescheduling strategies. The first rule is to determine precedence based on an optimal preference ranking derived from the CHASE survey (Doherty et al., 2002b). The second rule is to develop rescheduling strategies from CHASE, as seen in Figure 3a, although there are some that TASHA leaves out. One such example is that activities in TASHA cannot be shifted, lengthened, moved to another day, or skipped.

Auld et al. (2008) developed a rescheduling model that was based on four resolution strategies:

1) Modify Original
2) Modify Conflicting
3) Modify Both
4) Delete Original

To determine which resolution strategy would be used in each conflict the Exhaustive CHAID algorithm was used to build an if-then decision tree. From this model they find that resolution strategies are based on location, activity attributes, and conflict attributes (i.e. planning time horizon, travel requirements, duration, type of conflict, amount of overlap, etc.).

2.2.4.2. *Rescheduling Using Discrete Choice Models*

A discrete choice model determines a choice from a discrete set alternatives based on many variables. Roorda and Andre (2007) created a multinomial logistic regression model of the rescheduling strategy adopted for a hypothetical question of what to do when being one-hour late to an activity. Model results suggest that the type of rescheduling strategy depends on the activity type, planning time horizon, duration, and whether children are involved.

Nijland et al. (2007) developed a multinomial logit (MNL) discrete choice model from stated adaptation observations of how an individual will reschedule based on a given conflict situation. They found that the main rescheduling strategy is to modify duration. Other less frequently implemented rescheduling strategies include change of transport and change of mode.

2.2.4.3. *Rescheduling Using a Hazard Model*

Hazard models focus specifically on the duration of activities. Ruiz and Timmermans (2006) developed a rescheduling model using a parametric hazard model. The purpose is to discover how much an activity has been shifted forward/backward in time between the original and rescheduled time of the activity. The conclusions state that duration change will normally result as a change in start time. Types of change made can be found by examining the characteristics of the involved activities and gender of the individual.

2.2.4.4. *Assumptions of Rescheduling Models*

Throughout these three types of rescheduling models there are two general assumptions about behaviour that are often made: conflicts arise due to individuals trying to maximize the number of activities they can fit into a day; rescheduling heuristics are described as an iterative process that ends with the best possible combination which does not change the utility. It is relatively unknown how realistic these assumptions are. The authors commonly express the need for more observed data on how people actually proceed through the scheduling and conflict resolution process (e.g. (Roorda and Miller, 2005). This includes the very basics, such as how activities are selected for preplanning, the role of habitual activities, how and why activities are rescheduled, and the influence of personal and situational characteristics. Further information on this would greatly assist in the validation and calibration of the models.

2.3. Data Collection Methodology

Researchers are continually working to better understand the entire scheduling process, including the creation of the preplanned schedules, rescheduling of activities,

and the execution of the preplanned schedule resulting in observed activity-travel patterns. Understanding each of these stages will lead to a more dynamic and comprehensive model being created. Given the focus of this thesis, this section will review data collection methods that explicitly focus on the rescheduling of activities, including those that involve stated adaptation and activity diaries.

2.4. Stated Adaptation

Stated adaptation is a method by which an individual is given a schedule and asked to reschedule the activities and trips based on a given conflict or situation. There are different degrees of realism in a stated adaptation survey. The least degree of realism occurs when subjects are given a completely fictitious set of activities in a fictitious town and asked to schedule the activities, as in Hayes-Roth and Hayes-Roth (1979). Nijland et al. (2007) improved the realism of stated adaptation by giving subjects hypothetical situations that contain an activity with corresponding locations and travel mode that are known to the subjects. Finally, CHASE (Roorda and Andre, 2007) and OPFAST (Roorda et al., 2005) both were able to increase realism even more by having subjects reschedule their day from a hypothetical situation based on their own executed schedules, as collected in an earlier wave of the TAPS (Travel/Activity Panel Survey) panel surveys.

2.4.1. Stated Adaptation Methodology

Hayes-Roth and Hayes-Roth (1979) were the first to introduce stated adaptation into collecting data about scheduling decisions. Each subject was given a map of a fictitious town, a list of possible activities (activity agenda), and locations for each activity, from which they were asked to determine the order of execution. One caveat was that activities could be omitted from the schedule. At the end of the study, there

were two related problems that were a direct result of survey bias. First, subjects underestimated the time taken to travel between locations and execute the activities. As a result, the created schedules were too crowded and next to impossible to execute. Second, the subjects rarely omitted activities that were on the original activity agenda, which led to an overcrowded schedule.

Since Hayes-Roth and Hayes-Roth, stated adaptation was used mostly to examine scheduling, along with other transportation research. In 2007, Nijland et al. used an internet-based stated adaptation study where a subject was given a fictitious scenario asked to resolve/reschedule the conflicting activities. Each scenario given was written in a general form (as seen below) with activity (A), mode choice (M), location (L), and reduction in time (R) being determined by the researcher based on a survey completed by the subject.

> *"Assume you intend to conduct activity A today. For the activity including travel time you have M minutes. You want to conduct the activity at location L and you arrive there by transport mode T. Unfortunately, today you have encountered a delay with as a consequence that the available time (for activity and travel) has been reduced to R minutes. After this, you should be back for another activity. What would you do in this situation? Indicate for each of the following options the probability that you would choose this" (Nijland et al., 2007).*

Each subject was then asked to reschedule this hypothetical scenario three times with R changing and all other variables staying constant. In order to reschedule the given activity there are eight different strategies that are used to allow the subjects to avoid an all-or-nothing response (Nijland et al., 2007):

1) I change location

2) I change transport mode

3) I shorten the duration of the activity

4) I change the location and transport mode

5) I change the location and shorten the duration of the activity

6) I change the transport mode and shorten the duration of the activity

7) I change the location, the transport mode and the duration

8) I cancel the activity

Overall, this study has done some excellent work to allow the subjects to be more familiar with the situations than in the Hayes-Roth and Hayes-Roth study. Although by being given only one activity of an entire schedule there is little context in which the subjects are asked to reschedule.

For TAPS Wave 2 (Roorda et al., 2005), researchers in both Quebec City and Toronto collected a two-day diary that they then used to develop a stated adaptation survey. In Toronto, computer-assisted telephone interviewing (CATI) software was used to allow for easy coding and helping the interviewer proceed through the interview. The Quebec City study used a mail-back survey ,but had the same intention. From the two-day survey, the subjects' schedules are altered to create conflict and then open-ended questions are asked to determine the actions of the subjects, such as (Roorda et al., 2005)

1) What would have happened if you had an unexpected one-hour delay in getting to this activity?
2) What would you have done if the _____ mode were not available to get to that activity?

3) (For parents of children in school or child care only) What would you have done if you got a call while you were (doing the activity) that your child was sick and would need to be brought home?

4) Imagine that [description of activity 1] was going to take longer than planned. If you decided to spend more time at [description of activity 1] it would have caused you to be one hour later than planned for [description of activity 2]. What would you have done?

For each of these four questions, a detailed discussion needs to take place to allow the interviewer to fully understand the reasoning behind decisions, and furthermore to gain more information regarding the impact of the decisions on other people, activities, and days. The four additional discussion questions are (Roorda et al., 2005)

- *How would it have affected the other activities you did that day?*
- *Please estimate the times of the revisions to your plans. (This question was customized depending on the types of revisions that were suggested by the respondent)*
- *Would this have affected the plans of other members of your household?*
- *Would this have affected your plans on other days?*

This method of collecting rescheduling decisions appears more accurate than the previous examples given. Unlike the work by Hayes-Roth and Hayes-Roth (1979) and Nijland et al. (2007) the TAPS Wave 2 project dealt with a more realistic situation where subjects were asked to modify their own schedule based on a hypothetical situation.

2.4.2. Benefits and shortcomings to stated adaptation

Stated adaptation methods allow researchers to focus on a small set of questions regarding rescheduling decisions. The shorter survey length also allows for larger

samples of data and lower respondent burden. The most significant drawback is the reality of the hypothetical situations. Anytime there are new situations that are not experienced the subjects are essentially guessing on how they would react to the situation. Some of the subjects may have experience with certain hypothetical situations, but many others will not have any experience at all. The narrow scope of the survey can also be a negative aspect of this type of survey as it does not allow subjects to see the context in which the hypothetical situations exist. For example, if only one activity is being considered, a subject will not know if there is anything else during the day that may influence how the rescheduling decision is made.

2.5. Revealed Adaptation

Revealed adaptation is another methodology that can be used to examine the rescheduling process. Instead of having hypothetical situations to reschedule, subjects are required to fill in a diary-type survey that tracks how the subjects schedule and reschedule their actual day. These diaries have been used to different degrees of success throughout the last 10 years utilizing pen and paper, internet, and computerized technologies. Each type of diary is used to a different extent to examine scheduling and rescheduling decisions.

2.5.1. Pen and Paper Surveys

A recent pen and paper method developed to examine scheduling *and* rescheduling decisions is presented by Lee-Gosselin (2005) called OPFAST. It consists of a seven day diary survey with a fax machine to allow snapshots of the scheduling process to be collected. At the beginning of the survey subjects were asked to write down everything that they had already planned for the week. Then at the end of each day

the subjects were required to update their schedule to match their executed schedule and to update the planned activities for the rest of the week. After updating the schedule the subjects were asked to fax the updated schedule to the researcher (from a fax machine provided to the subject) to allow preparation for the final interview. An example of the faxed schedule can be seen in Figure 4.

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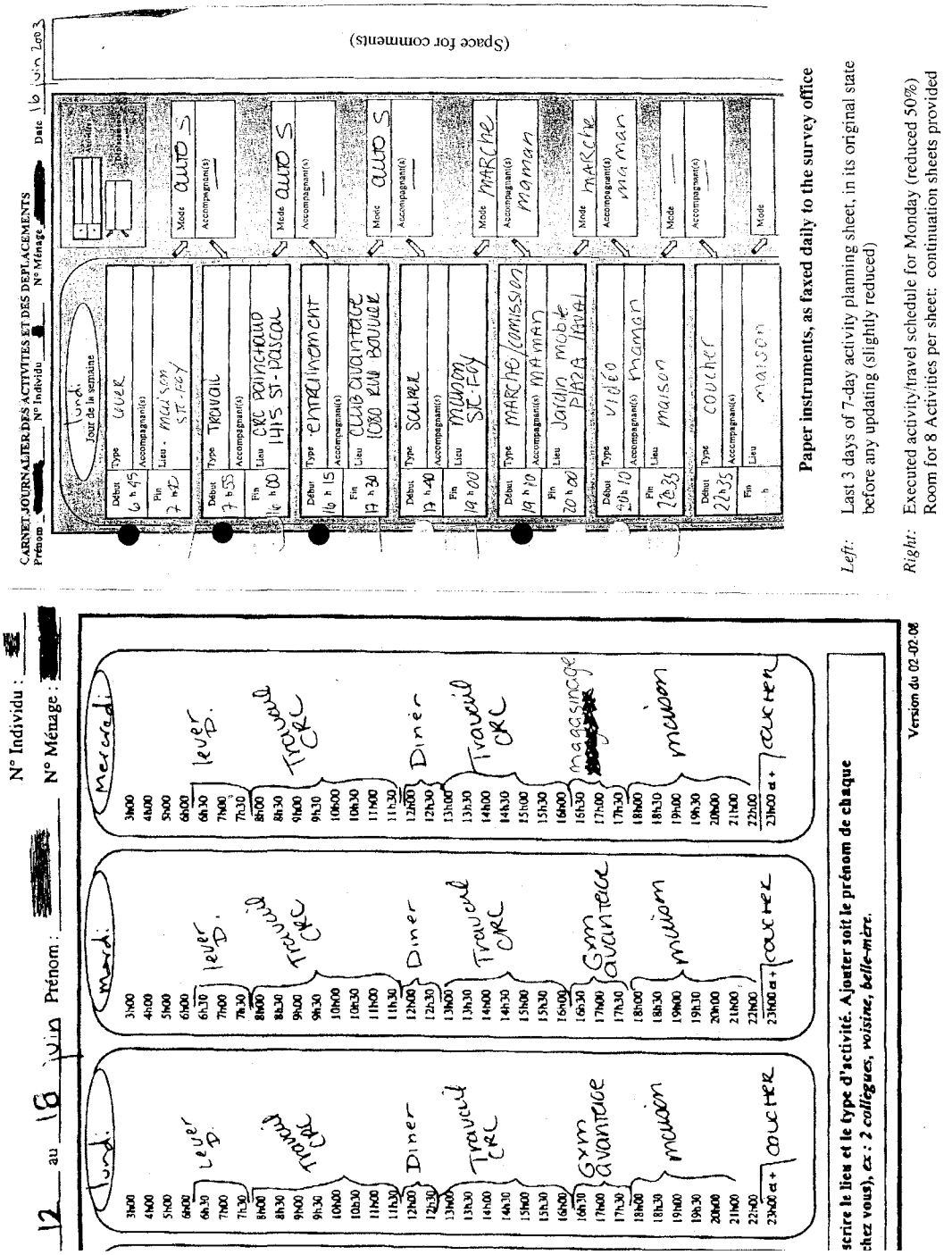
During the final interview the focus was on (Lee-Gosselin, 2005)

- *validation of paper instrument*
- *perceived spatial/temporal fixity of activities*
- *details on planning time horizons and interdependence*
- *interpretation of each approach of spatial and temporal organization of activities*
- *interview about jointly-planned activities, activity negotiation, improvement of activity pattern, and use of telecommunications in planning and negotiation*

Figure 3: OPFAST example of a preplanned schedule



Source: Reproduced with permission from Roorda et al. [11]

The last point talks about rescheduling issues, specifically discovering methods and telecommunication used to plan and negotiate the schedule of activities. Although these data have yet to be fully analyzed there are some excellent opportunities to delve deeper into the rescheduling aspects collected in this study.

2.5.2. Computer-Based Surveys

The final group of survey methods to examine reschedule decisions utilize programs written for a computer (but not the internet), PDA's, Cell Phones, or other interface. Three studies that involve these new technologies include CHASE (Doherty and Miller, 2000), REACT! (Lee and McNally, 2001), and EX-ACT (Rindsfüser et al., 2003). Each of these surveys is built on the previous survey to create comprehensive self reporting surveys.

CHASE (Computerized Household Activity Scheduling Elicitor) was the first survey to explore the scheduling process as it occurred in reality over a week-long period. There were two main stages: an upfront interview and week-long computerized scheduling process survey. In the original upfront interview, the household's activity agenda is ascertained by asking for details such as location, duration, earliest and latest start time, earliest and latest end times, and day of the week that applies for each activity. After establishing the basic agenda for the subjects, they are asked to log into the software (as seen in Figure 4) and follow these instructions to complete the survey (Doherty and Miller, 2000):

- *Try to login to the program at least once a day for the entire week.*
- *Starting tonight, add activities anywhere in your schedule that you have already thought about doing before logging on to the*

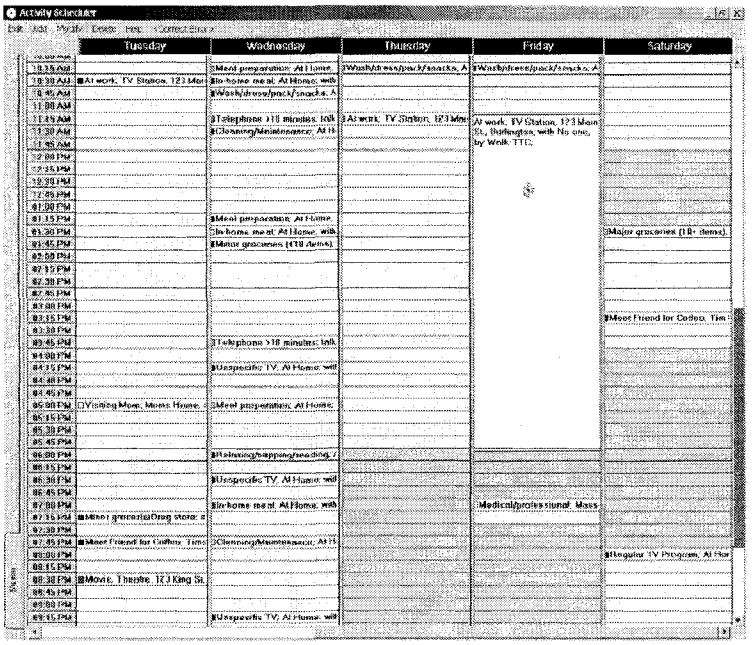
computer. These include even those activities that you think may change at a later date.

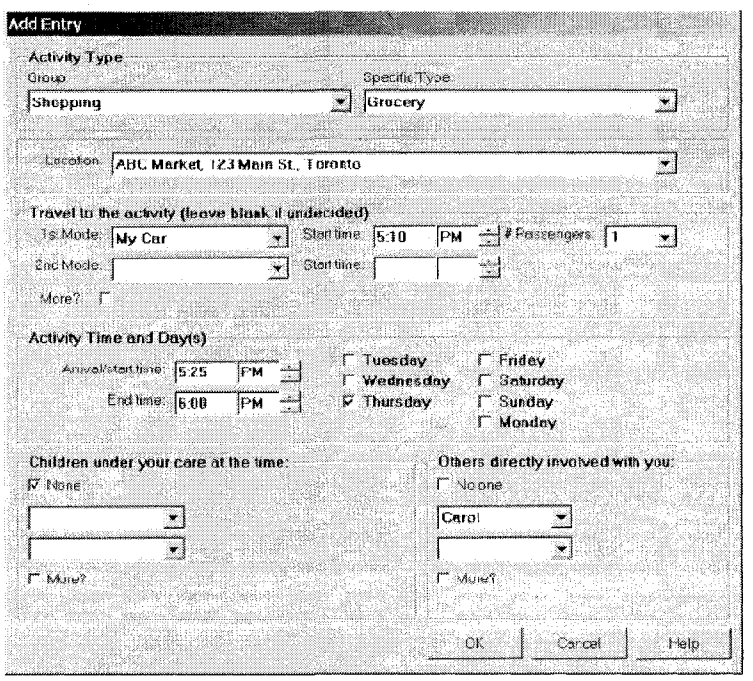
- *On subsequent days, continue to add new activities to your schedule, but review your previous and future entries and modify/delete them according to any changes that have occurred. This may include modifying/deleting a past event to reflect what actually occurred, or modifying/deleting a future planned event because of further changes in your plans.*
- *Include all activities that last longer than 10 minutes; the exception is for short activities involving travel – include all of these (e.g. quick stop at the dry cleaners).*
- *You may overlap activities that take place at the same time (e.g. eating and watching TV) or that intervene within a longer activity (e.g. going out for lunch at work).*
- *Activities start when you leave for them and end when you leave from them. In this way, travel time to the activity is counted as part of the activity, whereas travel time away from the activity is captured by the next activity.*
- *Try to complete the schedule alone; do not access your partners' schedule.*

From these instructions, the subjects are required to have the planned and executed activities for the entire seven days of the study period.

Some unique features to CHASE include the ability to place multitasking activities in the schedule. In the past, subjects were required to choose the activity that was the most important. For example, individuals may watch TV while they are eating dinner, so these are both allowed on the schedule instead of having to pick one over the other. Another unique feature of CHASE is the ability to learn more about each activity that is planned. Depending on the type of modification made to the schedule (modify, add, or delete) a different question set would be asked to enable more to be learned about each decision. An example of a question set can be found in Figure 5. The questions asked all have a direct result of answers given to previous questions.

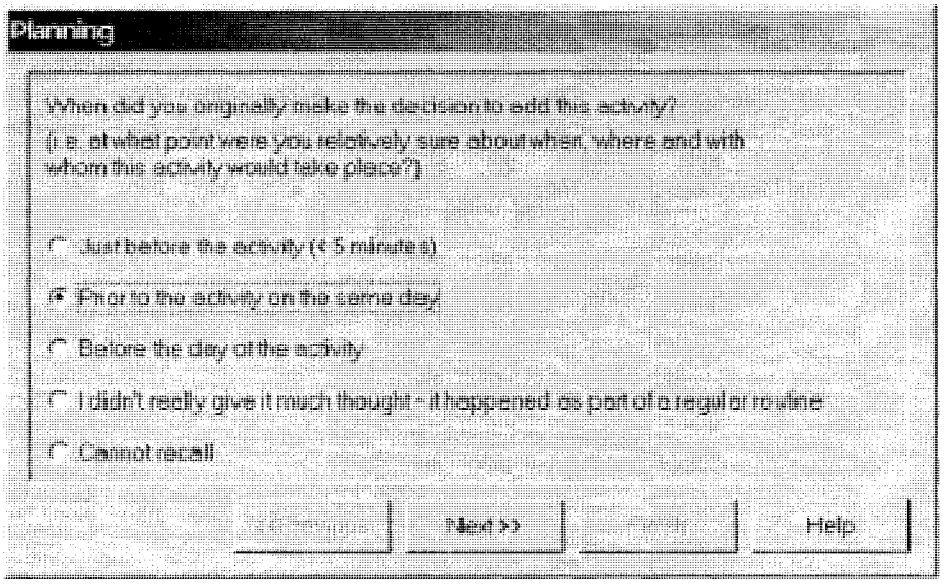
Figure 4: Examples of CHASE interface as described by Doherty and Miller (2000)





Building on CHASE, the REACT! (Lee and McNally, 2001) computerized survey collected weekly diary data including preplanned and executed activities. The key advance was allowing for partially elaborated activities to be placed on the preplanned (tentative) schedule thereby reducing the pressure to estimate or guess unknown details, and likely reducing the potential for "fill-up" bias. The program interface allows the subjects to view their preplanned schedule, executed schedule, and any day activities (as defined during pre-study interview). By including all of these in different areas, it allows subjects to easily confirm, modify, add, and delete activities as they were executed. The in-depth questions are also included in REACT! to learn more about the rescheduling and scheduling decisions.

