THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

Activity-based Travel Demand Analysis: The Past, The Present, and The Future

Chandra Bhat
Center for Transportation Research
The University of Texas at Austin

Tongji University – July 2016

COLLABORATE. INNOVATE. EDUCATE.

Outline

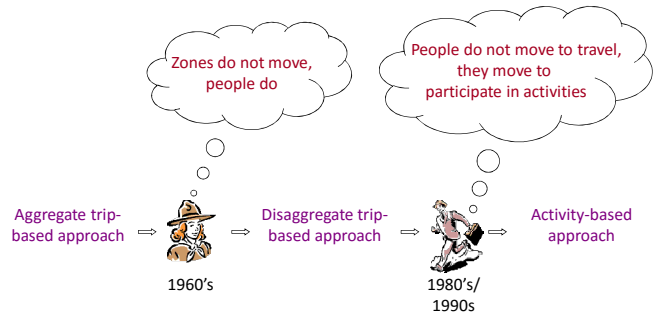
- History and evolution of activity-based approach
- Foundations of trip-based vs. activity-based approaches
- Important aspects of activity-based analysis
  - Time, Space, and Inter-personal interactions
- A review of activity-based travel forecasting systems
- Integration with other modeling systems
- Emerging Methods
  - Incorporating time and space dimensions in activity based modeling
- Future research directions

COLLABORATE. INNOVATE. EDUCATE.

HISTORY

COLLABORATE. INNOVATE. EDUCATE.

Evolution of Travel Demand Forecasting Techniques



COLLABORATE. INNOVATE. EDUCATE.

A brief history of transportation planning

Earlier	Over past 3 decades	Today
Focus of Transportation Planning → Provide adequate transport infrastructure to meet long-term mobility needs → Long-tem focus → Supply oriented nature	→ Accelerating travel demand → Space-cost constraints → Adding new infrastructure has become difficult → Non-sustainability - Suburban sprawl - High auto-dependency → Traffic congestion → Environmental concerns	**Focus of Transportation Planning** → Manage travel demand within available amount of supply → Short-term policy emphasis Travel demand management Congestion pricing
Role of Travel Demand Models → Statistical prediction of aggregate travel demand for long-term socioeconomic, land-use, and transport system scenarios		**Role of Travel Demand Models** → Understand disaggregate-level behavioral responses to policies

COLLABORATE. INNOVATE. EDUCATE.

History: Origin of activity-based research

- Origins of activity-based research: Dates back to 1960's and 70's
  - Chapin's(1971 and 1974) research on activity patterns of urban population
    - Provided an activity participation framework with societal constraints and individual motivations
  - Hagerstrand's (1969) presidential address at a Regional Science congress
    - Explicitly discussed activity participation in the context of time and space
    - Identified constraints that shape activity participation
      - Authoritative → Spatio-temporal constraints (Space-time prisms and paths)
      - Capability → Biological needs & resource constraints (sleep, income, car availability)
      - Coupling → Inter-individual interactions
    - Related works: Cullen and Gordon (1975), Cullen and Phelps(1975)
  - Jones(1979)
    - Explicitly identified the relationship between activities, travel, time, and space
    - Travel is derived from the need to participate in activities dispersed in time and space

COLLABORATE. INNOVATE. EDUCATE.

History: Evolution of activity-based approach

- Activity-based research started gaining increasing attention in1980's
  - A conference in1981 on *"Travel Demand Analysis: Activity-based and Other New Approaches"*
- 1990's (and subsequent years) saw increasing…
  - Public policy mandates (such as ISTEA, TEA-21, and CAAA in United States)
  - Information demands placed on travel demand models
  - Needs to assess and formulate short-term travel demand management policies
  - Realization of the behavioral and forecasting limitations of the trip-based approach (e.g. Jones et al., 1990, Axhausen and Garling 1992, Bhat and Koppelman 1999, Pendyala and Goulias, 2002)
- Other factors that accelerated the shift to activity-based paradigm
  - Improved analytic tools and modeling methods
  - Faster and efficient computing capacity and increasing computing power
  - Availability of data

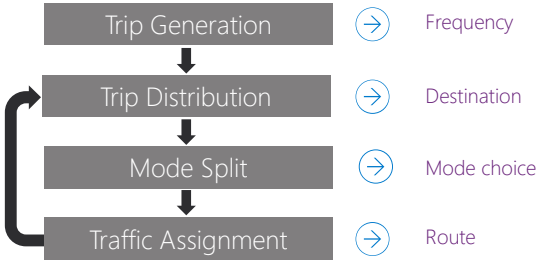
COLLABORATE. INNOVATE. EDUCATE.

FOUNDATIONS

Trip-based vs. Activity-based approaches

COLLABORATE. INNOVATE. EDUCATE.