Figure 5: Example question asked by CHASE to collect more information regarding the activities and trips (Doherty et al., 2004)



Finally, EX-ACT (Rindsfüser et al., 2003) built upon the CHASE platform by tracking how individual attributes of activities are planned, providing an interface that users can use regularly to improve recall and accuracy (a PDA), and reduce survey costs and respondent burden. In order to accomplish these goals, the authors decided to use a PDA to allow for situational data entry. By carrying these PDA's anytime, when a decision is made the subject can quickly input the plan and/or executed activities as they arise instead of waiting until they get home at night. The ability to define attributes at a different time also allows individuals to input more information regarding the entire scheduling process instead of just a portion of the process. This increases the detail of data and is "more behaviourally realistic" (Rindsfüser et al., 2003). Other than the above mentioned changes the CHASE survey is basically intact including asking additional questions when a modification occurs, the tracking of scheduling changes, among others.

Ruiz (2005, Ruiz and Timmermans, 2006) developed an internet-based survey that specifically examines how rescheduling decisions are made. Subjects were asked to complete the survey for one to four non-consecutive survey days over a four-week period. The subjects were then required to fill out a preplanned schedule for all four days, which means that some preplanned schedules could be planned as early as 28 days ahead of time. At the end of each day an email was sent out to remind the subject to fill out their executed activity schedule. Subjects were required to input the executed schedule through an internet-based interface to the best of their recollection. The executed schedule as entered by the subject is then compared to the preplanned schedule to allow modifications, additions, and deletions of activities to be found.

2.5.3. Strengths and Weaknesses of Revealed Adaptation

Overall, the revealed adaptation methods reviewed above have increased our knowledge of the scheduling process, improved the accuracy of the data, and have taken efforts to minimize respondent burden. A particular strength is adding the ability to describe partially elaborated activities on the preplanned schedule and thus helping to avoid forcing subjects to either estimate or guess the unplanned attributes. A second strength of revealed methodology is the amount of detail that is collected about each activity and its attributes such as the key role that activity flexibility plays. Finally, revealed methods are based on real situations unlike stated adaptation methods. Individuals are able to describe the activities and decisions that they have made because they have experienced these decisions. There is no longer any supposition needed, instead subjects can recall, to some degree of certainty, what they were thinking when a decision was made.

Although there were a number of strengths in the revealed methodology, there is always room for improvement. Improvement can be attained through a more comprehensive survey or increased use of technology to minimize respondent burden further and increase accuracy. One particular weakness is the need for more detail regarding how and why rescheduling decisions are made. Second, the reliance of self-reporting of rescheduling decisions is subject to significant recall bias. Finally, sample bias is always a major problem in any survey using new technology or multi-day surveys.

2.6. Passively Tracked Scheduling Decisions

The final group of surveys applicable to tracking rescheduling decisions is passively observed/tracked adaptation studies. These studies involve use of various

techniques to automatically or passively detect what subjects are doing, instead of relying on self-reporting. To this point, most researchers are focusing on techniques for tracing observed travel patterns, rather than underlying decision processes. This includes especially the development of "prompted recall" diaries that use GPS tracking in combination with an algorithm to predict what activities are being executed, followed by a prompted recall diary to verify or add to the results of the algorithm (Stopher et al., 2002, Stopher et al., 2004, Itsubo and Hato, 2005, Doherty et al., 2006, Tsui and Shalaby, 2006, Bohte and Maat, 2008, Li and Shalaby, 2008, Wolf, 2006, Stopher et al., 2007). Some researchers, such as Wolf et al. (2001) and Stopher (2008), believe that the future in observed data collection is a completely passive GPS tracking where no prompted recall diary is needed.

Doherty et al. (2001) and Doherty and Papinski (2004) were the first to propose that new technologies such as GPS would be used in combination with other survey methods to *passively* track activity re-scheduling decisions without the need for self reports. This involved subjects describing their preplanned schedule during a prestudy interview. As the study progressed the subjects are then passively tracked using a GPS device for a set number of days. As data are collected, the GPS data are run through an algorithm that predicts the activities and trips that were executed by location and mode. A prompted recall diary would then allow the subject to correct the algorithm and indicate the actual activities and trips that were executed. Finally, a comparison can be done to determine additions, deletions, and modifications between the original planned activities and the final executed activities.

2.7. Summary and Context of Current Study

After reviewing modelling trends and emerging data collection methodologies there does seem to be a need to create new methods that focus explicitly on observed/revealed rescheduling decisions. There are three main goals that this study needs to attain to advance beyond past methodologies:

1) Data that have a greater degree of detail
2) Data with a greater degree of accuracy
3) Maintain a reasonable degree of respondent burden

These goals would seem to warrant an interview process involving in-depth and open-ended queries that allow subjects to express their thoughts and explain their decision-making process in their own words as it occurred over time. This more qualitative data should lead to a greater degree of accuracy and detail. Reducing respondent burden will require creative utilization of emerging technologies for tracking activity-travel behaviour which would then provide a detailed basis from which to discuss underlying decision processes.

CHAPTER 3: Methodology

Authors Note:

This chapter is reproduced from a paper titled "*Use of GPS to Automatically Track Rescheduling Decisions*" presented at the 8th International Conference on Survey Methods in Transport in Annecy, France, May 25-31, 2008. Copyright for this latter paper is held by the authors. Co-author and thesis supervisor Dr. Sean Doherty has provided his permission to reproduce this paper in this thesis. The paper has been modified to minimize redundancies (e.g. literature review) and to improve overall flow and continuity.

3.1. Objectives

The overall objective of this chapter is to describe and assess a multi-stage data collection methodology for exploring the activity scheduling decision process in everyday life, including pre-planning, execution, and re-scheduling decision processes. Included is an attempt to address past design concerns, including issues of respondent burden and data validity. A new theoretical framework, as shown in Figure 6, is based on Doherty's (2002) original framework and will be the foundation for the methodology and findings of this thesis. The key to this new methodology is the use of person-based passive Global Positioning System (GPS) tracking – this paper will demonstrate how this technology can not only reduce the burden of tracking observed activity-travel patterns, but also assist with passively tracking underlying rescheduling decisions that can form the basis of further in-depth probing. Results from a pilot study of 40 subjects who completed the survey are used to illustrate the survey and assess the quantity/quality of resulting data.

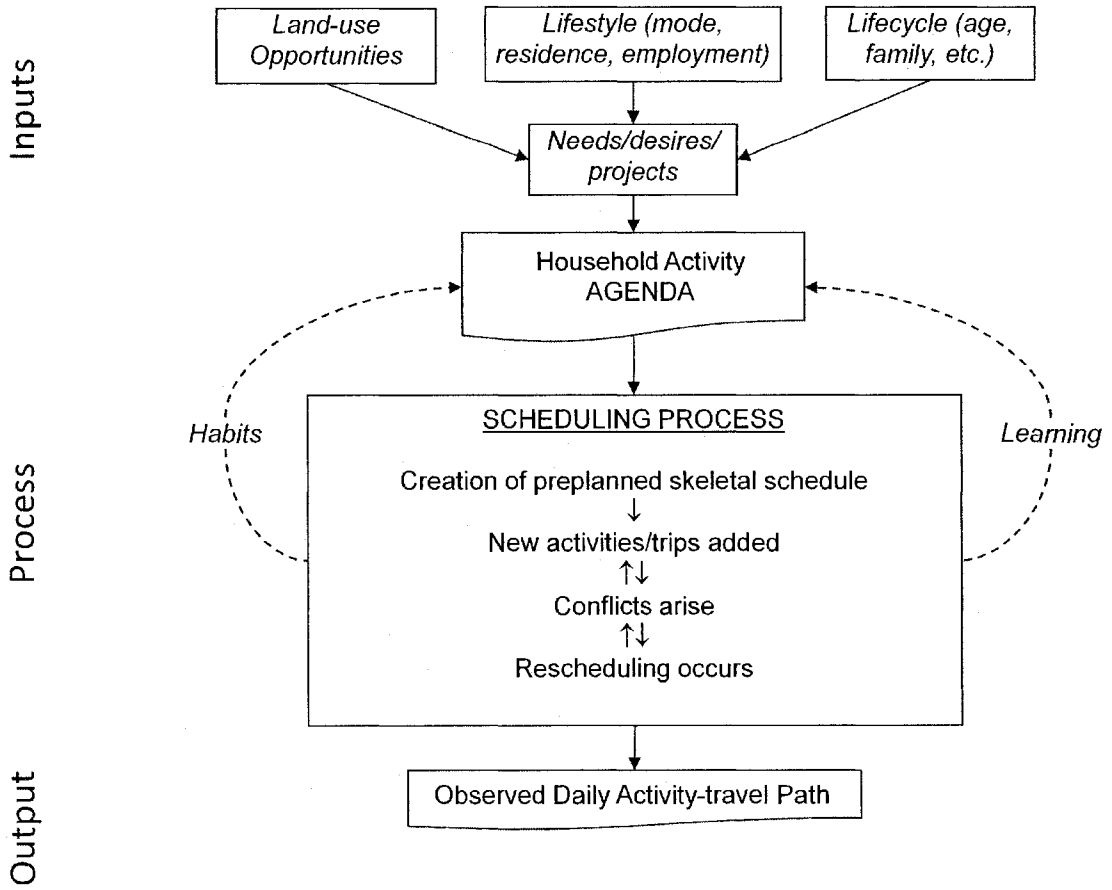
3.2. Methodology and Analysis

The new methodology can be broken down into six stages:

1) **Preplan Interview:** Collect the preplan schedule via open-ended personal interview
2) **Coding of the Preplan Schedule:** Code results of above in the form of a table (researcher only, to support stage 5)
3) **GPS Tracking:** Passively track subjects using GPS while monitored by researcher
4) **Internet-Based Prompted Recall Diary (IBPRD):** Subjects completed this with assistance from researcher
5) **Comparison of Planned vs. Executed Schedules:** goal is for the researcher to identify rescheduling scenarios (without self-reporting) as a basis for discussion.

6) **In-depth Rescheduling Interview**: In-depth interview to further explore the how and why of rescheduling scenarios identified above.

Figure 6: Updated theoretical framework for scheduling decision process, based on Doherty (2002)



The remainder of this paper describes and critiques each of these stages with more in-depth discussion and illustrative examples drawn from a pilot study of forty individuals from Waterloo, Canada who completed the survey in early 2007. Subjects were recruited via advertisements and word-of-mouth from several major employers in the region. To entice people to participate a $20 gift certificate to a local restaurant chain was provided. The small sample is reasonably representative of the overall population. Ages ranged

from 19 to 63 with an average of 41, 65% working full-time earning an average of $37,000 (CAD) per year, 20% of the sample were married with children (ranging in age from infants to college students), 35% were single, and the rest were couples without children. These statistics were not significantly different from the overall Ontario population statistics from Statistics Canada.

3.3. Stage 1: Preplan Interview

A preplanned schedule can be viewed as a set of activities and trips that have been planned for a future time period, typically with one or more of the start/end time, location, involved persons and other attributes at least tentatively decided. Past methods for capturing preplans include using computer programs (Doherty and Miller, 2000, Lee and McNally, 2001, Rindsfüser et al., 2003) and paper and pen (Lee-Gosselin, 2005, Roorda et al., 2007). One specific challenge of these methods concerns how to effectively capture partially elaborated aspects of preplanned activities/trips as well as their flexibility. As discussed in a previous paper (Clark and Doherty, 2008), many individuals do not plan all of the attributes of the activities at the same time or to the same degree of certainty/fixity. For instance, an individual may know that they are going grocery shopping in the following evening but are uncertain as to where they are going or with whom they are going with.

The current method attempts to overcome these issues by adopting a combined verbal and hand-written record of the preplanned schedule in the words/writings of the subject. Basically, subjects were given a *blank* piece of paper and asked to:

> "*Write down your schedule for the next two days in as much or little detail as you know*".

The subjects were encouraged to voice their thoughts as much as possible, analogous to a "think aloud" verbal protocol (Chen et al., 2004) to allow the decision processes to be explored in more depth, and so that subjects did not have to write every aspect of their voiced schedule down on paper. The subsequent vocal recording allowed for later playback and transcription. Subjects were also reminded that they could leave unplanned times of day or unplanned attributes of activities blank.

Following these instructions, subjects were left uninterrupted to describe their preplanned schedule. Immediately following this, and based on careful observation, the interviewer would then probe subjects to ensure that all important preplanned activity attributes were discussed, including start time, end time, location, activity type, and involved persons. The interviewer was especially careful to allow subjects to voice partial elaboration of these attributes in the subjects own words (e.g. "I'm not sure of the start time, but probably after dinner"). Once a complete list of preplanned activities and attributes were obtained, the interviewer was systematically probed for the relative flexibility of each attribute for each activity, if not previously mentioned. The questions asked to establish flexibility are based on Cullen and Godson's early principles (1975), including:

- For activity type: *Could you have done anything else at the time?*
- For timing: *Could you have done this at a different time?*
- For location: *Could you have done this elsewhere?*
- For involved persons: *Could you have done this with anyone else?*

If any question was answered positively, then a follow-up question was asked to establish the degree of flexibility, which was worded "*What are the other*

<locations/times/people> that you consider?". From these questions, the subjects were able to voice or write their response in any manner that suited them.

There were three main reporting formats of preplanned schedules that were elicited from subjects: verbal only, point form, and calendar formats. An example transcript of a verbal-only schedule can be found in Figure 7a, which was used by 7 of the 40 subjects (18%). The verbal only schedules tended to have much more detail in the verbal transcription than the subjects who wrote and talked together. Figure 7b shows an example of a point form format used by 12 of the 40 subjects (30%), which tended to have bullet points with no set structure to the attributes. A calendar format was used by 21 of the 40 subjects (53%), an example of which is provided in Figure 7c. It can be described as a highly organized and structured temporal listing. Only one subject used a combined approach involving reporting of a calendar format for one day, and point form for the next. The variety of reporting formats elicited, demonstrates the versatility of this approach in capturing formats comfortable to the subject: indeed, during the interview, some subjects did not feel comfortable talking and writing at the same time, therefore they decided they would rather just talk through their schedule. Another subject did not write comfortably in English, and so opted for a verbal record only. The variety of reporting formats also suggests that use of any single one used in a study may introduce an instrument bias; but that a calendar format would likely have the least bias.

Figure 7: Preplanned schedules examples as written/verbalized by subjects a) verbal only subject; b) point form schedule c) calendar schedule

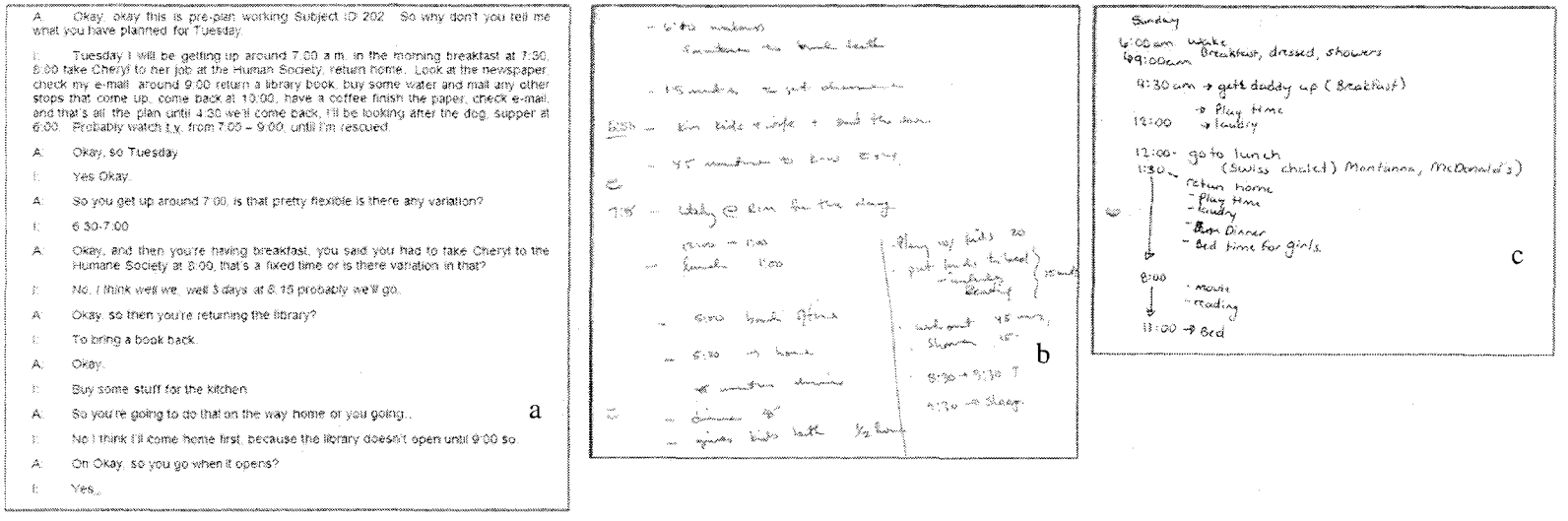


Table 1: Strategies used to describe partial elaboration of activities

Partially Elaborated Methods	Start time		End Time		Activity/Mode Choice		Location	
i. Interval	74	33.9%	44	48.4%	0	0.0%	0	0.0%
ii. Verbal	143	65.6%	43	47.3%	0	0.0%	0	0.0%
iii. Symbols	1	0.5%	4	4.4%	0	0.0%	0	0.0%
iv. General Statement	0	0.0%	0	0.0%	112	86.2%	24	47.1%
v. List of Choices	0	0.0%	0	0.0%	18	13.8%	27	52.9%

Table 2: The frequency to which different attributes are preplanned, partially elaborated or unplanned

	Start Time		End Time		Activity/Mode Type		Location		Involved Persons	
Fully Planned	453	62.7%	402	55.7%	580	80.3%	498	88.3%	236	32.7%
Partially Planned/elaborated	218	30.2%	91	12.6%	130	18.0%	51	9.0%	153	21.2%
Unplanned	51	7.1%	229	31.7%	12	1.7%	15	2.7%	333	46.1%

Frequency of partial elaboration was highest for start time (32.8%), and lowest for location (9.0%). Note also that elaboration was voiced in a variety of ways by subjects depending on the attribute, as shown in Table 1. For example, start and end times are described by subjects in three different methods: verbally (i.e. "I will start the activity sometime after dinner"), interval (i.e. "I will start the activity sometime between 3:00 and 3:30"), or symbols (i.e. Using question marks or arrows to indicate uncertainty or approximations). In terms of survey design, this suggests that a single closed ended format for responses will be problematic.

Conceptually, these results alone provide strong evidence that the planning process is not only continuous, but involves constant further elaboration of attributes. Whilst the distributions in Table 2 are of interest on their own, methodologically, their high percentage, and variation in how they are voiced, verifies their significance for capture and the varied ways in which this could be done. It also explains why it can be so problematic for subjects to respond to generic questions of "When was this activity planned" (for example, as an attribute on a traditional activity-travel diary), since in the vast majority of cases, one or more key attributes will be only partially elaborated or even unplanned, forcing subjects to generalize, misinterpret, or provide erroneous responses.

The weaknesses of this method for collecting preplan schedules concerned the collection of certain types of attributes. The involved persons attribute was a difficult attribute to collect because of the additional invasion of privacy that some people feel. For example, when one subject was asked who they were planning on eating with they said that they did not want to tell. For some reason 10% of the subjects felt that the involved persons attribute is more information than needed for the study. The other

attribute collection problem was with duration, which was not included in the study. After completing the study the duration of activities seems to have been an important attribute that was left out. Certain activities may have flexible start and end times but the duration is static. Despite not asking direct questions regarding duration, many of the subjects still did indicate the duration and the flexibility of the duration without prompting to allow the attribute to be at least considered in the analysis.