The Four-Step Process



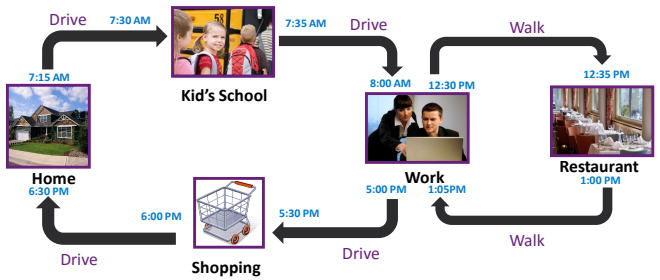
COLLABORATE. INNOVATE. EDUCATE.

Issues

- Oversimplified representation of daily travel patterns
- Statistical / ad-hoc approach to modeling - NOT behaviorally-oriented!!

COLLABORATE. INNOVATE. EDUCATE.

Daily activity-travel undertaken by an individual



COLLABORATE. INNOVATE. EDUCATE.

How the four-step process views it:

O – Origin
D - Destination

Two Home-based trips

Drive: O1 → D1 (Peak)

Drive: O2 → D2 (Peak)

Four Non Home-based trips:

Drive: O3 → D3 (Peak)

Walk: O5 → D5 (Off-Peak)

Drive: O4 → D4 (Peak)

Walk: O6 → D6 (Off-Peak)

COLLABORATE. INNOVATE. EDUCATE.

Using the four-step approach to travel modeling: Limitations and concerns

- Changes in traveler behavior
  - Trip chaining
- Change in the focus of the planning process
  - Evaluating policy actions
  - ITS technologies and dynamic control
- Air quality modeling
  - Soak time distributions ⇔ activity durations
  - Evaluating policy actions
- Emergence of in-home technologies

COLLABORATE. INNOVATE. EDUCATE.

Summary: The four-step process

- Focus is on ***trips*** and not on the ***activities*** that motivate making the trips: Methodology is more statistical; less behavioral
- Does not recognize the spatial, temporal, and modal linkages among the different trips of a person
- Duration and timing of trips are not considered explicitly
- Time is represented simply as a "cost" of making a trip
- Does not consider intra-household interdependencies
- Not suitable for evaluating impacts of policy actions and for air quality modeling

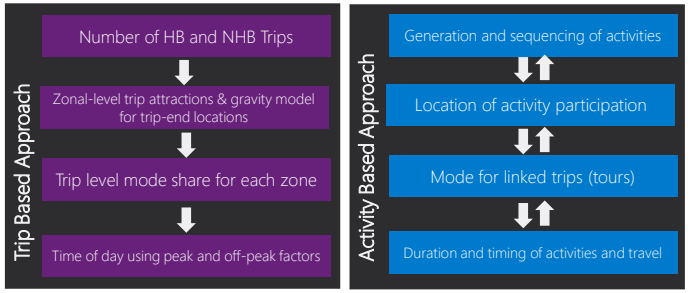
COLLABORATE. INNOVATE. EDUCATE.

Features of the Activity-based Approach

- Views travel as a "Derived" demand
- Focus on activity participation behavior
  - Attempts to understand behavioral basis for activity participation (and resulting travel) in certain places at given times
  - Behavioral basis includes the why, how, when, where, and with whom of activity participation
- Focus on sequences or patterns of activity participation and travel behavior
  - Spatial, temporal and modal inter-dependencies in activity-travel choices recognized
  - Complexity of travel patterns recognized
  - Tours (not individuals trips) are used to represent travel patterns
- Analysis is at the disaggregate-level (i.e., individual and household-level) at which activity-travel decisions are actually made
- Appropriate treatment of the time dimension
- Emphasis on inter-personal interactions

COLLABORATE. INNOVATE. EDUCATE.

Contrasting Trip-Based and Activity Based Approaches



COLLABORATE. INNOVATE. EDUCATE.

ABM Applications

- **Enhanced policy sensitivity**
  - Sensitivity of work start/end times-of-day to LOS
- **Enhanced policy evaluation capability**
  - Travel demand management measures, and Congestion pricing
  - Transit improvements
  - Parking pricing and strategies
  - Employer-based schemes
  - Land-use policies
- **Ability to assess the impacts of demographic shifts**
- **Potential applicability in homeland security and evacuation**
  - Population location distribution throughout day

COLLABORATE. INNOVATE. EDUCATE.

EVALUATION USING ABMs

COLLABORATE. INNOVATE. EDUCATE.