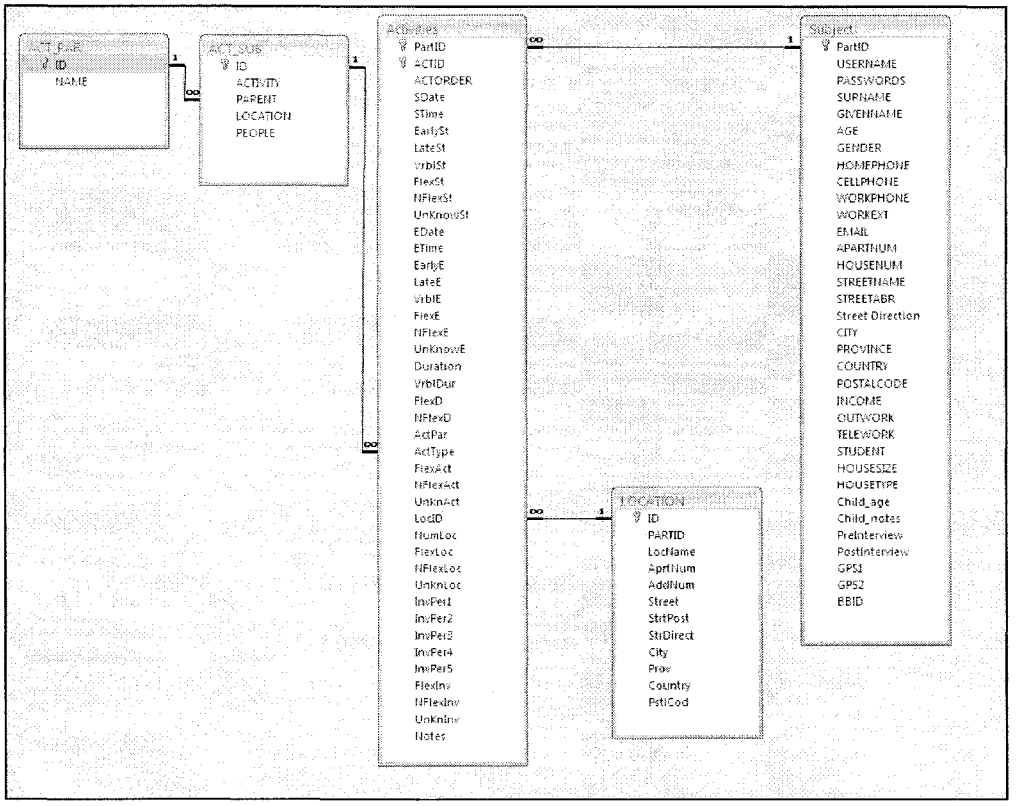
3.4. Stage 2: Coding of the Preplanned Schedule

In preparation for the comparisons and discussion to be conducted in stage 5 and 6 (i.e., of preplanned schedule to actual executed schedule), the various preplanned schedules needed to be coded in a more systematic (list) format. The most logical way to do so was to create a database of preplanned events as records along with all the various attributes as fields. Microsoft Access was chosen primarily because of the easy ability to customize forms for data entry. Given the wide variety of ways to specify attributes, especially their partial elaboration, this was not a straightforward task, and deserves some attention here.

Figure 8 shows the different tables and their relationships and how the fields were designed. The ACTIVITIES table is the one used to input all of the preplan schedule data and the complexity of the table can be seen in the figure. Using an open-ended method for collecting data does not allow for easy storage because there is no common input for each attribute. As a result extensive fields needed to be created for each attribute to allow all possible descriptions to be input. For example, start time has eight

different fields to allow for different types of input. Start time can be voiced using a definite time, an interval, or a verbal description of time such as "After Dinner".

Figure 8: Relational database used to input preplanned schedule showing the fields for tables



After the database was created, the forms were then developed to assist in data entry. Not only do the forms make data entry easier they also allow for data quality rules to be created to restrict data entry to valid values. As seen in Figure 9, there are multiple input boxes for each attribute and check boxes to indicate if any flexibility exists. By allowing multiple types of wording to be placed in the database the later analysis can be done more accurately without having to return to the transcription of the verbal or written schedule. An example of the database is in Figure 10 where a subject's start and end time are entered into the table.

Figure 9: Input forms from MS Access to import preplanned schedules

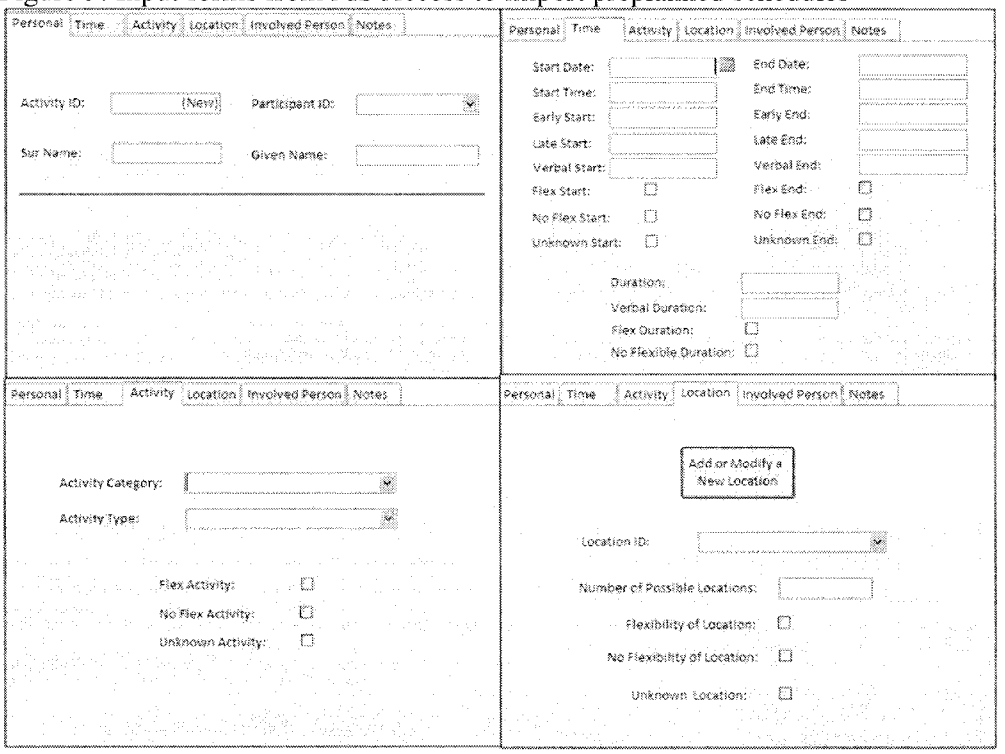
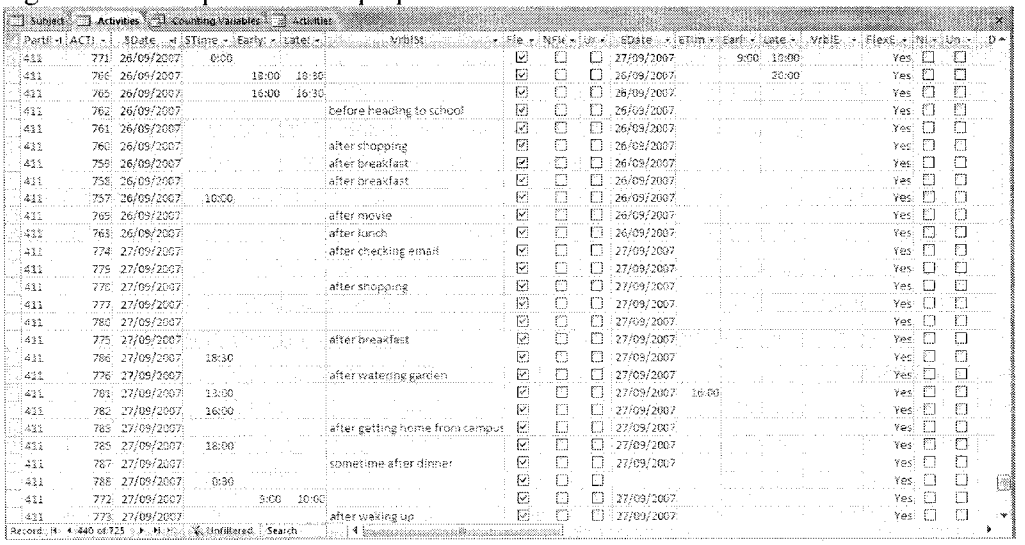


Figure 10: Example of coded preplanned schedules within table view of MS Access



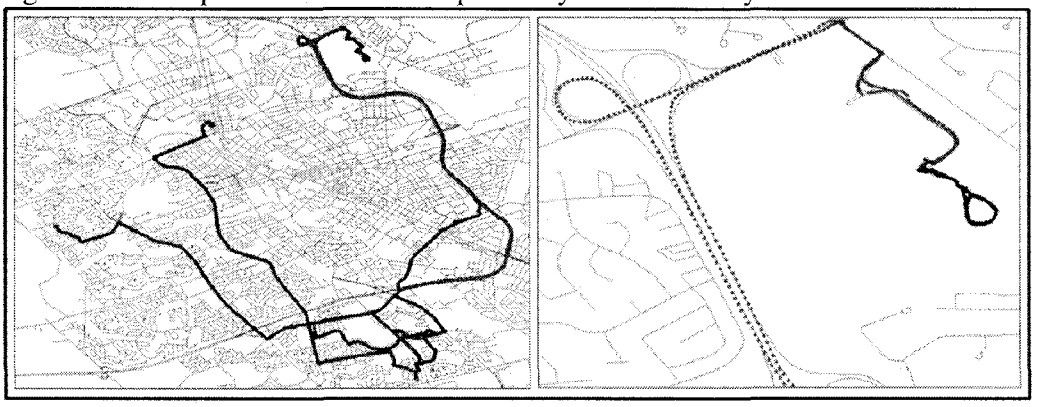
3.5. Stage 3: GPS Tracking

Following stage 1, the goal was to elicit a two-day activity-travel diary from subjects representing their executed schedule. In an attempt to increase accuracy and reduce respondent burden, a GPS tracking system and subsequent prompted recall diary were utilized. For this study, subjects were provided with a RIM Blackberry 7520 and a Bluetooth GlobalSat GPS receiver (SiRF Star III chip). The Blackberry was programmed to log second-by-second NMEA sentence that included latitude/longitude coordinates, time, speed, and signal quality variables. The on-board program then compressed and wirelessly sent the data at regular intervals via a Blackberry Enterprise Server (BES) to a remote server for storage and analysis – in particular, to be utilized in the prompted recall dairy.

Subjects were asked to carry both devices at all times whilst out of home, and to charge them over night using provided cables. They were given the option to clip the two devices onto a belt or similar (using provided cases), or to carry them within a purse. The only other responsibility of the subjects was to look at the Blackberry screen only if it starts to vibrate. This occurred only if the on-board program detected a problem with the GPS receiver, such as low power or accidental shut-off. An on-screen message would instruct them to restart the GPS receiver, or to opt to place a phone call to research staff (they need only press a single button to do this; the phone # and the call was placed automatically). Note that using the BES server allowed both the status of the Blackberry and the GPS receiver to be remotely monitored by the research team to detect specific equipment problems (e.g., no GPS signal for > 10 minutes, low battery, program freezes). Automated messages to research staff would be sent out in such cases, and research staff

could "push" commands to the device in an attempt to solve the problem (e.g., restart the Blackberry and/or logging program). These features are very much unique to the Blackberry, and increased the data capture rates to over 80%. Figure 11 gives an example of the GPS tracked data coordinates overlaid on the road network. As with most modern GPS devices, the accuracy of the data in relation to the road network is very high. Outside of the days of complete equipment malfunction, the BlackBerry-GPS was successful in capturing at least 10+ hours of continuous data from subjects (but could reach a maximum of 17 hours depending on network power consumption). The only substantive weakness of the BlackBerry-GPS tracking was the percentage of cases (less than 10%) that the GPS and BlackBerry completely malfunctioned for a full day as a result of hardware problems. As a result, the subjects were asked to record the activities on a piece of paper to allow for easier recall during the final interview.

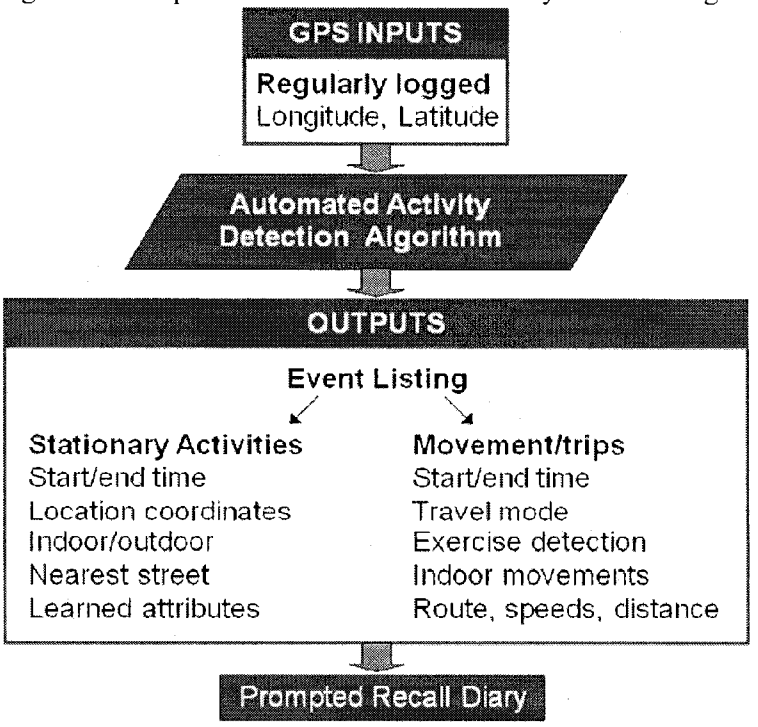
Figure 11: Example of GPS data as captured by the Blackberry and GPS devices



3.6. Stage 4: Internet-Based Prompted Recall Diary (IBPRD)

The wireless transmission of personal GPS data to a central server allowed for timely processing of the data to automatically predict the subjects' executed daily activities and trips. As shown in Figure 18, an algorithm takes the GPS point location as inputs and outputs a wide range of activity and trip attributes. These outputs are then displayed back to subjects via an internet-based prompted recall diary (IBPRD) as shown in Figure 12 (see also Doherty et al., 2006). Unlike traditional diaries or scheduling interfaces, the IBPRD provides an initial automated determination of event types (activity or trip), activity type, travel modes, locations and start/end times in a compact interface (see Figure 13a). There are four columns in the IBPRD corresponding to activity attributes: start/end time, event type (activity/trip, followed by multi-level sub-categories), location (via interactive map), and involved persons.

Figure 12: Outputs from an automated activity detection algorithm

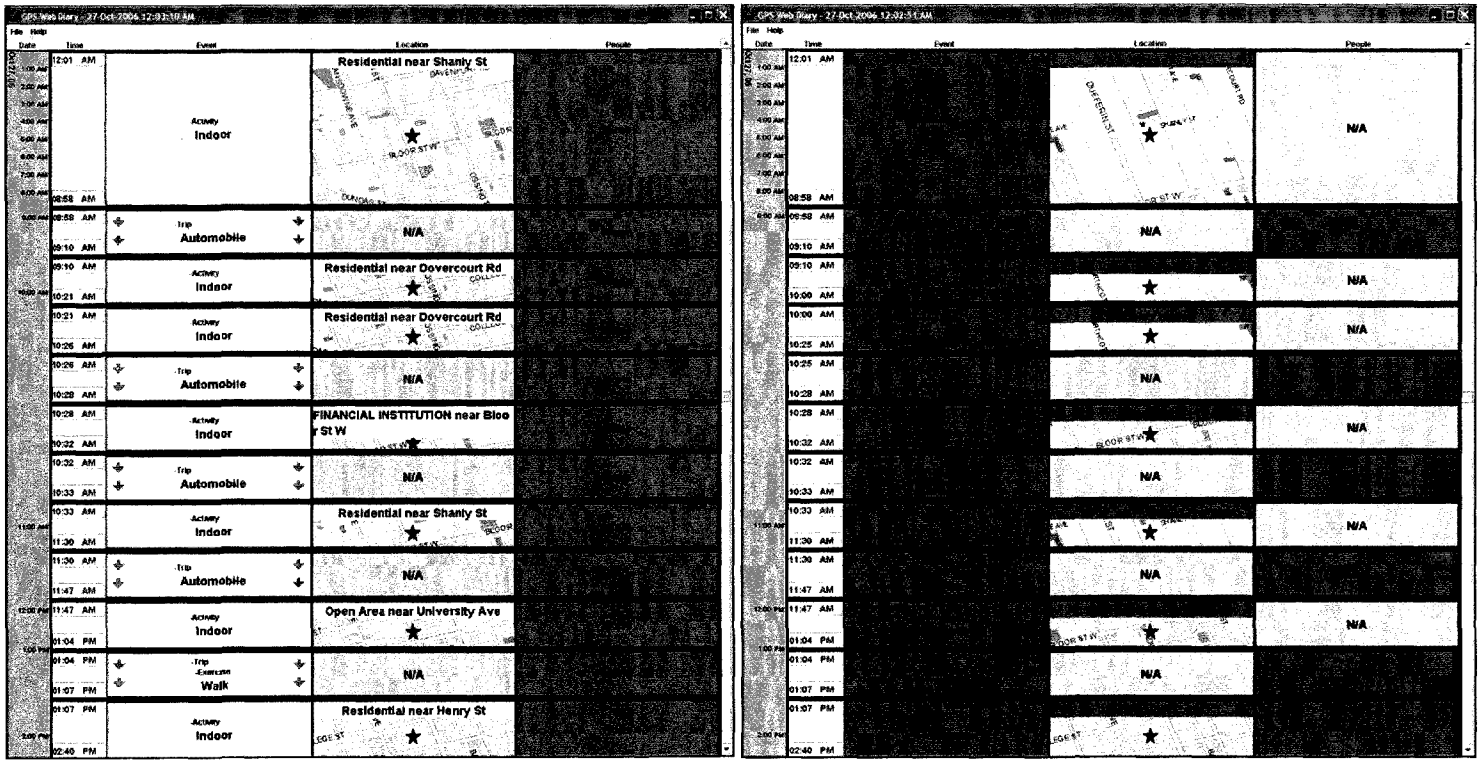


Cognitively, it is well known that people have difficulties recalling start/end times accurately, and in specifying locations accurately (e.g. addresses). A GPS supported recall interface goes a long way towards solving this problem, and reducing respondent burden in the process. However, because GPS cannot provide all the diary details required for this study, and because verification of the accuracy of automatically detected events was desired, a manual review of the diary and prompting for refined/additional attributes was conducted.

The procedure for interaction with the IBPRD was for subjects to sit with an interviewer and review the schedule event by event, updating and adding information as needed. This included especially, more specific event types, location names, and involved persons. Colour was used to remind the subject that editing and/or confirmation still needs to be done (as shown in Figure 13a), wherein yellow entries/boxes require confirmation and possible updating, red require new entries, and green signifies the entry is complete. The result is a complete daily activity-travel diary as shown in Figure 13b.

Overall, an average of 21.8 activities, and 13.1 trips were collected from subjects for two days. On average, this required 14 minutes. The biggest strength of the algorithm and the IBPRD is the ability of a subject to enter all of their activities into the schedule without having to write them down in a diary. By a researcher doing the data entry the only thing the subject is responsible for is ensure that the data is correct. A major weakness to using the IBPRD was the occasional inaccuracies in the algorithm, which occurred due to erroneous data or incorrectly identified short stops. Algorithm errors ranged from no errors to five errors per day usually pertaining to incorrect identification of short stops along trips that were really just traffic delays.

Figure 13: Internet Based Prompted Recall Diary a) after algorithm is run and prior to prompted recall with subjects; b) after prompted recall



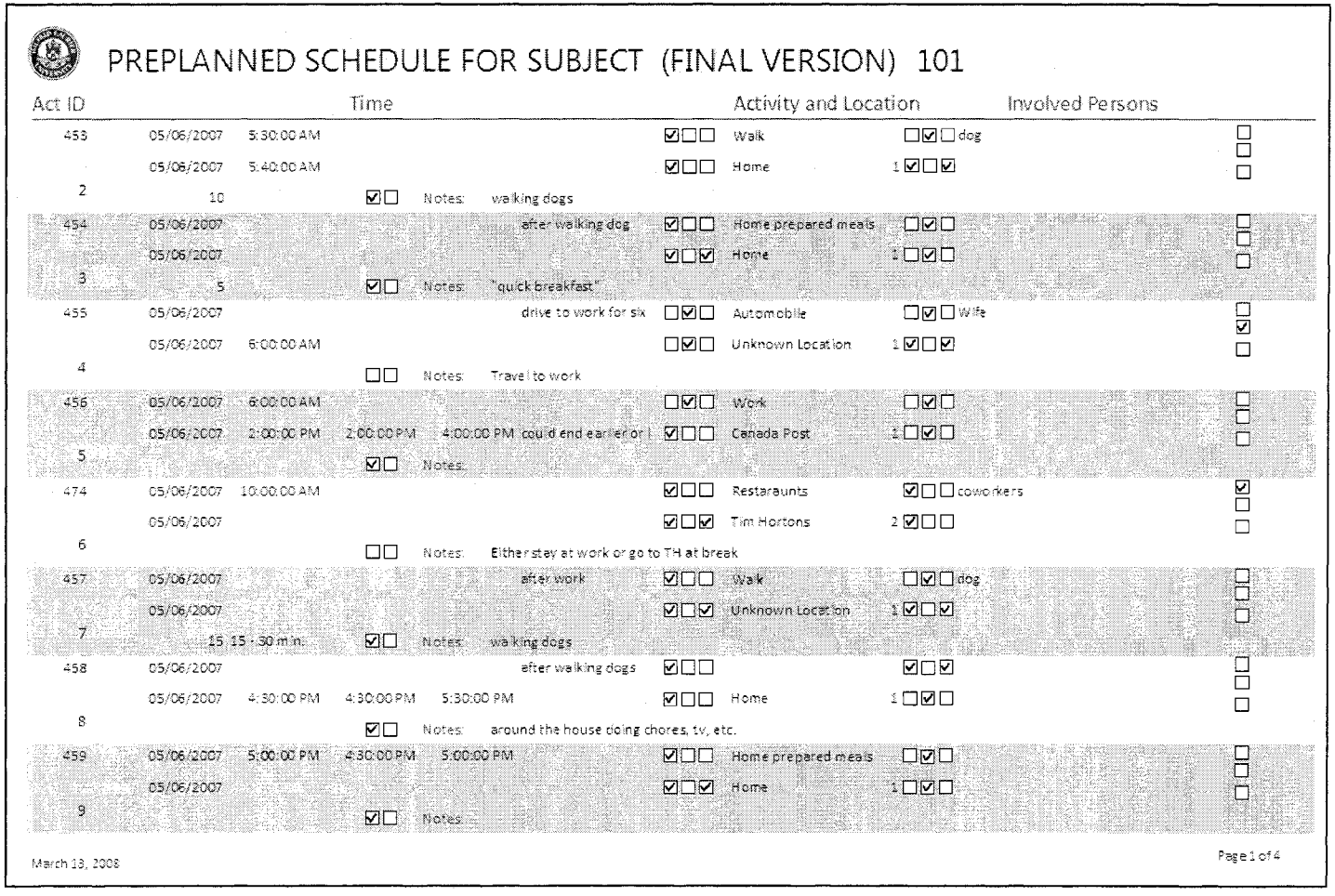
Note: Red - Attribute requires manual entry; Yellow - Attribute can be updated with more detail; Green – attribute complete

3.7. Stage 5: Comparison of Planned vs. Executed Schedules

The next step in the data collection was for the *researcher* to compare the planned schedule to the GPS-tracked executed schedule to detect major changes between the two that are indicative of rescheduling changes and subsequent (more impulsive) planning – rather than rely on subjects to self-report the same. In this sense, rescheduling decisions were automatically tracked using GPS without requiring self reporting – a unique aspect of this method beyond previous techniques that likely reduces respondent burden and increases validity. However, such an approach has obvious limits with respect to tracking certain attribute changes (e.g., involved persons), and in tracking multiple rescheduling decisions and explanatory factors that may have preceded a final change in outcome. For this reason, an in-depth interview was conducted to more fully explore the automatically detected rescheduling decision scenarios.

The procedure for detecting rescheduling changes involved visual comparison of two key documents: the preplanned schedule from Stage 1 (example Figure 14) and the executed schedule from stage 3 in simple table format (example Figure 15). The interviewer carefully compares the two schedules in order to identify additions, deletions, and modifications made from preplanning to execution of the schedule. This included timing changes (minimum of 15 minute change), location changes, activity type changes, addition of new activities, deletion of activities, mode changes for trips, and changes to involved persons. When a change has been found, the cells in the table are colour coded to highlight them for eventual discussion with subjects: modifications in blue, additions in green, and deletions in red. An example of detected changes can be seen by the colour coding shown in Figure 15.

Figure 14: Example of report created by MS Access to display preplanned schedule



PREPLANNED SCHEDULE FOR SUBJECT (FINAL VERSION) 101

Act ID		Time				Activity and Location	Involved Persons
453	05/06/2007	5:30:00 AM				Walk	dog
	05/06/2007	5:40:00 AM				Home	1
2	10			Notes:	walking dogs		
454	05/06/2007				after walking dog	Home prepared meals	
	05/06/2007					Home	1
3	5			Notes:	"quick breakfast"		
455	05/06/2007				drive to work for six	Automobile	Wife
	05/06/2007	6:00:00 AM				Unknown Location	1
4				Notes:	Travel to work		
456	05/06/2007	6:00:00 AM				Work	
	05/06/2007	2:00:00 PM	2:00:00 PM	4:00:00 PM	could end earlier or l	Canada Post	1
5				Notes:			
474	05/06/2007	10:00:00 AM				Restaraunts	coworkers
	05/06/2007					Tim Hortons	2
6				Notes:	Either stay at work or go to TH at break		
457	05/06/2007				after work	Walk	dog
	05/06/2007					Unknown Location	1
7	15	15 - 30 min.		Notes:	walking dogs		
458	05/06/2007				after walking dogs		
	05/06/2007	4:30:00 PM	4:30:00 PM	5:30:00 PM		Home	1
8				Notes:	around the house doing chores, tv, etc.		
459	05/06/2007	5:00:00 PM	4:30:00 PM	5:00:00 PM		Home prepared meals	
	05/06/2007					Home	1
9				Notes:			

March 18, 2008

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Figure 15: Example of executed activities as entered into the IBPRD

	Start Time	Start Date	End Time	End Date	Main Event	Sub Event	Location	Person1	Relationship1	Person2	Relationship2
2	Day 1										
3	9:45 AM	07/07/2007	10:46 AM	07/07/2007	Activity	Recreation->Surfing Net	Home				
4	10:46 AM	07/07/2007	12:30 PM	07/07/2007	Activity	Entertainment->TV Programs	Home				
5	12:30 PM	07/07/2007	1:15 PM	07/07/2007	Activity	Basic Needs->Wash/dress/pack	Home				
6	1:15 PM	07/07/2007	3:30 PM	07/07/2007	Activity	Household obligations->Cleaning/maintenance	Home				
7	Why did rebecca not come over?										
8	3:30 PM	07/07/2007	4:45 PM	07/07/2007	Activity	Social->Hosting visitors	Home	Klaudia	Friend		
9	4:45 PM	07/07/2007	4:54 PM	07/07/2007	Trip	Automobile		Klaudia	Friend		
10	4:54 PM	07/07/2007	5:27 PM	07/07/2007	Activity	Normal Shopping->Major Groceries (10+ Items)	Great Canadian Superstore	Klaudia	Friend		
11	5:27 PM	07/07/2007	5:32 PM	07/07/2007	Trip	Automobile		Klaudia	Friend		
12	5:32 PM	07/07/2007	5:45 PM	07/07/2007	Activity	Normal Shopping->Minor Groceries (<10 Items)	Price Chopper	Klaudia	Friend		
13	5:45 PM	07/07/2007	5:46 PM	07/07/2007	Trip	Automobile		Klaudia	Friend		
14	5:46 PM	07/07/2007	6:45 PM	07/07/2007	Activity	Social->Hosting visitors	Home	Klaudia	Friend		
15	6:45 PM	07/07/2007	7:00 PM	07/07/2007	Activity	Basic Needs->Home prepared meals	Home	Klaudia	Friend		
16	7:00 PM	07/07/2007	7:37 PM	07/07/2007	Activity	Basic Needs->Home prepared meals	Home	Father	Relative	Klaudia	Friend
17	Why no church??										
18	7:37 PM	07/07/2007	9:57 PM	07/07/2007	Activity	Entertainment->TV Programs	Home	Klaudia	Friend		
19	9:57 PM	07/07/2007	11:00 PM	07/07/2007	Activity	Recreation->Surfing Net	Home				
20	11:00 PM	07/07/2007	11:17 PM	07/07/2007	Activity	Basic Needs->Wash/dress/pack	Home				
21	11:17 PM	07/07/2007	9:30 AM	08/07/2007	Activity	Basic Needs->Night sleep	Home				
22											
23	Day 2										
24	9:30 AM	08/07/2007	10:15 AM	08/07/2007	Activity	Recreation->Surfing Net	Home				
25	10:15 AM	08/07/2007	10:45 AM	08/07/2007	Activity	Basic Needs->Wash/dress/pack	Home				
26	10:45 AM	08/07/2007	11:00 AM	08/07/2007	Activity	Recreation->Surfing Net	Home				
27	11:00 AM	08/07/2007	11:14 AM	08/07/2007	Trip	Automobile		Father	Relative		
28	11:14 AM	08/07/2007	11:43 AM	08/07/2007	Activity	Social->Religious events	St. Anne's	Father	Relative		
29	Why no Tim Horton's??										
30	Did you do Planner stuff at all?										
31	11:43 AM	08/07/2007	11:48 AM	08/07/2007	Trip	Automobile		Father	Relative		

The methodology presented in this paper has discovered an overall average of 16.4 changes per person per day, including 10.8 additions (65.9%), 1.6 deletions (9.7%), and 4.0 modifications (24.4%). The majority of these changes were modifications of time and duration, but a small subset of the changes made where modifications of other attributes such as location, involved persons, and activity type. These modifications will be analyzed in a future paper. The number of modifications was more than double the results reported by past methods such as CHASE, which elicited an average of only 2 modifications and 1 deletion per day (Roorda and Miller, 2005, Doherty and Miller, 2000). This provides strong evidence that the combination of preplanning and GPS tracking has considerable potential in tracking not only observed behavioural patterns, but underlying activity scheduling decisions. The variety of attribute modifications also suggests that time is not the only factor causing conflicts.

Several lessons were learned as a result of this experiment. Anytime a manual comparison is made there is always a chance of missing an important modification. Taking a systematic approach to the comparison will help in minimizing the chance of a mistake. To minimize mistakes a two-step approach is undertaken where first the executed activities are compared to the preplanned activities and then the preplanned activities are compared to the executed activities. By going through the comparison twice in two different directions there is a much smaller chance of a mistake being made. After minimizing mistakes in the comparison, all major changes seem to have been highlighted. Each highlighted change is to be addressed by the subject during the final interview.

3.8. Stage 6: In-depth Rescheduling Interview

The ultimate step of this new methodology is a post-study interview in which the subjects are engaged in an in-depth discussion concerning not only *what* changed, but the *how* and *why* of their rescheduling decisions – attributes rarely explored in past studies. The procedure for doing this consisted of a set of questions for each type of rescheduling change that had been detected as a result of Stage 4, including:

1) *When did you decide to add/delete/modify the activity?*
2) *What caused you to add/delete/modify the activity?*
3) *What process did you go through to add/delete/modify the activity?*
4) *Did the addition/deletion/modification change the remainder of the two days?*

These questions were intended to elicit more detail about a subject's decision process associated with an automatically tracked rescheduling change. Table 1Table 3 shows some example responses given to each of the above questions.

A more complete qualitative analysis of these results is shown in Chapter 5. Methodologically, there are several key strengths that should be highlighted. Past methods have not fully dealt with an event or conflict that impacts multiple activities, and in establishing which those activities are. This has largely left modellers to make assumptions about activities involved in a more mechanical approach, as for example, shown in Figure 3. The strength of the methodology is that it establishes the chain reaction occurring as a result of a single conflict on a schedule. A second methodological strength is the ability of a subject to explain the reasoning behind an alteration of a schedule, and whether it was a result of their own scheduling pressure, other people, external factors, or some other reason. Again, this allows the conflict scenarios to be more fully elaborated, rather than limited to an assumed set (for example, between

Table 3: Example responses given by subjects when asked about rescheduling decisions

When did you decide to add/delete/modify the activity?	*What caused you to add/delete/modify the activity?*	*What process did you go through to add/delete/modify the activity?*	*Did the addition/ deletion/modification change the remainder of the two days?*
Question: Okay so then you went to work you never you said you are going to get a ride with a friend to and from work. When did you decide you aren't going to get a ride. **Answer:** Well before I phoned her to see if I could get a ride with her and she said she had a seven o'clock shift, which is an hour earlier start than me. So I just decided to take my car.	**Question:** What caused you to come back to work at 11:53. **Answer:** Actually in the morning when we were about to head out Scott had realized that we had a tax board meeting which starts at 12:00 and runs until about 1:00 and we said...well I mean we signed up for it and RIM isn't too far away so we'll come back for that.	**Question:** How did you go about making this decision with him to go meet him there? **Answer:** I called him the morning of.	**Question:** Did that change the rest of your day at all? **Answer:** Not the rest of my day. I was more worried about getting to work on time, but I made it on time, so then everything was okay.
Question: When did you make this decision to go to Williams. **Answer:** Around 4:15 they told me they were going out, so they invited me along.	**Answer:** Okay. So you ended up going to work as you planned. You were a little late getting there. You said you started at 1:00. Any reason for this? **Question:** Yes, I decided to get a ride with my mom. So we had to go by her time table.	**Question:** Can you explain the process you went through when you realized you wouldn't be going to get the car fixed? **Answer:** Oh well we weren't going to get the car repaired after I phoned the dealership and the tire can't be found except in Saskatoon. I decided to order this other tire and I will be going tomorrow when I get the oil changed and car washed.	**Question:** Did that change what you were planning the rest of your day at all? **Answer:** Just that I had to work at that, I might have covered that fifteen minutes or so I had to squeeze in. It really didn't change it significantly.

activities on a single persons schedule resulting from internal scheduling pressure only). Lastly, this method allows conflict resolution strategies and rules to be explored and identified, allowing a more critical examination of modelling approaches (decisions trees, discrete choice, hazard models, etc.).

3.9. Conclusions and Discussion

This chapter has outlined a multi-stage data collection method targeting the preplanning and rescheduling decision process, utilizing a combination of manual, open-ended, computerized, and passive tracking survey technologies. Results from a pilot test with 40 subjects were used to illustrate each stage, discuss and critique the various components, and assess the quality and quantity of data to result. Four key methodological discoveries discussed throughout this paper can be summarized as follows:

- Preplanned activity scheduling surveys should pay careful attention to the interface/report-format, as it was discovered in this paper that subjects prefer a variety of mediums including point form, calendar, and verbal only. If only one approach is desired, a calendar format would appear to be the most popular (and hence, involve least instrument bias)
- The significant proportion of non- or partially-elaborated attributes of planned activities discovered in this paper (ranging from 1/10 locations, 1/3 start times, almost ½ end times, and 2/3 involved persons) suggests that much care is needed in designing planning time horizon survey questions to avoid forcing subjects to generalize, misinterpret, or provide erroneous responses. Our suggestions is that a separate question for each attribute of interest be formulated (as "When was the <attribute> planned", rather than the generic "When was this activity planned").
- The variety of ways people expressed the partial elaboration of activity attributes discovered in this paper (statements, intervals, or specific

values) also has clear implications for future survey design – for example, subjects were not always able to quantify specifically the limits of partial elaboration (such as "I'm planning to start the activity between 5 and 7 pm"), and instead provided more qualitative responses (such as, I'm planning the activity sometime after dinner). This suggests that varied response categories/approaches are needed to capture such variables.

- The method of comparing preplanned schedules to GPS-tracked executed schedules led to the discovery of an automated/passive means to detect rescheduling decisions (start/end time, locations changes, and more impulsive additions), and led to discovery of twice as many modifications as that elicited from past methods. This method also addressed the shortcoming of past techniques by reducing respondent burden (an average of 7 minutes per diary day) and providing a means to validate self-reports. Perhaps more valuable was the opportunity this provided to pose these automatically detected rescheduling changes back to subjects as a form of memory-jogger and framework for more thorough discussion on the when, how and why of the rescheduling process.

Overall, the new methodology can contribute to the development of more accurate and valid models of the entire scheduling process, especially rescheduling and conflict resolution sub-models. Although this paper focuses on survey methodological results, some of the empirical results shed light on the nature of the scheduling process. In particular, the results clearly demonstrate that the scheduling process is not only continuous, but involves constant further elaboration of attributes, a higher number of modifications than typically reported in past methods, and a wide variety of reasons why conflicts arise that reflect more than just an attempt to maximize the number of activities fit into a day (a key assumption of past conflict resolution models). Location conflicts, involved persons conflicts, and personal choices are all potential causes of conflict, which have not been discussed previously in the literature.

The pilot test of this method also revealed several challenges and areas of potential improvement. Capturing preplanned schedules in an interview requires a skilled interviewer capable of ensuring that all attributes are discussed in a viable way; despite best efforts, certain attributes were missed or overlooked in this study. The GPS tracking system, algorithm, and the IBPRD all worked together to allow the subjects' actual schedules to be accurately predicted with a reasonable respondent burden (average 14 minutes for two day diary, or 7 minutes per day). However, the hardware and prediction algorithm had occasional flaws that should be focus of continued improvement to ensure less need for respondent interaction and transferability to other settings and cultures.

CHAPTER 4: Preplanned Schedules

Authors Note:

This chapter is reproduced from a paper titled *"Examining the Nature and Extent of the Activity-travel Preplanning Decision Process"* in press for the Transportation Research Record. An earlier draft of this paper was presented at the 87th Annual Meeting of the Transportation Research Board in Washington, D.C., January 2008. Copyright for this latter paper is held by the authors. Co-author and thesis supervisor Dr. Sean Doherty has provided his permission to reproduce this paper in this thesis. The paper has been modified to minimize redundancies and to improve overall flow and continuity.

4.1. Introduction

Over the last decade activity/travel rescheduling has become a key focus of travel behaviour and decision-making research. Rescheduling is viewed as a key behavioural mechanism whereby individuals adapt their activities/travel in response to emerging policy changes and trends including demand management and information and communication technologies. Rescheduling often involves a variety decisions made over time, space and across individuals affecting the timing, location, and interpersonal nature of observed human activities and travel.

A more complete understanding of rescheduling behaviour requires that such decisions be conceptualized as part of a more comprehensive activity/travel scheduling process. An overall framework for this process is shown in Figure 12, based strongly on time-geographic roots of Hägerstrand (Hägerstrand, 1970), Cullen and Godson (Cullen and Godson, 1975), and Root and Recker (Root and Recker, 1983) among others. The scheduling process is viewed as having several interconnected main components: a household activity agenda, a dynamic scheduling process starting with preplanning of selected activities from the agenda and followed by a continuous planning and rescheduling over time, and ending with the final execution of the schedule in the form of observed activity-travel patterns.

The agenda embodies the total choice set of activities and trips that an individual may potentially participate in along with their salient attributes, such as typical frequency, typical duration, temporal/spatial flexibility, social constraints, etc. It is important to realize that activity attributes on the agenda embody potential variability,

whereas final observed activities/travel have specifically chosen attributes (actual start/end times, locations, involved persons, etc.). This includes activities considered "routine", such as having to sleep at night or eat during the day, which despite their routine nature, will often vary in time, location, or involved persons, etc. It is easy to realize how critical agenda attributes are to preplanning and subsequent rescheduling, yet how much more difficult they are to empirically observe and document compared to final observed choices traditionally documented via activity/travel diary surveys.

From the agenda, an individual can be thought to initiate the scheduling process by starting to consciously preplan selected activities involving further decisions and elaboration on select attributes, including routine activity attributes. A key realization is that each preplanned activity may have only certain attributes planned, and even then, the attributes may be only partially elaborated upon beyond how they exist on the agenda. For example, a person may preplan a social event on a Friday evening with friends, which involves a specific decision on day, a partial decision on time ("evening"; will require subsequent elaboration), no decision on location yet, and only a partial decision on involved persons. This preplanned or "skeletal" schedule will continue to be modified and updated via further activity attribute decisions as individuals move close to engaging in actual activities, including rescheduling or abandoning of past activities/attributes and impulsive decisions. The end result is observed daily activity travel patterns.

Table 4: Comparison Table of Different Preplanning Collection Methods

Method	# of Days	Method of Preplan	What attributes are planned?	Allow description of Flexibility, if so what?	How is flexibility recorded?	Allow Partial Elaborated Activities	Details on Preplanning	Purpose of Method
CHASE Doherty and Miller	7, sequential	Computer Program	Activity, Time, Duration, Location, Mode, Participants	Yes: time, space, mode, participants	Questions are asked through popup windows when an activity is added or *modified*	No	Continuously gaining planning information	Examination of scheduling and rescheduling decisions
OPFAST Martin Lee-Gosselin	7, sequential	Paper and Pen with Fax Machine	Activity, Time, Duration, Location, Mode, Participants	Yes: time, space, mode, participants	In-depth post interview asks questions regarding flexibility	No	Planning sheet faxed to laboratory at the end of each day; 7 different planning horizons	Examination of scheduling and rescheduling decisions
TAPS Wave 3 Roorda and Miller	2, sequential	Mail-back survey with phone interview	Activity, Time, Duration, Location, Mode, Participants	Yes: time, space, mode, participants	Using colour and different line types	No	Planning done only for routine activities	For the purpose of routine activities; tracked with a GPS for accuracy
Spain Project Ruiz and Timmermans	4, non-sequential	Web based survey	Activity, Time, Location, Duration, Travel	No	N/A	Yes	Gain information on all four days the first day of the study	Movement of two preplanned activities to adjust to added activity
REACT! Lee and McNally	7, sequential	Computer Program	Not Stated	No	N/A	Yes	Continuously gaining planning information	Collect data to examine planning horizon; how far in advance are activities planned
EX-ACT Rindsfüser et al.	7, sequential	Computer Program on PDA	Activity, Time, Duration, Location, Mode, Participants	Yes: time, space, mode, participants	Using Key words	No	Continuously gaining planning information	Collect data to develop a new model of trip generation

Various components of this scheduling process have begun to be observed in recent years, using a variety of techniques that go beyond traditional activity diaries, as shown in Table 4. Common to all approaches is the capturing of preplanned activities and their attributes to varying degrees, and their final observed outcome. CHASE (Computerized Household Activity Schedule Elicitor) (Doherty et al., 2004, Doherty and Miller, 2000) provided a weekly computerized scheduling interface that required that all activity attributes (event type, day, time, location, involved persons) be specified for preplanned activities prior to placement on the schedule, although they could be later modified over the multi-day study period. At the end of the survey, participants were asked to indicate the spatial, temporal, interpersonal flexibility of executed activities via a computerized sequence of questions. For instance, for duration flexibility, subjects were asked if it varied, and if so, by how much time [see (Doherty, 2006) for details]. Building on CHASE, REACT! (Lee and McNally, 2003, Lee and McNally, 2006) provided an internet-based scheduling interface but allowed partial planning of activities by allowing time, day, location and/or involved persons to remain unplanned. On subsequent scheduling days they were reminded to update them until completed. EX-ACT (Rindsfüser et al., 2003) took a similar approach, but used a hand-held computer, allowed partially planned activities, but added prompts concerning the flexibility of activities. OPFAST (Observed and Perceived Flexibility of Activities in Space and Time) collected preplans using a pen-and-paper weekly calendar that was updated daily with new plans and sent via fax-machine to researchers, as shown in Figure 3. During a follow-up interview subjects further categorized observed activities by flexibility using colour-coded stickers. Ruiz and Timmermans (2006) developed an internet survey to

capture activities preplanned for a four day period, wherein not all of the attributes such as start time, end time, location, and activity type needed to be known. Flexibility of these attributes was not collected for the dataset. TAPS (Roorda et al., 2005, Roorda et al., 2007) inferred preplanned schedules from a sketch people drew of their "routine" activities on a calendar-style grid, as seen in Figure 16. An elaborate set of instructions were given to subjects instructing them to indicate flexibility using colour and wavy lines, focusing on time, location, and participants.

To this point, no clear consensus exists on how best to capture preplanned activities, partially elaborated activity attributes, and the related concept of flexibility – key components of the scheduling and rescheduling process. Key areas for further exploration thus include:

1) *Basic structure and extent of preplanned schedules* – continued examination of how people express/depict their preplanned events, the frequency of activity/trip planning, and related explanatory factors.
2) *The nature and extent of partially elaborated activities* – whilst several past surveys have allowed some attributes to categorized as planned/unplanned (e.g. leaving end time blank and updating later), fewer have provided an effective means to convey partial elaboration of such attributes (e.g. an end-time range), and none have allowed all attributes to be partially elaborated.
3) *Displaying preplanned schedules* – both computerized scheduling interfaces and paper-and-pencil calendar grids have been used to document preplans, but it unclear how effective these are, the biases they may introduce into the process, and how best to display partially elaborated attributes (e.g. if start/end time or day partially planned, how do you display on a timeline?).
4) *Capturing flexibility* – the validity and scope of categorical responses to flexibility is unclear, and most researchers recognize that difficulties that subjects often have interpreting and conveying such information, likely due to the circumstantial nature of flexibility. Further exploration of how to ask for flexibility, how to categorize it, and what dimensions of flexibility to focus on (temporal, spatial, interpersonal, etc.) are needed.

Figure 16: TAPS example of routine preplanned schedule (Roorda et al., 2005)

Instructions for the Routine Weekly Schedule

Your routine schedule consists of **activities and trips that you normally do every week.** Please enter all routine activities and trips on the attached schedule, following the instructions on this sheet.

You **do not** need to fill all of the time. Please **do not** enter any activities or trips that are **not** normally done every week.

Please use the pencil and markers provided to complete the following 5 steps.

STEP 1:
Begin by entering routine activities as shown below:
With the **PENCIL**, write in a description of the activity and the most frequent location. If the start or end times change from week to week by more than 15 minutes, use a wavy line.

STEP 2:
Please enter trips you normally make every week. Include the normal mode of transportation, the usual travel time and the origin and destination of travel (e.g. home to work).

STEP 3:
Some activities may be routine in time, but do not have a single routine location. With a red marker, draw for each activity either:

RED O: The activity is normally done at the same location
RED X: The location is not normally the same.

STEP 4:
Some routine activities may not always be accessed using the same mode of transport (e.g. car, TTC, GO train, walk). With a blue marker, draw for each activity either:

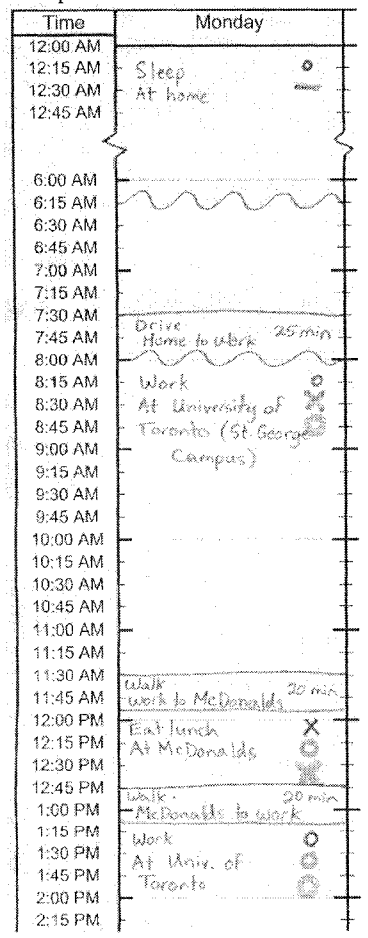
BLUE –: No transportation is required (same location as previous activity)
BLUE O: Same mode of transport is normally used to get there
BLUE X: Different modes of transport are used

STEP 5:
Some routine activities are not always done with the same people. With a green marker, draw for each activity (except for sleeping) either:

GREEN –: Activity is normally done alone
GREEN O: Activity is normally done with the same people.
GREEN X: The activity is done with different people.

When all members of your household have filled out their routine weekly schedule, please mail them back to us in the enclosed self-addressed envelope. Thanks!

Example



It would appear to be the right time to take a small step back and adopt an even more exploratory and open-ended approach to investigating these issues as a means to discovering new ways to ask such questions.

4.2. Objectives

The objective of this chapter is to present a method and the results from in-depth method for capturing the content and attributes of peoples' preplanned schedules. In particular, the focus is on preplanned daily activity and travel events, their typically observable attributes (event type, start/end time, location, involved persons), the extent to which these attributes are specified/elaborated upon and/or are flexible. Discussion on the implication of the results for survey design and the nature of preplanned schedules will also be made.

4.3. Data Collection

The data utilized for this paper are derived from the first stage of a small sample but in-depth survey of the various components of activity scheduling and rescheduling decision proccss, as conceptualized above. The survey involves three main stages:

1) An open-ended interview concerning subjects preplanned schedule for the following two days
2) A GPS-supported internet-based "Prompted Recall" diary for the same period, to capture the actual executed schedule
3) An immediate follow-up interview to explore rescheduling decisions that occurred between preplanning and execution of the schedule.

The goal of the first stage is to elicit the preplanned schedule of the subject in as open-ended fashion as possible and in the subjects own words, whilst at the same time providing enough guidance and prompts to ensure that all activity attributes (start time,

end time, activity type, location, involved persons), their level of elaboration, and their flexibility are voiced. To do so, subjects were given a *blank* piece of paper and simply asked to:

> *"Write down your schedule for the next two days in as much or little detail as you know".*

As part of this, they were told that the schedule need not be complete, and that they could voice unknown or partly planned aspects/attributes of their plans (e.g. "*I am planning on going to the grocery store sometime tomorrow but I do not know when or where.*"). During this exercise, they were asked to openly verbalize their thoughts as they wrote them down, in a think-aloud fashion which was also used by Chen et al. (2004), when examining hypothetical rescheduling decisions. A voice recorder was used during the interview in order to capture this information, as it was expecting that subjects would voice much more than they actually wrote down. Note also, that there are no direct questions regarding trips – the open-ended nature of starting question is intentionally designed to allow any type of event to emerge without undue attention to activity or trip types.

Only after the subjects finished this task did the interviewer begin to intervene to elicit further details on their preplanned schedule. In particular, the interviewer would first ensure that all attributes of preplanned activities and trips (start time, end time, activity type/mode, location, involved persons/passengers) have at least been voiced by the subject (but not required to be written down) even if they may be unknown or only partially thought-through/elaborated. To assist with this, the interviewer paid close attention not only to the written preplan, but to what was voiced during the process,

taking notes in preparation for probing questions. For unmentioned attributes, they would generally be asked "*Have you thought about <when, where, with whom> you will do this activity?*" and if so "*to what extent?*". This type of probe was often very effective in eliciting not only if the attribute was planned/unplanned but in what ways they may be partially elaborated. However, to gain even further insights into partially elaborated activity attributes and how flexible they may be, subjects were further asked questions inspired by Cullen and Godson (1975), including:

- For activity type: *Could you have done anything else at the time?*
- For timing: *Could you have done this at a different time?*
- For location: *Could you have done this elsewhere?*
- For involved persons: *Could you have done this with anyone else?*

If they answered in the negative, the attribute was then considered inflexible or fixed. If they answered in the affirmative, they were further probed concerning the degree of flexibility if not already voiced, as in "*What are the other <locations/times/people> do you consider?*". Subjects were free to convey their responses in whatever manner suited them, including simply voicing their response and/or making written notes on their preplan.

Although not analyzed in this chapter, the subsequent two stages in the survey were designed to capture the actual activity/travel schedule executed by subjects over the two days they planned for as a basis for a follow-up interview. Briefly, the second stage involved passive tracking of subjects over the next two days using a GPS-enabled Smartphone capable of continuously recording one-second geo-coordinates and transmitting them wirelessly to a central server. An automated algorithm reads the data and outputs a sequential listing of activities and trips that are displayed in the form of an

Internet-Based Prompted Recall Diary (see also Doherty et al., 2006). At the start of the follow-up interview, subjects reviewed the diary to confirm, update and add additional event attributes such as specific activity types, location names, and involved persons. This was followed by an in-depth interview regarding the changes that were made between the preplanned schedule and the executed schedule, especially rescheduling scenarios.

4.4. Recruitment and Sample

Forty individuals from Waterloo, Canada completed the survey in early 2007. Subjects were recruited via advertisements and word-of-mouth from several major employers in the region. Although the sample is small, it was reasonably representative of the overall population. Ages ranged from 19 to 63 with an average of 41, 65% worked full-time earning an average of $37000 (CAD) per year, 20% of the sample were married with children (ranging in age from infants to college students), 35% were single, and the rest were couples without children. These statistics were not significantly different from the overall Ontario population statistics from Statistics Canada.

From these subjects a total of 564 preplanned activities and 158 preplanned trips were captured over a total of 80 observation days, representing an overall average of 9.0 preplanned events per subject per day. The observation days-of-week varied: one half of the 40 subjects started on a Tuesday, with the rest starting on a Wednesday to Saturday.

4.5. Results

4.5.1. Preplanned Schedule Depiction Formats

Visual analysis of preplanned schedules revealed that subjects adopted three distinct approaches when tasked with writing out and discussing their schedule on a blank piece of paper:

1) *Verbal only*: preferred to just talk through their schedule without writing anything down, as they felt awkward writing and talking at the same time (6 of 40 subjects, or 15%). See example in Figure 7a.
2) *Point form*: a less structured listing of events and attributes (16 of 40 subjects, or 40%). See example in Figure 7b.
3) *Calendar format*: a structured sketch with activity type, time, and/or location organized into columns of varying sorts (19 of 40 subjects, or 45%). See example in Figure 7c.

All but one of the subjects in calendar format group verbalized their schedule as they sketched, thereby expressing further details on event attributes (which were coded for analysis, but don't appear on written schedule). One subject in this group opted to think aloud after the sketch because she was uncomfortable with writing and talking at the same time. One subject for whom English was their second language, asked the researcher to transcribe their schedule while they talked because they were not comfortable writing in English.

4.5.2. Types of preplanned activities and travel

The types of activities that subjects tended to preplan were fairly typical and somewhat consistent. All subjects indicated that they were planning basic-needs/subsistence activities such as sleep (wake up and bedtime), getting ready for the day (i.e. wash, dress, brushing teeth, etc), and meals. In total, these basic needs accounted for 41.5% of preplanned activities. Subjects also indicated major staple

activities that they are involved with, such as work and school, accounting for 19.5% of all preplanned activities. The remaining preplanned activities consisted of leisure/entertainment/recreation (16.5%), household obligations such as cleaning, meal preparation, & attending to children (8.3%), shopping (3.9%), socializing (3.4%), and other miscellaneous activities (1.8%). A total of 5% of the events were specified without a specifically planned activity type.

Trips were specified in subjects' preplan by the purpose of the trip and/or the mode used. Three main types of trips were mentioned: work-based trips (37.3%), non-work-based trips (32.3%) and leisurely tours (30.4%). Work-based could be further broken down into car trips (79.7%), bike trips (11.9%), and walk trips (8.5%). Non-work based trips divides into car trips (62.7%), bike trips (19.6%), walk trips (15.7%), and public transit trips (2.0%). Leisurely tours were made for their own sake could be broken down into walking tours (68.8%) and bike tours (29.2%), often involving a dog and/or other people.

4.5.3. Demographic and Day-of-week Differences

The demographics of the study group had modest to little influence on the preplanning of events (activities and trips). Differences in the average number of preplanned events per person per day were explored by gender, work/school status, and age. Gender did not have a significant effect on the number of events planned (Females averaged 9.3 preplanned activities per day; males 8.7). When comparing work and school status of the subjects there seems to be quite a variation depending on the combination of school and employment. For instance, full-time students had the most preplanned events (10.5), non-employed persons had the lowest (8.0), and fulltime

employed persons had the average number of preplanned events (9.0). In terms of age, the number of preplanned events appears to decrease with age: from 9.8 for the youngest subjects (aged 18 to 29), to 9.2 for middle aged subjects (aged 30-54), and down to 7.9 for the oldest subjects (aged 54 to 63).

The activities and trips were distributed differently depending on the day of week and the day of the study. As expected, subjects planned slightly more events for the first study day (average 9.8 events per day per subject) compared to the second day (8.3). By day of the week, subjects tended to preplan the most events on Friday (11.8 activities per subject) and the fewest for Saturday and Sunday, and an average amount on other days.

4.5.4. Preplanned Activity Attributes and their Extent

More unique to this study are the results concerning the extent/degree to which the attributes of 564 activities and 158 trips were planned. Each attribute – start time, end time, activity type, location, involved persons – are described in sequence here. The extent of planning is presented in a hierarchical format, ranging from planned with a specific single value for the attribute, to partially planned (in various sub categories), to not planned at all, as shown in Table 5.

When examining the overall frequency with which each activity attribute is planned (fully or partially) versus unplanned (see first row of Table 5), activity type, location and start time are most frequently preplanned (97.9%, 97.3%, and 93.4% respectively), whereas end times and involved persons are preplanned much less frequently (64.5% and 56.0% respectively). Thus, clearly, not all attributes are preplanned to the same extent or at the same time.

Table 5: The extent of activity and trip attribute planning

Activity Attributes

	Start Time	End Time	Activity Type	Location	Involved Persons
	Count (%)	Count (%)	Count (%)	Count (%)	Count (%)
1. Planned	**527 (93.4%)**	**364 (64.5%)**	**552 (97.9%)**	**549 (97.3%)**	**316 (56.0%)**
a. Fully Elaborated	342 (60.6%)	304 (53.9%)	440 (78.0%)	498 (88.3%)	169 (30.0%)
b. Partial Elaboration*	185 (32.8%)	52 (9.2%)	112 (19.9%)	51 (9.0%)	147 (26.0%)
i. Interval	*66 (11.7%)*	*39 (6.9%)*	*N/A*	*N/A*	*N/A*
ii. Verbal	*119 (21.1%)*	*9 (1.6%)*	*N/A*	*N/A*	*N/A*
iii. Symbols	*0 (0.0%)*	*4 (0.7%)*	*N/A*	*N/A*	*N/A*
iv. General Statement		*N/A*	*96 (17.0%)*	*16 (2.8%)*	*N/A*
v. List of Choices		*N/A*	*16 (2.8%)*	*19 (3.4%)*	*N/A*
2. Unplanned/Unstated	**37 (6.6%)**	**200 (35.5%)**	**12 (2.1%)**	**15 (2.7%)**	**248 (44.0%)**

Trip Attributes

	Start Time	End Time	Mode Choice	Involved Persons
	Count (%)	Count (%)	Count (%)	Count (%)
1. Planned	**144 (91.1%)**	**129 (81.6%)**	**158 (100.0%)**	**73 (46.2%)**
a. Fully Elaborated	111 (70.3%)	91 (57.6%)	140 (88.6%)	67 (42.4%)
b. Partial Elaboration*	33 (20.9%)	39 (24.7%)	18 (11.4%)	6 (3.8%)
i. Interval	*8 (5.1%)*	*5 (3.2%)*	*N/A*	*N/A*
ii. Verbal	*24 (15.2%)*	*34 (21.5%)*	*N/A*	*N/A*
iii. Symbols	*1 (0.6%)*	*0 (0.0%)*	*N/A*	*N/A*
iv. General Statement	*N/A*	*N/A*	*16 (10.1%)*	*N/A*
v. List of Choices	*N/A*	*N/A*	*2 (1.3%)*	*N/A*
2. Unplanned/Unstated	**14 (8.9%)**	**29 (18.4%)**	**0 (0.0%)**	**85 (53.8%)**

* See text for further explanation and description of categories.

The results uniquely allow for an even further examination of how "elaborated" or "flexible" each attribute was if preplanned. In this case, the preplanned attribute was either "fully elaborated" with a very specific stated value, or only "partially elaborated" in a variety of ways depending on the attribute. The frequency of full elaboration (second row of Table 5) shows that locations and activity types tend to be most fully elaborated (88.3% and 78% respectively), followed by start and end times (60.6% and 53.9% respectively) and involved persons (30%). Thus, not only are activity attributes preplanned to varying frequencies, the extent of elaboration (and implied flexibility) varies considerably amongst attributes.

Partial elaboration was expressed in a variety of ways, and depended on the nature of the attribute. Based on the results, an attempt was made to categorize the distinct types of partial elaboration, as shown in Table 5 (see i. to v.). With respect to start/end times, subjects tended expressed partial elaboration in three distinct ways. Time "Intervals" (i. in Table 5) refers to cases where subjects identified a specific time interval such as "*I will be starting work between 7:00 am and 8:00 am*" or "*I must work seven hours every day ... sometime between 6:00 am and 6:00 pm.*" "Verbal" (ii. In Table 5) statements of start/end times refer to other events or general time periods such as '*after lunch*', '*before breakfast*', '*in the morning*', '*in the evening*', '*during work*', '*after my husband and I are done dinner*', etc. "Symbols" (iii. In Table 5) on paper were only occasionally used, and include using question marks or arrows between activities on paper. Results suggest that intervals and generally verbal statements are both frequently used to express partial elaboration of times.

Although only rarely partially elaborated (19.9% of the time), two categories of activity types were evident: "General statements" or a "List of choices" (iv. and v. in Table 5). "General Statements" refers to cases such as '*I may do ...*', as in "*I may go grocery shopping on Friday but it all depends if I have food at home to eat*". "List of choices" refers to cases when subjects state two or more potential activity types, as in "*I am deciding between these activities*". Most common were lists of in-home activities which always included at least two of: watching TV/Movies, using the computer, reading, or cleaning. Similarly, for the very few partially elaborated locations (9%; the rest all had a very specific fixed locations), subjects most often listed two or more choices, such as a short list of restaurants where they could eat. Grocery shopping is one of the activities that most subjects are fairly habitual and non-flexible about, although some did indicate that they will shop at different locations if they were looking for specialty items or responding to advertisements.

With respect to involved persons, not only were they more rarely preplanned, but getting subjects to elaborate was often a sensitive issue, making probing difficult in many cases, and thus details were not acquired and reported here. In many cases the subjects do not know specifically who they are participating with, didn't want to state them, or listed names or a group of potential people such as "*friends*", "*family*", or "*co-workers*". Even when asked "*is there any flexibility in these people?*", subjects most often simply stated yes or no without giving any further details.

4.5.5. Preplanned Trip Attributes and their Extent

One important aspect of this study is that there were no direct questions regarding trips, only a general question regarding *what* has already been planned, allowing both

activities and trips to be elicited more naturally without going into a separate trip planning mode during the interview. A smaller number of trips (158) were preplanned compared to activities, likely reflecting their relative infrequency or because the subjects tend to focus more on planning activities without devoting much thought to trips. Trips have slightly different characteristics than activities including: start time, end time, mode, and involved persons. These differences can be seen in Table 5b.

When examining the attributes of the trips and how they are planned, some attributes are planned far more frequently than others. The mode type was always preplanned (100%), followed by start time (91.1%), end time (81.6%), and involved persons (46.2%). This is not dissimilar to similar attributes for activities, except perhaps for more preplanned trip end times.

The hierarchy of response categories for start and end time follow the same definitions as the activity attributes in the previous section. Note the high percentage of end times that are unplanned, and start/end times that are only partially elaborated. This is a result of the type of trips that are planned. Many of these activities are leisure trips (30.4%) where subjects are walking their dogs, going for a walk, or riding their bike. These types of trips are voluntary with the subject saying, "*I will take the dog for a walk sometime in the evening if I feel like it*" or "*my husband and I will go for a bike ride today*".

The preplanned travel modes are the most likely to be specified with a specific mode stated. All of the partially elaborated trip modes had to do with flexibility in mode for leisure tours, such as "*I might be going for a bike ride or walk*". Involved persons are

fairly certain for most of the trips that are planned by the subject, especially for many routine trips such as walking a dog, going on bike rides, and driving to work. In 18 cases (11.4%) the subjects were actually chauffeuring (or getting chauffeured) which tends to have little flexibility involved.

4.6. Discussion and Conclusions

4.6.1. Key Behavioural Process Findings

Allowing subjects to write out and openly verbalize their own preplan schedule provided considerable insights into the structure and nature of preplanned schedules. The main findings are that the different activity and trip attributes, such as start time, end time, location, activity type, and involved persons, are planned and elaborated in different ways and to different degrees. Attributes for trips and activities were also found to be planned at a similar rate. Subjects most often preplan the activity type/mode choice, location (for activities), then start time, end time, and finally involved persons. The one difference for trips and activities was that the end time of trips has a much greater frequency of being planned than the end time of an activity. This discrepancy is a direct result of the start time of activities being known. For example, if a subject knows when he/she must be at a location they will know when the end time of the previous trip will occur. The high frequency of event types (activity type/travel mode) being planned is as expected, as without a type the subjects do not have an event to plan around. The one exception to this is that the subjects sometimes plan free time by listing a choice set of possible activities to execute in a given time period. End times having a low frequency of planning is also as expected, since we often devote much more thought to getting places on time and tend more often to have flexibility in the end time. Naturally enough,

when one activity had a partially elaborated end time the subsequent activity would normally have a partially elaborated start time.

In terms of the ways in which subjects partially elaborated on attributes, the time attributes – start and end time –tended to have the most complex responses. In over one-half of the cases when start/end times are only partially elaborated, subjects choose verbal statements to convey their response, rather than specific time intervals that are more quantifiable. This would explain why exploration of temporal flexibility is so challenging to document, both from a question design and subjects perspective, such as is the problem in CHASE (Doherty and Miller, 2000), TAPS (Roorda et al., 2005), and OPFAST (Roorda et al., 2005). These results suggest that future surveys would allow a variety of response categories, and certainly separate questions for each attribute.

With regard to the entire scheduling decision process, the results suggests that the development of a preplan is indeed on-going process, wherein tentative decisions on many attribute are often made, then revisited at some point closer to execution. These results lend supports to the conceptual framework of the activity/travel scheduling process in Figure 12, but also provide further details on the mechanics of this process. In particular, the results suggest that certain attributes (end times, involved persons) are more likely to evolve over a longer time period, whereas others (start time, activity/mode type, and location) are planned much in advance and not likely to be elaborated upon. Results also support the contention that subjects most often plan "routine" activities (work, school, weekly sporting activities, social events, etc.) with a fixed start time and location, followed by addition or inserting of other activities with specific, partial or unknown start times and often no specific end times.

This type of decision process would seem to lend itself to potential micro-simulation, a nested choice modelling system, or at least a modelling system that first seeks to narrow choice sets down at one level, followed by a more specific choice. Alternatively, modellers could adopt a continuous planning loop, wherein the first time through the loop there will be certain decisions made and each time through the loop the activities and their attributes become more elaborated and more fixed in time and space.

4.6.2. Key Methodological Findings

Past methods of collecting preplanned scheduled data have varied, and considerable exploration is still needed at this early stage in our understanding of scheduling decisions processes. This paper has introduced a new method which has allowed individuals to write down and/or talk through their planned activities without having to conform to a given scheduling structure/display or question formats associated with past methods. As a result, more in-depth information was captured on *nature* and *extent* of planned and partially planned/elaborated activities and trips, including a detailed hierarchy of response categories.

Allowing subjects to create their own framework to record their preplanned schedule was particularly insightful. As a result, one half the subjects adopted a fairly structured written calendar-like format, whereas the other half adopted a written point-form or completely verbal format. This suggests that any structured preplanning survey, whether using paper-and-pencil or computerize approaches, will invariable evoke a biased set of responses, and that designers should opt for open-ended responses where feasible. Similarly, the wide range of partially elaborated responses suggests that a

closed-ended categorical response may not be very effective or feasible, and potentially biased.

There were also many challenges associated with this approach worth mentioning. Firstly, the trade-off common to all more open-ended verbal approaches is the subsequent more challenging coding task. In this study, a research assistant coded responses into a database based on written and verbal records; but even then, some of the coding had to be repeated owing to changes in coding structure was we proceeded. However, the intent of such in-depth surveys is not to lead to larger sample sizes, as much as it is to provide insights into new aspects of behavioural, to assist with conceptualizing larger decision process frameworks, and refine the types of questions and response categories that may be of priority in future studies. Thus, samples should be kept reasonably small in order to minimize the subsequent coding task.

A particular weakness of this study was the omission of activity/trip duration as an attribute. With some activities start and end times may be planned in a flexible way, but the duration may not be. For example, if a subject is planning on going to the gym they will state, "*I am going to gym sometime on Saturday, I don't know when but it takes one and a half hours*". To address duration more fully, the following questions could be added:

How long are you planning on participating in this activity?
How much can that amount of time vary?

Another weakness of this method is concerns the instructions given to the subjects. Firstly, they may encourage subjects to artificially go into a planning mode while they are being interviewed. Thus, instead of getting activities and trips that they had already

planned, the subjects will start making new decisions on the spot. No obvious solution to this problem is currently in site. Secondly, for some, the instructions were not specific enough to get them to start writing and voicing their preplan. In these cases, the interviewer proceeded to give an example to show the level of detail that was required for the study. The example that was given to the subjects started "For Example, I plan to wake up at 7:30 am, get ready for the day, eat breakfast, etc." Inevitably, no matter what example is chosen, it will potentially bias subsequent responses. Thirdly, the vagueness of the instructions will leave subjects with little understanding of the level of detailed desired by the researchers. They will invariably skip over certain activities or attributes, especially very routine events that they just don't think about or are thought to be meaningless. This was the main reason for the variety of subsequent prompts given to subjects following the main instructions.

The difficulty of attaining information regarding the involved persons attribute is another challenge. Many activities are private and getting people to voice them is difficult enough, much less asking with whom they will do it. Many subjects refuse to answer because of privacy concerns. As a result, the interviewer eventually started avoiding asking about involved persons for sensitive activities such as sleeping. In some cases the involved persons can be accurately guessed from the terminology that the subject uses, such as "*my husband and I watch T.V. then we go to bed*". But in other cases the involved persons attribute is completely unknown.

4.6.3. Future Directions

The insights into preplanned schedules gained from this study can be used better conceptualize the scheduling and rescheduling process, provide structural ideas for model

development, and assist with designing questions for subsequent larger scale surveys. The highest priority future task is to link the preplanning data collected for this paper to subjects actually activities and trips recorded in the on-line GPS-supported prompted recall diary. This will allow rigorous examination of subsequent scheduling and rescheduling decisions that took place after initial planning. These differences can then be discussed in-depth with the subject to discover how a subject adjusts their schedule, why they adjust the schedule the way they do, and what they must do to make a change in the schedule.

CHAPTER 5: Qualitative Analysis of Rescheduling Decisions

Authors Note:

This chapter is reproduced from a paper titled *"Activity Rescheduling Strategies and Decision Processes in Day-to-Day Life"* Submitted for presentation at the *88th Annual Meeting of the Transportation Research Board*, Washington, D.C., January 2009 and for publication in the Transportation Research Record. Copyright for this latter paper is held by the authors. Co-author and thesis supervisor Dr. Sean Doherty has provided his permission to reproduce this paper in this thesis. The paper has been modified to minimize redundancies and to improve overall flow and continuity.

5.1. Review of Dataset and Methodology

Data collected during the final interviews of this study are mostly in the form of qualitative data derived from interviews, as described in Section 3.8. The interviews took from 30 to 60 minutes per subject and were completed with 40 subjects, one of which opted out half way through the interview. Each interview dealt with the changes that were made to their schedule between the preplanned schedule described in the initial interview and the final schedule that was executed. For each rescheduling scenario a set of questions was asked to better understand the thought process, timing, cause, and ramifications of the rescheduling decisions.

5.1.1. Content Analysis Technique

In an effort to accurately establish trends and understand how individuals schedule and reschedule their daily lives, a content analysis of the qualitative data was performed using descriptive codes. Content analysis is a "system of identifying terms, phrases, or actions that appear in a document of video and then counting how many times they appear and in what context" (Cope, 2005). By using a content analysis it is possible to group answers that appear to be very diverse into generalized categories in order to have a more compact and understandable dataset. The descriptive codes are used as category labels that "reflect themes or patterns that are obvious on the surface or stated directly by subjects" (Cope, 2005).

For this study a content analysis was performed on the four questions that were asked during the post-study interview. The content analysis includes a description of the categories, distribution of categories, and example quotes. Of particular focus is the type

of decisions that were made for each category. For instance, changes that are made spontaneously can be either an added, deleted, or a modified activity. For each of these categories a cross-tabulated count and chi-square test was used to assist in identifying significant patterns in the data. The definitions that will be given for coding categories in this section and all of the subsequent sections are determined by combining the researcher's ideas and the quotes given by the subjects.

5.2. Types of Rescheduling Decisions

The first task in analyzing rescheduling decisions was to examine the various types of decisions that were made and discussed. In total, 443 rescheduling decisions were identified and discussed from the 40 subjects. There was also an additional 839 activity modifications that were identified but not discussed because they had time differences of less than 15 minutes (197 activities) or they were in-home activities that were discussed during the preplanned schedule (605 activities). Activities with a time difference less than 15 minutes were not discussed in the interview given their relatively minor nature and the likely inability of subjects to appreciate/recall such small changes. Modifications of in-home activities were not discussed in-depth for several reasons, owing to time constraints, lack of ability to automatically detect in-home activity changes, and because of the tendency for subjects to multi-task at home and thus blur the lines between activity modifications. For instance, a common statement by subjects was "When I get home I plan to watch T.V., play on the computer, maybe some video games, among other things". Such activities tend to be done sporadically throughout the evening, are multitasked, and as a result, the nature of these activities (especially start and end times) and any modifications to them are very difficult to recall and discuss.

Qualitative analysis of the 443 rescheduling decisions revealed nine distinct types of rescheduling decisions as shown in Table 6. The vast majority were adding an activity, deleting an activity, and modifying the time of an activity (start time, end time, or both). Note that modifications also include changes in the schedule when unplanned activity attributes become planned. Other changes such as modifying location, activity type, and involved persons were very rarely reported, representing only 0.03% (15 cases) of rescheduling decisions.

Table 6: Categories and frequency of rescheduling decision types

	Frequency	Percent
Add Activity	214	48.3
Delete Activity	65	14.7
Modification - Activity Type	2	.5
Modification - Duration	1	.2
Modification - End Time	38	8.6
Modification - Involved	4	.9
Modification - Location	9	2.0
Modification - Start Time	74	16.7
Modification - Time	36	8.1
Total	443	100.0

5.2.1. Relationship of activity types and rescheduling decisions

Activity type has been found to be significant in the types of rescheduling decisions that have been made, as seen in Table 7. There are a few trends that have been found in the data. Shopping and eating are predominately added activities and are such because of their opportunistic nature. Activities such as school/work and exercise are activities where time attributes are commonly modified due to the flexibility of each activity type.

Table 7: Frequency of rescheduling decision types by activity type

		Rescheduling Decision Type			
		Add Activity	Delete Activity	Modification - Time Attributes	Total
Activity Type	Eat	30	9	14	53
		56.6%	17.0%	26.4%	100.0%
		14.0%	13.8%	9.5%	12.4%
	School/Work	20	12	41	73
		27.4%	16.4%	56.2%	100.0%
		9.3%	18.5%	27.7%	17.1%
	Shopping	78	6	4	88
		88.6%	6.8%	4.5%	100.0%
		36.4%	9.2%	2.7%	20.6%
	Household Obligations	9	3	7	19
		47.4%	15.8%	36.8%	100.0%
		4.2%	4.6%	4.7%	4.4%
	Entertainment	10	3	6	19
		52.6%	15.8%	31.6%	100.0%
		4.7%	4.6%	4.1%	4.4%
	Exercise	14	14	21	49
		28.6%	28.6%	42.9%	100.0%
		6.5%	21.5%	14.2%	11.5%
	Pick Up Person	6	3	6	15
		40.0%	20.0%	40.0%	100.0%
		2.8%	4.6%	4.1%	3.5%
	Visitors	16	5	2	23
		69.6%	21.7%	8.7%	100.0%
		7.5%	7.7%	1.4%	5.4%
	Miscellaneous	31	10	47	88
		35.2%	11.4%	53.4%	100.0%
		14.5%	15.4%	31.8%	20.6%
	Total	214	65	148	427
		50.1%	15.2%	34.7%	100.0%
		100.0%	100.0%	100.0%	100.0%

χ^2 =104.630, d.f. = 16, p<0.000, n=427

5.2.2. Relationship of socio-demographics and rescheduling decision

Socio-demographics in this dataset, as described previously, are representative of the province of Ontario. There are six main variables that have been collected: gender, age, income, employment status, household size, and household type. After a chi-squared analysis was completed between all of the demographic variables and the

rescheduling decisions, no significance was found. As a result of no significance being found, the characteristics of the people making decisions do not impact the type of decision that is made.

5.3. Planning time horizon of a rescheduling decision

Responses to the question "*When did you decide to add/delete/modify the activity?*", henceforth known as planning time horizon, are categorized in Table 8 along with selected illustrative quotes. For the remainder of this The **'Spontaneous'** (23.5%) category represents decisions that were reported to have occurred within 15 minutes of the start time of the executed activity. **'Partially planned spontaneous'** (1.1%) decisions have certain attributes already planned and others unplanned until immediately before execution of the activity. **'During the activity'** (4.5%) refers to decisions involving modification of activity attributes during the actual execution of an activity. Decisions that are made during the **'Previous activity'** (16.9%) are made during conduct of the previous activity, but not less than 15 minutes prior to the executed activity. Decisions that occurred **'Earlier in the day'** (35.7%) are those that do not fall into above categories, but do occur during the same day as the executed activity. A decision that occurs on a **'Previous day'** (13.5%) was made well in advance of execution. Approximately 1% of these decisions were forgotten during the pre-study interview. **'Routine'** (4.3%) decisions are defined as decisions in which the subject has indicated in some way that the decision is routine in nature, that it required little thought or tends to occur on a regular basis.

Table 8: Categories and example quotes describing the planning time horizon of rescheduling decisions (n=443)

Spontaneous	Partially Planned, *Spontaneous*	During Activity	Previous Activity	Earlier in Day	Previous Day	Routine
23.5%	1.1%	4.5%	17.2%	35.7%	13.6%	4.1%
Right then I believe, because I wanted to take [the dog] for a walk.	It's something I was thinking about for a couple of days it had to be down and it had been raining previously so it was reasonable outside so I just did it. It was kind of spur of the moment.	I do think because Canadian Idol was on for two hours instead of one.	When he decided that during lunch we decided to kind of hit all that stuff after we finished.	In the morning. My parents called in and asked if we wanted to go to Kitchener with them.	Well the night before I phoned her to see if to get a ride with her and she said she had a seven o'clock shift, which is an hour earlier start than me. So I just decided to take my car.	If we're eating pizza and watching a movie, you know, sometimes it depends on some other circumstances and you just don't remember, there's some routine in it you know.
It just happened at 4:30 when I just wanted to finish some work	Not really. Well I knew I was going to make the call some time that night, I just didn't know what time I was going to make it.	When it ended. There was no plan, it just happened. The first client didn't take a whole hour, so I just went ahead and saw the next client that I had to see, and both of them took about 45 minutes each, so I didn't have to spend the whole 2 hours there, so I left at 11:30 because I was done.	That was while we were eating I said I'd go to get laundry detergent	Usually it's flexible so, it's based on our schedule in the morning. It kind of took up the morning and then we just decided to do nothing	But a girl switched with me on Tuesday she wanted, she had a medical appointment. So asked me to switch with her, that's why I had the nine o'clock.	Pretty much when we get in the car. We realized that we are going to stop and grab a coffee. We always do.
We just decided to leave at that time. We just stood around and talked for a little while and I just decided that I had to come back, because I had to go to work the next morning, so we decided to leave.	I have a list in my head. I just, I'm in the mood to go I go and do it		When I was having a fight because I was getting upset so I wasn't in the mind frame to I guess help her but she was studying on her own too.	On the sixth of September I talked to the guy. I decided to order this other tire and will be fixed on the seventh. I will also get the oil changed and the car washed.	I kind of decided the day before, while we were at the park and we decided to come back the next day for a picnic. So I knew from the day before that I would be getting up to do groceries.	We usually do it every day.
			I got a little lost driving [and that delayed me].			I usually go after I have done the dishes; to get it out of the way
When we got back, my parents were in the driveway and the kids saw them so, they wanted to go over for a visit	It was after I was through; I was doing whatever I was, now I knew that I'd be doing it in the afternoon sometime. It was just a matter of when I finished doing what I was doing.	Well a colleague had informed me or had asked me to set up a website for him or an account and I was having difficulties accessing the account after I had set it up and so I had to call the customer service or technical service and I was chatting with them online for quite a while until the issue was resolved so this was a little addition to the day.	Well, I didn't really choose but Amy and them, the friends said that is where they wanted to go and they decided during predrinking before we went out to the bar.	When I got in, I realized I had my hours wrong.		
A couple of minutes before I went over to pick it up. It was just one of those things on the list that had to be done.	It was spontaneous, we usually chat either on the phone or e-mail back and forth, at least once a day, and usually in the evenings.			There was a message when I got home from my walk saying that she was coming over.	It would have been the night before when we got the phone call.	I forgot to tell you about this routine activity because of forgetfullness.
When there was nothing on TV.		Probably almost immediately [when I arrived at work].	As soon as the game was over. I thought that the event ended at 2:00, so I checked as to what time the game was over and we still had time to get to the Humane Society.	I think around 1:00-1:15. Around there he asked me to take him.	It would have been like Tuesday or Monday when I knew when I was going up to RIM.	I always just turn my computer on when I get home and I just sort of happen to start talking to people or I check my e-mail and stuff...

Of particular interest is whether the above planning time horizons (from Table 7) vary by rescheduling decision type (from Table 6), as shown in the cross-tabulated Table 9. Note that the categories of each variable have been grouped together to allow for effective comparison and less biased chi-squared analysis. The chi-squared test suggests that the association is statistically significant. Examination of the table reveals a tendency for additions and deletions to occur earlier in the day whereas timing modifications tend to predominately be done closer to execution of the activities. Further cross tabulations of these variables is performed in subsequent sections.

Table 9: Frequency of Rescheduling decision types by planning time horizon

		Rescheduling Decision Types			
		Add Activity	Delete Activity	Modification - Time Attributes[c]	Total
Planning Timing Horizon	Close to Execution[a]	55	8	65	128
		43.0%	6.3%	50.8%	100.0%
		27.2%	12.5%	46.1%	31.4%
	Earlier in Day[b]	114	46	63	223
		51.1%	20.6%	28.3%	100.0%
		56.4%	71.9%	44.7%	54.8%
	Previous Day	33	10	13	56
		58.9%	17.9%	23.2%	100.0%
		16.3%	15.6%	9.2%	13.8%
	Total	202	64	141	407
		49.6%	15.7%	34.6%	100.0%
		100.0%	100.0%	100.0%	100.0%

a. Close to execution includes the categories spontaneous, preplanned spontaneous, and during activity categories

b. Earlier in day includes the categories earlier in day and previous activity

c. Modification of time attributes refers to a modification to start time and/or end time

χ^2 =27.462, d.f. = 4, p<0.000, n=407

5.3.1. Impetus for rescheduling decisions

Responses to the question *"What caused you to add/delete/modify the activity?"*, henceforth known as impetus for change, are categorized with illustrative quotes in Table 10. The category **'Interpersonal factors'** (25.1%) includes decisions that are made either by other people directly or in concert with other people, reflecting Hägerstrand's coupling constraints. **'Conflict/scheduling issues'** (23.9%) reflect attempts to fit two or more activities into limited time periods, and captured in recent rescheduling models (e.g. Roorda & Miller (2005); Auld et al. (2008); and Ruiz & Timmermans (2006); see also Figure 3) The next impetus for change is defined as **'personal need'** (23.9%), which reflects the subject's belief in the basic need for the decision with little to no options available. The category **'personal choice'** (23.3%) reflects a subject's personal choice, preference or desires, often in reaction to on-going events or plans. **'Flexibility'** (4.5%) is an impetus for change in so much as there was uncertainty of timing or location during the initial interview; in this sense, the modification is more indicative of reaching a conclusion and finality to the original uncertainty or unplanned variable. **'Outside factors'** (4.5%) refers to events/factors normally outside the control of subjects including weather, facility opening hours, daylight, and road conditions. **'Convenience'** (3.6%) refers to the desire to be more efficient during the scheduling process through such phenomenon multitasking and trip chaining. Finally, **'survey bias'** (1.4%) refers to activities that are added, deleted, or modified as a direct result of the survey design, such as mistakenly entering an incorrect activity, then modifying it. These should essentially be ignored as they do not represent true scheduling decisions, but are important to keep track of for survey assessment purposes.

Table 10: Categories and example quotes describing the impetus for change (n=443)

Interpersonal Factors	Conflict/Scheduling Issues	Personal Needs	Personal Choices
25.1%	23.9%	23.9%	12.2%
The 3 teenagers love to shop there. That's their prime spot, and it's an outlet, so it's not as expensive as some of the other stores, since they were shopping with their own money they like to save it.	I had originally decided on 4 hours because I didn't know how long it would take to get through the material, but we ended up getting through it fairly quickly and finished around the time we I think we had originally planned to, maybe just a little bit after, I'm not sure, but I think the other activities that followed were altered innately, it didn't have anything to do with the amount of time we spent studying.	We decided we were hungry and we'd get something to eat.	I actually ended up pulling my quad on Friday night, so I decided that the gym and swimming were out for the weekend.
		I was tired and I thought 2:00 was enough.	
		I was tired.	We knew that we needed chicken to make a stir fry.
I think just because the kids weren't done.		We weren't going to go anywhere, we were just going to hang out here, but then we figured, we always used to have barbecues and go swimming. We figured 'the good old days,' we went out to get some stuff for the barbecue, and that's when we decided to go out.	Just when I woke up, I didn't really feel, I wasn't planning on going anywhere, so I figured I would just lounge around for a while.
Just as we were packing our things, from studying, she mentioned that she was hungry and didn't really feel like coming out for dinner, because she wanted to sit and read for a little while longer. She kind of suggested somewhere that would be on the way a little bit.	Because I was standing out in the front yard watering the grass. So I left later.		Because I was thinking that in case I needed alterations I better not leave it so late. So that's why I changed that one. And groceries was not anything hugely urgent. So I didn't get them until yesterday.
We decided to get together because we were both free.	There was quite a bit left to do in the day, so we pretty much cut it short, for that reasons, we all have stuff to do.	...was when I got hungry and then work and school had to be done.	

Flexibility	Outside Factors	Convenience	Survey Bias
4.5%	4.5%	3.6%	1.4%
Yes, it's kind of a working break, so if there's issues we're talking about sometimes it just goes a little bit longer.	Heavy dew in the morning, everything was really wet. By the time things would dry out, it was too late to do anything, because I had to get the kids ready for their dance.	We just usually do, unless for some reason we decide to sit at the table and eat, we usually watch T.V. while we eat.	When I was putting on the blackberry in the morning I had the hourglass thing so it seemed like it wasn't working so I was trying to get that up and running properly.
Yes, yes it was just a flexible appointment my doctor said I should go a week after I saw her.	Once again the only thing I consider is what other things I have to do. Here's the amount of time that I have to do the other things and is there enough time to allow me to do that.	I think it was, Shawn had said during the day that he needed to take some things back to Canadian Tire and it was then that I knew I had to pick up	Right then I believe, because I wanted to take the GPS equipment for a walk [to see what happens].
Before I left for the meeting. I decided that since I worked during my lunch hour, I decided that I would probably not come back after my meetings, and my secretary told me not to come back. I have flexible hours.	I got a little lost driving.	When doing the plant work outside I noticed alot of spiders so I was looking for some spray that we had at home. We didn't have any so that was actually the thing that got us to going out to begin with. Then we just added the other things if were going out we might as well do everything all at once.	So when I was stopping to fix the pizza oven I stopped at your house to get the GPS repaired
	Well like I said that approximately what time I got to work but some days on a nine o'clock shift it will take me longer than that I think that is a true fact but lots of times it takes me longer.		
I usually allow an hour for a meeting, but this one didn't really take an hour, it only took abut 45 minutes.			Okay, so it is that I do that every day and it is so routine that they just don't think about it.

Of initial interests is whether the impetus for change varies by rescheduling decision type, as shown in Table 11. The chi-squared test suggests that the association is significant. Examination of the table reveals three particular impetuses for change effect rescheduling decision types: 'Personal needs' appear more likely to cause activities to be added to the schedule, whereas 'conflict/scheduling issues' are more commonly the cause of modifying time attributes and deletions, and 'Interpersonal factors' more commonly lead to activity additions and modifications of start time.

Table 11: Frequency of rescheduling decision types by impetus for change

		Rescheduling Decision Type			
		Add Activity	Delete Activity	Modification - Time Attributes	Total
Impetus for Change	Personal Choices	19	11	23	53
		35.8%	20.8%	43.4%	100.0%
		8.9%	16.9%	15.5%	12.4%
	Miscellaneous Impetus	29	9	26	64
		45.3%	14.1%	40.6%	100.0%
		13.6%	13.8%	17.6%	15.0%
	Conflict/Scheduling Issues	26	25	53	104
		25.0%	24.0%	51.0%	100.0%
		12.1%	38.5%	35.8%	24.4%
	Interpersonal Factors	61	12	29	102
		59.8%	11.8%	28.4%	100.0%
		28.5%	18.5%	19.6%	23.9%
	Personal Needs	79	8	17	104
		76.0%	7.7%	16.3%	100.0%
		36.9%	12.3%	11.5%	24.4%
	Total	214	65	148	427
		50.1%	15.2%	34.7%	100.0%
		100.0%	100.0%	100.0%	100.0%

χ^2 =63.420, d.f. = 8, p<0.000, n=427

5.3.2. Impacts of a rescheduling decisions

Just as important as the cause of a rescheduling decision, is the *impact* the rescheduling decision has on their overall schedule. Subjects were asked *"Did the addition/deletion/modification change the remainder of the two days?"*, henceforth known as impact of decision,. Responses are categorized in Table 12 with illustrative quotes. In 90.4% of the cases the decision was reported to have no affect or only a minor impact on a single activity in isolation, and thus are considered **'minor'** in nature. The other 9.6% of the decisions had a **'major'** impact on the schedule involving two (7%), three (1.4%), or three plus (0.7%) affected activities. This discrepancy suggests that under real-world conditions people typically do a significant amount of simple and low impact schedule fine-tuning with only occasional (~10% of time) significant modifications that require multiple decisions.

Interestingly, the association between the impact of decision and the rescheduling decision type (i.e. from Table 6) was not statistically significant. This suggests perhaps that the various rescheduling decision types are equally likely to have minor and major impacts; however, the evidence for this should be considered weak as the sample of major impacts is relatively small.

5.3.3. Process used to make a rescheduling decision

In order to explore the rescheduling process in even more depth, the probing question *"What process did you go through to add/delete/modify the activity?"* was asked. Responses tended to include information on the method(s) used to make the decision, henceforth known as decision making method, and the dependence of a decision on other people, henceforth known as number of people. Table 13 summarizes the six

Table 12: Categories and example quotes of the impact of a single rescheduling decision (n=443)

Minor Impact (0 or 1 activity impacted)		Major Impact (2 or more activities impacted)	
90.3%		9.7%	
No it didn't.	Well, I thought I would be working late at Luke's, so I didn't think I'd have much to work here, but instead I got to do a lot more work here.	Well I was late for work. But she had to tell me about some stuff that I really needed to know, it was really important, so I couldn't cut it short. I called my boss and told her I was going to be late, other than that, I just showed up for work, and I didn't take a lunch, because I was 20 minutes late, I decided not to take a lunch on my work time because I needed extra banked hours for Thursday. Thursday is National Aboriginal Day, and I wanted to leave work early, so I didn't take a lunch. But, then I never went to the gym like I were planning to do.	It did, it did to some extent. It changed the next day for sure because as you will see I spent an extra 3 hours or so after RIM on Thursday just to get things to get work done. I came in early and left late.
Everything was fine. I got to work on time, which is good. Other than just having to, I think instead of eating breakfast at home, I took a banana and a yogurt with me. So I skipped stuff to take later, I guess that's how I made it.	Yes, I had planned on going to a party, but I found out earlier in the day that that wasn't going to happen, so that was one reason why I took the shift, because I knew I didn't have any plans that night, so I may as well work and make some money.		Well it did in the sense that you know typically I would play with the kids for a little bit and spend some time with them before hand, before putting them down to bed, so I mean getting home late they were already asleep when I got in, dinner was obviously pushed back a little bit and the shower and getting ready for bed and the bedtime was obviously pushed back as well.
No not really, no it didn't.			
No because it's happening over lunch time.	That's why I left at 4:00 was to try to estimate how long it would take. I left a bit before 4:00 and got to the humane society 20 minutes early.		
No		No I incorporated it into the other activities I had that day. The library, the water, Canada Trust, so I made that all one trip. So, it really didn't give me an excuse to go out.	Kind of like I see here that we have no bike ride I was planning to go home and have lunch and stay home and work at home but, because I had pre-planned with the participant in the morning and he said he could do it in the afternoon so that I cancelled everything else I was going to do I didn't do any work at all.
Actually no because I ended up watching the movie anyway instead of watching the TV.	No , it just changed the way I got to work.		
No I just ran a little bit shorter and a little bit more quickly.	Well it was my lunch so my dinner was pushed back a little bit	Yes actually because I got home early and there wasn't that hungry okay so I walked to do some more shopping [at three locations].	

Table 13: Categories and example quotes showing the process used to make the rescheduling decisions (n=443)

Self Decisions	Talk in Person	Decision of Others/Uncontrollable	Phone	Non-Conscious Decision	Internet - Email/Messenger
41.8%	26.2%	12.0%	9.7%	9.0%	1.4%
On the way back from exercising. I usually stop somewhere. It wasn't something I was thinking about when I was writing the plan.	We decided earlier in the day that we were going to do it and then we just had to decide what time after Ryan got home around 3 o'clock, he was coming with us.	We had a staff member on vacation, so I covered for reception. The receptionist goes for lunch from 12:30 to 1:30. So it backed everything up by ½ an hour	I gave her a call and just asked her if that was okay. It actually worked out better for her as well, because a friend was visiting her from out of town. So we decided on a new time.	My mental clock seems to wake me up, whether there is an alarm or not. I'm sure if it was a work day it wouldn't have worked that way. On weekends I'm as wide awake as I am during the week.	I knew Monday, I found an e-mail that nobody had signed cheques . So I knew that by the end of the day that nobody did, so I called in found out nobody had come in Monday. So I said OKAY I will come in.
I think just because the kids weren't done. So I was just a slave to them basically.					
No I would of, I decided on the way back from the gym I would like to eat some cream cheese and I realize, oh yes right,. I should stop in and get some crackers.	Yes, it was probably sometime during Melissa's phone call that we decided to just get out and go for a bike ride.	I was going to hang around if I was needed, and it turned out that I wasn't, so it wasn't a conscious decision. I wasn't going to be attending the show, just being there in the same building. I wasn't needed, so I left.	Just as we were leaving to go to Canadian Tire, I gave her a call to see how much time I had. She was fine with going a little bit later because we wanted to do it more as a dinner thing.	I didn't make a conscious decision, it just didn't happen.	That's right and she wrote [an email] to say that Tuesday was not a good day.
It wasn't more so to work late but rather it get a couple of returns to a point where I can finalize it and then that's how long it took.	I found out that I wasn't just shopping with my two daughters, I was taking one of my daughter's two friends, and we had to coordinate their schedules.	As soon as I found out the internet was down at home. I couldn't do anything from home.	I talked to my dad [on the phone] around 4:00, and he had said that he was going to church on Sunday morning, so I figured I would just hang out with Claudia for the night then, and then go tomorrow with my dad.	Well, it probably wasn't a conscious decision, it was, I was watching flipping back and forth between a couple of talk shows and they were interesting, they had some interesting guests, Michael Moore was on, so that got my interest, then after that was over, I was just tired, so my decision to fall asleep came from within.	We had been chatting [through email] about getting together, and he had the week off and I was free, so we figured it was a good time to get together.
No, I just do it. I only have one person at home that I need to answer to, and it's fine.	Around 6:45, maybe my roommate was checking out times while we were sitting around	As soon as I got to Tina's place. They told me I was going there, I didn't really get to decide.			My sister left me a message on Facebook asking me if I'd come in on Tuesday.

main categories of decision making methods along with illustrative quotes. The category **'Self decisions'** (41.9%) was the most frequently used method and reflect decisions that are made in isolation and do not require communication with any other individuals. **'Talking in person'** (26.1%) reflects joint decisions with other people face to face without needing to use a communication device. **'Decision of others/uncontrollable'** (11.9%) reflects decisions made either by someone else entirely or because of authority constraints. **'Phone'** (9.7%) method reflects decisions made by at least two people involving one or more phone calls. **'Non-conscious decisions'** (9.0%) are a method whereby subjects report giving little to no conscious thought toward the decision. Finally, **'Internet – Email / Messenger'** (1.1%) reflects joint decisions made using communication technologies.

The association between the decision making method and rescheduling decision types is shown in Table 14. There are four trends that can be discovered from examining the data. The first is that adding and deleting activities requires relatively more talking in person compared to modifications. Second, modifications to timing are made more non-consciously compared to additions/deletions. Third, deletions are less frequently the result of decisions of others. Finally, self decisions involve a relatively equal amount of additions, deletions, and modifications.

5.4. Impacts of Socio-demographics on rescheduling decisions

This section will be comparing the four aspects of rescheduling (planning time horizon, impetus for change, impact of decision, and decision process/decision making method/number of people) to the demographic (age, gender, income, household size,

household type) and activity (duration and type) variables. Separate analyses are performed in sequence for each type of rescheduling decision (added activities, deleted activities, and modification of start time).

Table 14: Frequency of rescheduling decision types by method of decision making

		Rescheduling Decision Type			
		Add Activity	Delete Activity	Modification - Time Attributes	Total
Decision Making Method	Talk in Person	72	17	17	106
		67.9%	16.0%	16.0%	100.0%
		34.0%	26.6%	11.7%	25.2%
	Phone	17	11	15	43
		39.5%	25.6%	34.9%	100.0%
		8.0%	17.2%	10.3%	10.2%
	Self Decision	93	25	62	180
		51.7%	13.9%	34.4%	100.0%
		43.9%	39.1%	42.8%	42.8%
	Non-Conscious Decision	6	7	27	40
		15.0%	17.5%	67.5%	100.0%
		2.8%	10.9%	18.6%	9.5%
	Decision of Others / Uncontrollable	24	4	24	52
		46.2%	7.7%	46.2%	100.0%
		11.3%	6.3%	16.6%	12.4%
	Total	212	64	145	421
		50.4%	15.2%	34.4%	100.0%
		100.0%	100.0%	100.0%	100.0%

χ^2 =48.228, d.f. = 8, p<0.000, n=421

5.4.1. Decisions to add activities

This section examined activities added to people's schedules after the initial preplanning stage. Interestingly, the comparison of planning time horizon of added activities by demographic/activity variables did not yield any significant results. In contrast, the distribution of the impetus of change was found to be significantly associated with several other variables, including: duration, household size, age, activity type, and planning time horizon, as shown in Table 15. In particular:

- *The higher the household size, the more frequent are personal needs and interpersonal motivating factors for adding activities*

- *Younger subjects reported the most scheduling conflicts as cause for activity additions*
- *Personal need is a common cause of adding shopping activities*
- *Interpersonal factors commonly cause additions of visiting activities*
- *Personal needs and interpersonal factors appear to more commonly lead to addition of short duration activities*

The distribution of the impacts of change for activity addition was found to be significantly different with household type and income, as shown in Table 16. In particular:

- *People in the middle income bracket ($20,000 and $50,000) tended to have a higher frequency of major impacts.*
- *Couples with children have a high relative frequency of minor impacts*

The number people involved in making a decision, as seen in Table 17, is significantly associated with household size, duration and impetus for change. Note in particular that:

- *As expected, large households and decisions made due to interpersonal factors tend to be associated with decision processes that involve more people.*
- *The more people involved in a decision, the longer the duration of the resulting added activity*
- *Conflict/scheduling issues and personal needs normal involve decisions being made alone*

5.5. Decisions to delete activities and modify activity attributes

After analyzing the added activities a similar analysis was conducted for deletion and modification rescheduling decisions. However, taking the cross-tabulations to this extent reduced the sample size in most cases to an unreliable extent. It became obvious that either a larger sample or alternative method (e.g. multivariate choice model) would be needed to conduct such analysis. This is left for future consideration.

Table 15: Frequency of added activities by impetus of change and a) activity duration; b) household size; c) age; d) activity type; e) planning time horizon

a) Activity Duration

		Duration			
		Short Activitiy (Less than 30 Minutes)	Medium Activity (Between 30 and 90 Minutes)	Long Activity (Greater than 30 Minutes)	Total
Impetus of Change	Conflict/Scheduling Issues	12	10	4	26
		46.2%	38.5%	15.4%	100.0%
		9.2%	18.5%	13.3%	12.1%
	Interpersonal Factors	31	16	14	61
		50.8%	26.2%	23.0%	100.0%
		23.8%	29.6%	46.7%	28.5%
	Personal Needs	62	11	6	79
		78.5%	13.9%	7.6%	100.0%
		47.7%	20.4%	20.0%	36.9%
	Miscellaneous Impetus	25	17	6	48
		52.1%	35.4%	12.5%	100.0%
		19.2%	31.5%	20.0%	22.4%
	Total	130	54	30	214
		60.7%	25.2%	14.0%	100.0%
		100.0%	100.0%	100.0%	100.0%

χ^2 =17.907, d.f. = 6, p<0.036, n=214

b) Household Size

		Household Size				
		1 Person	2 People	3 People	Many people (4 or more)	Total
Impetus for Change	Conflict/Scheduling Issues	6	11	1	8	26
		23.1%	42.3%	3.8%	30.8%	100.0%
		11.5%	26.2%	2.5%	10.0%	12.1%
	Interpersonal Factors	15	9	10	27	61
		24.6%	14.8%	16.4%	44.3%	100.0%
		28.8%	21.4%	25.0%	33.8%	28.5%
	Personal Needs	22	13	14	30	79
		27.8%	16.5%	17.7%	38.0%	100.0%
		42.3%	31.0%	35.0%	37.5%	36.9%
	Miscellaneous Impetus	9	9	15	15	48
		18.8%	18.8%	31.3%	31.3%	100.0%
		17.3%	21.4%	37.5%	18.8%	22.4%
	Total	52	42	40	80	214
		24.3%	19.6%	18.7%	37.4%	100.0%
		100.0%	100.0%	100.0%	100.0%	100.0%

χ^2 =20.298, d.f. = 9, p<0.002, n=214

c) Age

		Age			
		25 to 34	35 to 54	55 to 64	Total
Impetus of Change	Conflict/Scheduling Issues	22	3	1	26
		84.6%	11.5%	3.8%	100.0%
		19.8%	4.7%	2.6%	12.1%
	Interpersonal Factors	33	19	9	61
		54.1%	31.1%	14.8%	100.0%
		29.7%	29.7%	23.1%	28.5%
	Personal Needs	41	23	15	79
		51.9%	29.1%	19.0%	100.0%
		36.9%	35.9%	38.5%	36.9%
	Miscellaneous Impetus	15	19	14	48
		31.3%	39.6%	29.2%	100.0%
		13.5%	29.7%	35.9%	22.4%
	Total	111	64	39	214
		51.9%	29.9%	18.2%	100.0%
		100.0%	100.0%	100.0%	100.0%

χ^2 =20.383, d.f. = 6, p<0.002, n=214

d) Activity Type

		Activity Type				
		Eat	School/Work	Shopping	Household Obligations	Total
Impetus of Change	Conflict/Scheduling Issues	3	7	9	7	26
		11.5%	26.9%	34.6%	26.9%	100.0%
		11.5%	35.0%	11.5%	7.8%	12.1%
	Interpersonal Factors	10	4	11	36	61
		16.4%	6.6%	18.0%	59.0%	100.0%
		38.5%	20.0%	14.1%	40.0%	28.5%
	Personal Needs	8	7	47	17	79
		10.1%	8.9%	59.5%	21.5%	100.0%
		30.8%	35.0%	60.3%	18.9%	36.9%
	Miscellaneous Impetus	5	2	11	30	48
		10.4%	4.2%	22.9%	62.5%	100.0%
		19.2%	10.0%	14.1%	33.3%	22.4%
	Total	26	20	78	90	214
		12.1%	9.3%	36.4%	42.1%	100.0%
		100.0%	100.0%	100.0%	100.0%	100.0%

χ^2 =49.700, d.f. = 9, p<0.000, n=214

e) Planning time horizon

		Planning Time Horizon			
		Close to Execution	Earlier in Day	Previous Day	Total
Impetus for Change	Conflict/Scheduling Issues	5	12	9	26
		19.2%	46.2%	34.6%	100.0%
		9.1%	10.5%	27.3%	12.9%
	Interpersonal Factors	20	31	9	60
		33.3%	51.7%	15.0%	100.0%
		36.4%	27.2%	27.3%	29.7%
	Personal Needs	14	49	11	74
		18.9%	66.2%	14.9%	100.0%
		25.5%	43.0%	33.3%	36.6%
	Miscellaneous Impetus	16	22	4	42
		38.1%	52.4%	9.5%	100.0%
		29.1%	19.3%	12.1%	20.8%
	Total	55	114	33	202
		27.2%	56.4%	16.3%	100.0%
		100.0%	100.0%	100.0%	100.0%

χ^2 =13.910, d.f. = 6, p<0.031, n=202

Table 16: Frequency table for added activities by impact of choice with a) income and b) household type

a) Income

		Impact of Choice		
		Minor Impact	Major Impact	Total
Income	<$20000	77	8	85
		90.6%	9.4%	100.0%
		41.0%	32.0%	39.9%
	$20000 - $50000	73	16	89
		82.0%	18.0%	100.0%
		38.8%	64.0%	41.8%
	$50000-$75000	38	1	39
		97.4%	2.6%	100.0%
		20.2%	4.0%	18.3%
	Total	188	25	213
		88.3%	11.7%	100.0%
		100.0%	100.0%	100.0%

χ^2 =6.957, d.f. = 2, p<0.031, n=213

b) Household Type

		Impact of a Single Decison		
		Minor Impact	Major Impact	Total
Household Type	Single (No Child)	70	3	73
		37.2%	12.0%	34.3%
	Single (With Child)	13	3	16
		6.9%	12.0%	7.5%
	Couple (No Child)	30	8	38
		16.0%	32.0%	17.8%
	Couple (With Child)	75	11	86
		39.9%	44.0%	40.4%
	Total	188	25	213
		100.0%	100.0%	100.0%

χ^2 =8.135, d.f. = 3, p<0.043, n=213

Table 17: Frequency table for added activities by number of people with a) household size; b) duration; c) impetus for change

a) Household Size

		Number of People			
		Self	Two People	Group (3 or more)	Total
Household Size	1 Person	24	19	9	52
		46.2%	36.5%	17.3%	100.0%
		23.5%	21.8%	36.0%	24.3%
	2 People	27	15	0	42
		64.3%	35.7%	.0%	100.0%
		26.5%	17.2%	.0%	19.6%
	Many People (3 or more)	51	53	16	120
		42.5%	44.2%	13.3%	100.0%
		50.0%	60.9%	64.0%	56.1%
	Total	102	87	25	214
		47.7%	40.7%	11.7%	100.0%
		100.0%	100.0%	100.0%	100.0%

χ^2 =10.559, d.f. = 4, p<0.032, n=214

b) Duration

		Number of People			
		Self	Two People	Group (3 or more)	Total
Duration	Short Activitiy (Less than 30 Minutes)	70	53	7	130
		53.8%	40.8%	5.4%	100.0%
		68.6%	60.9%	28.0%	60.7%
	Medium Activity (Between 30 and 90 Minutes)	21	23	10	54
		38.9%	42.6%	18.5%	100.0%
		20.6%	26.4%	40.0%	25.2%
	Long Activity (Greater than 30 Minutes)	11	11	8	30
		36.7%	36.7%	26.7%	100.0%
		10.8%	12.6%	32.0%	14.0%
	Total	102	87	25	214
		47.7%	40.7%	11.7%	100.0%
		100.0%	100.0%	100.0%	100.0%

χ^2 =15.183, d.f. = 4, p<0.004, n=214

c) Impetus for Change

		Number of People			
		Self	Two People	Group (3 or more)	Total
Impetus of Change	Conflict/Scheduling Issues	19	7	0	26
		73.1%	26.9%	.0%	100.0%
		18.6%	8.0%	.0%	12.1%
	Interpersonal Factors	3	44	14	61
		4.9%	72.1%	23.0%	100.0%
		2.9%	50.6%	56.0%	28.5%
	Personal Needs	50	27	2	79
		63.3%	34.2%	2.5%	100.0%
		49.0%	31.0%	8.0%	36.9%
	Miscellaneous Impetus	30	9	9	48
		62.5%	18.8%	18.8%	100.0%
		29.4%	10.3%	36.0%	22.4%
	Total	102	87	25	214
		47.7%	40.7%	11.7%	100.0%
		100.0%	100.0%	100.0%	100.0%

χ^2 =73.107, d.f. = 6, p<0.000, n=214

CHAPTER 6: Discussion & Conclusions

6.1. Discussion of Results

This thesis has utilized a combined quantitative and qualitative approach to provide new analytical insights into the rescheduling process as it occurs on a day-to-day basis. The intent was to improve our understanding of this process and inform the development of an emerging class of activity scheduling-based travel demand models. In particular, this thesis makes two key analytical contributions related to preplanning and rescheduling.

6.1.1. Discussion of Preplanning Process

The upfront interview provided considerable insight into the preplanning process, including both how a subject describes their preplanned activities and the nature of those activities. The most significant overall finding was that different activity attributes are planned to differing degrees of elaboration. As discussed in Chapter 4, subjects most frequently preplan the activity type/mode choice, location (for activities), then start time, end time, and finally involved persons. Activity type/travel mode being planned is as expected, because without a proposed event the subjects would have virtually nothing to plan (even if this event was "do nothing", it is still an event type). The one difference between trips and activities is the end time of trips has a much greater frequency of being planned than the end time of an activity. This is a direct result of the start time of activities being known. For example, if a subject knows when he/she must be at a location they will know when the end time of the previous trip will occur. End times having a low frequency of planning is also as expected, since we often devote much more thought to getting places on time and tend more often to have flexibility in the end time.

Naturally enough, when one activity had a partially elaborated end time the subsequent activity would normally have a partially elaborated start time.

In many cases when start/end times are only partially elaborated, subjects choose verbal statements to convey their response. Quantifiable times are difficult to pinpoint in many cases because the exact times depend on preceding or proceeding flexible activities and because exact times do not matter to people. This would explain why exploration of temporal flexibility is so challenging to document, both from a question design and subjects perspective.

With regard to the entire scheduling decision process, the results suggest that the development of a preplan is an on-going process, wherein tentative decisions on many attributes are often made (leaving them partially elaborated on the preplan), then revisited at some point closer to execution. The results suggest that certain attributes (end times, involved persons) are more likely to evolve over a longer time period, whereas others (start time, activity/mode type, and location) are planned in advance and not likely to be elaborated upon. Results also support that subjects most often plan "routine" activities (work, school, weekly sporting activities, social events, etc.) with a fixed start time and location, and only later add or insert other activities with specific, partial or unknown start times and often no specific end times.

6.1.2. Discussion of Rescheduling Process

The post interview results have contributed a much deeper understanding of types of rescheduling decisions made, their frequency, the impetus for them, the impact of a single decision, and the process to make a decision, behavioural aspects largely

overlooked in past data collection methods. Four key findings are worth further discussion, including:

1) Activity conflicts and other modifications were reported by subjects in greater frequency compared to previous studies
2) The causes of rescheduling changes are varied, and go beyond what is captured in existing models or examined in the literature.
3) Fundamental concepts by Hägerstrand, Cullen & Godson, and Chapin all help to explain the rescheduling decisions
4) Socio-demographic variables appear to have a limited impact on rescheduling decisions, but the type of activities that are rescheduled seem to have a great deal of importance

As stated in Chapter 3, scheduling changes occur at a higher frequently in this study than in previous studies such as CHASE. For instance, there were 16.4 changes per person per day, including 10.8 new additions (65.9%), 1.6 deletions (9.7%), and 4.0 modifications (24.4%) representing double the amount captured by CHASE (Roorda and Miller, 2005, Doherty and Miller, 2000). This is likely the result of adopting a novel means to automatically track rescheduling decisions combined with an in-depth open ended interview, rather than relying on self-reports using a computerized interface. Specifically examining the scheduling conflicts that occur within the study finds 1.3 scheduling conflicts per person per day, compared to 0.6 for CHASE (Roorda and Miller, 2005). However, it should be noted that modifications of location, activity type, and involved persons were not frequently reported, perhaps related to the survey design, and thus could not be examined in-depth.

The cause of rescheduling decisions has in the past not been given full attention as modellers are more interested in how the rescheduling decision was made rather than why. But as found in this thesis, the impetus of change can directly relate to how

activities are rescheduled. Auld et al. (2008) focus on the conflict resolutions and how they are resolved, and do not consider the possibility that there are other causes of rescheduling decisions. Roorda & Miller (2005) do acknowledge that rescheduling decisions are not all captured or considered in their TASHA model, but they do not take the next step to find out these missing rescheduling decisions.

After analyzing the qualitative data in this study, there appears to be many other factors that cause these conflict decisions, such as interpersonal factors, personal need, and personal choice. Each of these different impetuses for change shows that modellers in the future need to move past the focus on scheduling conflicts. Instead they should incorporate the scheduling conflicts with social networks and other theoretical frameworks.

The results of this study reflect and expand upon key aspects of the conceptual frameworks introduced by the likes of Hägerstrand (1970), Cullen and Godson's (1975) and Chapin (1974). Hägerstrand's time geography is based on the three constraints (coupling, authority, and coupling) that limit what activities can be executed and the locations in which we can execute them. This is clearly evident in the results via interpersonal and outside factors. For instance, coupling constraints are embodied when interpersonal factors are the cause of a rescheduling decision the complexity of the decision increases. Likewise, capability constraints are taken into account when a decision is made because of outside factors such as weather, traffic congestion, and similar factors that limit the activities that can be executed.

Cullen and Godson take this approach a step further by formalizing the scheduling process and introducing the idea of flexibility into the discussion. This is evident in the flexibility of activities. In many cases these decisions are not even considered to be rescheduled because they fall within the spatial or temporal flexibility that was indicated during the initial interview. If the flexibility data was not collected during the interview for the preplanned scheduled more decisions would have appeared to be rescheduled, when in actual fact they were not.

Finally, Chapin takes a different approach altogether when he discusses that many decisions are actually made because of desires and opportunities of an individual rather than the constraints that limit the choices. This is reflected in the results through the rescheduling using trip chaining and a subject's own personal desire and/or choice. Trip chaining is when multiple activities are executed during a single trip. The decision to add activities normally occurs when an individual sees an opportunity during a trip to execute an additional activity. Trip chaining is opportunistic and in most cases occurs close to execution of the activity. A rescheduling decision is made because of an individual's own desires and choices and as a result is directly related to Chapin's ideas as well.

Another point of discussion is that the impact of socio-demographic variables on the various aspects of the rescheduling process, which turned out quite minimal in many cases. In particular, socio-demographic variables had no significant association with the types of rescheduling decisions, planning time horizons, and decision making methods. Instead, variables related to impetus for change, impact of change, and number of people had a much stronger association. The minimal impact of socio-demographic variables suggests some degree of stability in the way that people make rescheduling decisions.

Differences between people were found when it comes to the cause, impact, and people involved in the decision.

Two activity-related variables that do have a major impact on some aspects of rescheduling are activity type and the duration of the rescheduled activity. The type of activity is directly associated with the type of rescheduling decision made and the impetus for a decision. Duration is associated with the impetus of change and the number of people. This means that the characteristics of the activity being rescheduled are directly related to how the rescheduling decision is made.

6.2. Methodological Contributions

The novel methodology used in this study has allowed far more information to be collected about the rescheduling process compared to past methods. The initial interview allowed the subjects to discuss their own preplanned activities without having to place them in a certain interface. Instead they were able to write and verbalize them in a way that is familiar. Also allowing partially elaborated activities to be placed on the preplanned schedule allows a more accurate preplan to be created without the subject needing to enter a planning mode.

When preplanned schedules were collected subjects were allowed to include partially planned activities. In these instances some activity attributes were left unplanned and therefore subjects were not required to guess or plan these attributes during the interview. By allowing partially elaborated activities subjects can accurately describe exactly what they know about a planned activity and furthermore to describe during the final interview how these attributes were planned.

The use of GPS allows daily travel to be passively tracked and placed into the IBPRD for easy recall. In the past, the two major issues of surveys are respondent burden and self reported activity schedules. By using the GPS coupled with the IBPRD not only is the data observed because of the GPS, but respondent burden is minimized because subjects are no longer required to spend hours filling in an activity diary. By collecting observed data the subject and placing the data into the IBPRD the subject has a much easier time recalling the activities that were executed instead of having to complete a memory jogger or full diary during the study. Minimization of respondent burden is supported by the fact that the IBPRD entry taking only an average of 15 minutes for the entire study period compared to 16 minutes per day that CHASE required (Doherty and Miller, 2000).

The advances to methodology previously discussed have an impact on large scale studies. Obviously the methodology used for this thesis cannot be directly used for a large scale survey due to the cost of equipment and the time commitment needed by the data collection agency for interviews and technical support. Instead portions of the methodology first discussed by Doherty et al. (2006), then refined and put into the field for this thesis can be used to enhance activity-based travel surveys.

Mainly, large scale surveys can be improved by allowing more open-ended answers to scheduling questions. When asking questions of a subject, allow the subject to write a few sentences to describe their thinking instead of requiring them to circle a multiple choice answer. One challenge to this proposal is to get an in-depth answer without the prompting of an interviewer. The questionnaire can be enhanced by using a CATI (Computer Assisted Telephone Interview) to collect the appropriate level of detail

from a subject. This has been done to some degree in the past but usually questions are more structured. OPFAST (Roorda et al., 2005) is one example where the subjects were allowed to give more open-ended answers through the use of a CATI and as a result there are more details regarding the scheduling process, although the results have yet to be published.

Another improvement to be made on large scale surveys is the ability to collect more accurate data through the use of a GPS and prompted recall diary. Wolf (2001, , 2000) and Stopher (2008, , 2002, , 2004) promote the need to eliminate the use of diaries all together, to allow for more accurate data with a lower respondent burden. Although, eliminating diaries could be successful for trip-based surveys, which only require information regarding purpose and location, there would be no information at all available for any time-use or activity-based survey. Therefore a prompted recall diary is an excellent support to GPS to allow subjects to recall their activities without needing to take daily notes. In order to implement a GPS and recall diary at a large scale an easy to use internet based recall diary would need to be used to allow input without the need of technical support. A few such diaries have already been tested for large scale studies such as those by Itsubo & Hato (2005) and Li & Shalaby (2008). GPS can also be used for data verification as done by Stopher and colleagues (Stopher et al., 2007, Bullock et al., 2003, Wolf et al., 2003).

6.3. Contributions to the theoretical framework

The results of this thesis allow further elaboration of the theoretical framework for scheduling decision process shown in Figure 6. The 'creation of preplanned skeletal

schedule' can be expanded, in particular to allow activity attributes to be left unplanned; meaning that a single activity is not always planned entirely at the same time. As time progresses the unplanned attributes become more and more planned, right until the execution of an activity. Therefore another step can be added to the framework in which attributes of partially elaborated activities become planned.

The types of rescheduling decision can be expanded to include a focus on timing, but also location, activity type, and involved persons. More still needs to be learnt about these additional modifications but they are important to better understand the scheduling and rescheduling process.

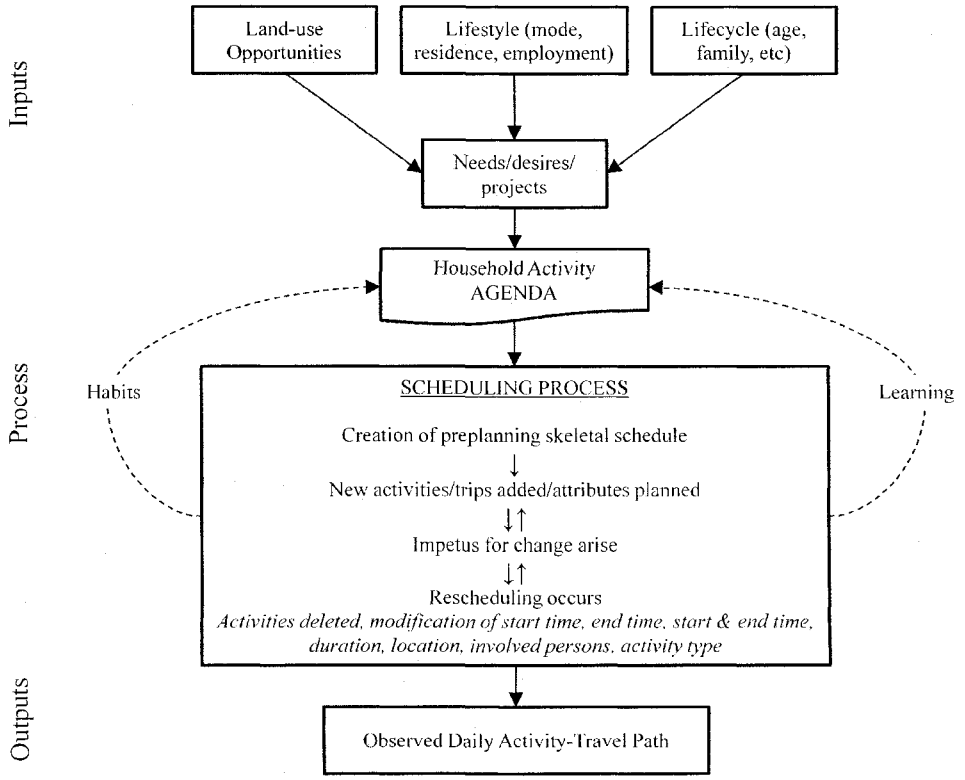
One modification that can be made to the structure of framework is that the 'conflicts arise' aspect of the framework is not always the cause of rescheduling decisions. Instead, the step should be called 'impetus for change', and allow for a greater variety of change scenarios including those that stem from interpersonal factors and personal choices. These three points of discussion allow for an updated version of the theoretical framework for scheduling decision process to be created, as seen in Figure 17.

6.4. Modelling Implications

The results found in this thesis have direct implication on the modelling of scheduling and rescheduling decisions. First, past rescheduling models have always focused on conflict resolution, but ignore other rescheduling decisions. This study has proven there are many more causes of rescheduling decisions than just conflict resolutions that should be accounted for. Secondly, rescheduling strategies modelled should go beyond additions, deletions, and the modification of time attributes and begin

to take into account the modification of location, involved persons, and activity type. Thirdly, the validity of certain modelling assumptions can be addressed. The use of simple heuristics in the form of if...then statements appears amendable to a large portion of rescheduling decisions that involved single step, simple decisions. However, the smaller sub-set of decisions that involved multiple activities and multiple persons should probably be modelled using alternative modelling approaches such as utility or constraint based in combination with more elaborate rules. The results in this thesis also support a continuation of constraints-based approaches to the scheduling process. In particular, coupling constraints were one of the most common and consistent constraint type for all people.

Figure 17: Modified theoretical framework for scheduling decision process as derived from thesis results, based on Doherty (2002) and Chapter 2.



The results of this thesis shed light on the underlying reasons for sequencing activities during the scheduling process. Utility-based approaches assume that individuals sequence activities to attempt to maximize utility while the constraints-based approach assumes that the sequence is chosen to avoid wasting time. Results of this thesis suggest that the reality is somewhere between the two assumptions depending on the activity and situation in which a decision is made. For instance, subjects reported that some rescheduling decisions such as multitasking and trip-chaining were done to minimize time, whereas others are made because of their own desire.

Overall, the results of this thesis suggest that the best method to model rescheduling decisions would be one that incorporates a variety of modelling approaches. For instance, a simple if-then rule-based approach could be used to model all of the minor decisions, whereas constraints and utility-based approaches could apply to more elaborate situations.

6.5. Challenges and Limitations

Despite the lessons learned from this study there were a few challenges and limitations that affected the quality of data collected for this thesis. The first limitation is the attributes that were collected during the preplanned schedule. When collecting data using the new methodology five major activity attributes were collected: start time, end time, location, activity type, and involved persons. For each attribute flexibility was also collected. As the final analysis concluded there was one variable that was noticeably missing: duration of the activity and its flexibility. In many cases subjects later mentioned whether duration was altered or not, some even indicated that start and end

times were flexible but the duration was always fixed. To not have this data could very well hurt model development using the collected data.

A major challenge with the data collection was frequent problems with the technology that led to missing data with almost every subject in the study. This was a direct result of connectivity issues between the BlackBerry and GPS device, and the age of the equipment (which was well used in previous studies). In the future, a new set of equipment with a built in GPS should be used to minimize downtime and eliminate connectivity problems between the GPS and BlackBerry.

Another limitation to the data collection was the lack of automated detection of scheduling changes. When comparing the executed activities with the planned activity the interviewer manually compared the two schedules to find the differences. The manual comparison resulted in only obvious rescheduling decisions being discussed during the post interview instead of all decisions. Computer software, as discussed by Doherty and Papinski (2004), can automatically detect differences between two schedules leading to a more complete idea of changes in a schedule. Although this would be beneficial in some ways, it is important to always keep in mind that looking at all modifications (not just greater than 15 minutes) could also add modifications that are only caused by the subject rounding times in the original preplanned schedule. These issues are much more evident when attributes such as activity type and involved persons are modified because start and end time are much easier to determine.

A fourth challenge to this data collection methodology is with the open ended interview and the inconsistencies in the questions that were asked. During the initial

interview the subjects were required to write down and talk about the activities they have planned over the subsequent two days. The problem is that they may leave out activity attributes which are then filled in by the interviewer through follow up questions. Although the interviewer attempts to capture all attributes of all activities through a systematic questioning there are some attributes that are missed. The same can be said for the final interview which asks the four questions to determine who, what, how, and why each decision was made. Although each questioning is systematic it was next to impossible to capture every bit of information that is required.

6.6. Recommendations for Future Work

There are three areas that need to be a focus for future work to add to a better understanding of the rescheduling process. The first item is to capture more of the secondary types of rescheduling decisions in more depth, such as the modification of locations and involved persons. Second, future work must focus on capturing more of the complex decision processes. Adopt a longer data collection period would help, as would collect the preplanned schedule further in advance so as to capture more of the actual scheduling and rescheduling decisions made. Third, future rescheduling studies could develop an automated (rather than by-hand) algorithm that would allow for a quick and accurate assessment of rescheduling changes. An algorithm would compare the preplanned schedule and executed schedule to look for added activities, deleted activities, and the modification of attributes. The attributes that would be searched for modifications include start time, end time, duration, travel mode, location, and involved persons. Results from the algorithm would then determine which decisions need to be the focus of the questions that follow. Finally, in order to better understand the correlates

of deleted and modified activities a multi-variant model should be developed. This model would allow for a concise and reliable analysis of the explanatory factors for the various choices made during the rescheduling process.

CHAPTER 7: BIBLIOGRAHY

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