Trip Length Changes

	Base Case	DA Cost Increase 100%		DA IVTT Increase 25%		Peak Period DA IVTT Increase 25%		25% Increase in Emp. & Pop. Densities	
Below Poverty			% Reduction		% Reduction		% Reduction		% Reduction
HBW	11.17	10.21	8.6%	10.68	4.3%	10.67	4.5%	10.70	4.2%
HBO	10.52	6.91	34.3%	5.48	47.9%	6.37	39.5%	6.95	33.9%
NHB	7.49	7.06	5.8%	5.74	23.3%	6.58	12.2%	7.12	5.0%
Total	9.69	7.28	24.9%	6.11	37.0%	6.87	29.1%	7.40	23.7%
Above Poverty									
HBW	11.19	10.53	5.9%	10.95	2.1%	10.92	2.5%	10.99	1.8%
HBO	10.15	8.37	17.5%	6.72	33.8%	7.77	23.5%	8.42	17.1%
NHB	7.99	7.71	3.5%	6.36	20.4%	7.27	8.9%	7.84	1.9%
Total	9.68	8.52	11.9%	7.39	23.6%	8.16	15.7%	8.72	9.9%

COLLABORATE. INNOVATE. EDUCATE.

Drive Alone Cost Increase by 100% (LA Region)

Base Case

Overall Pattern	Commute and additional tour
Total mileage (miles)	47.17
HW Commute	
Number of non-work stops	0
Mode	Drive alone
Activity at non-work stops	-
WH Commute	
Number of non-work stops	0
Mode	Drive alone
Activity at non-work stops	-
Tour 1	
Number of stops	1
Mode	Drive alone
Activity at stops	Eat out

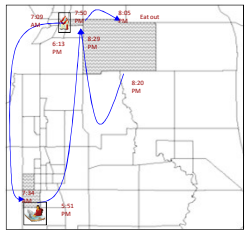
Policy Case

Overall Pattern	Commute tour
Total mileage (miles)	35.21
HW Commute	
Number of non-work stops	0
Mode	Drive alone
Activity at non-work stops	-
WH Commute	
Number of non-work stops	1
Mode	Drive alone
Activity at non-work stops	Eat out

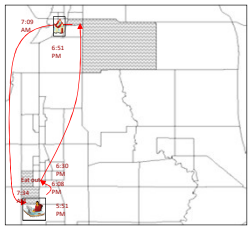
COLLABORATE. INNOVATE. EDUCATE.

Drive Alone Cost Increase by 100%
(LA Region)

Base Case



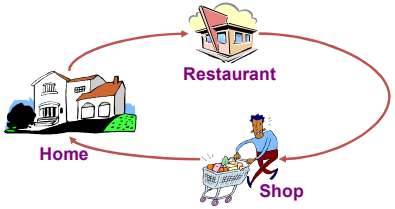
Policy Case

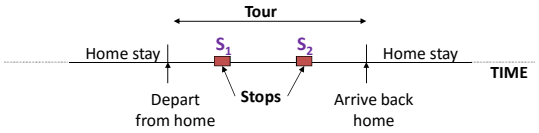


COLLABORATE. INNOVATE. EDUCATE.

Representing Activity-travel Patterns

Patterns, Tours, and Stops





COLLABORATE. INNOVATE. EDUCATE.

Representing Activity-travel Patterns

Recognizing Fixities

Non-Workers

- No obvious activity with spatial and temporal fixities
- Person more flexible in scheduling his/her activities

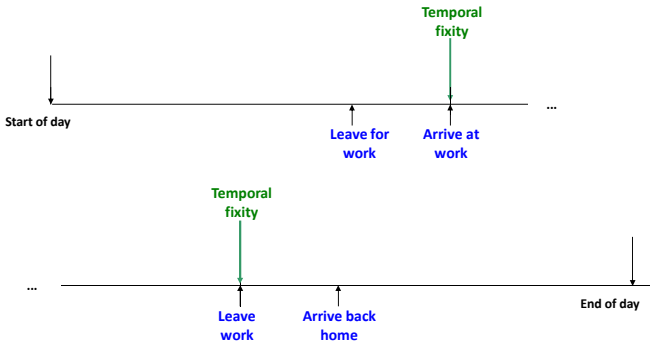
Workers

- The "work" activity has spatial and temporal fixities
- Person schedules his/her activities around the work activity

COLLABORATE. INNOVATE. EDUCATE.

Representing Activity-travel Patterns

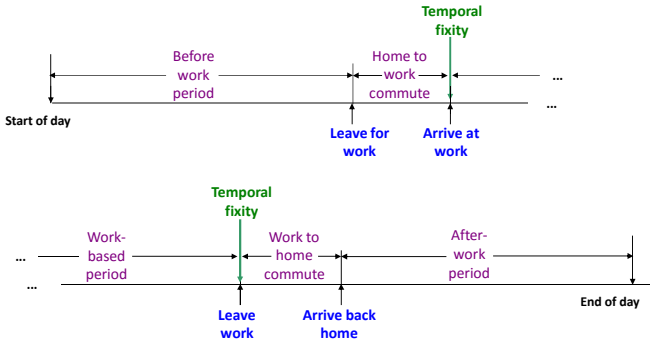
Workers



COLLABORATE. INNOVATE. EDUCATE.

Representing Activity-travel Patterns

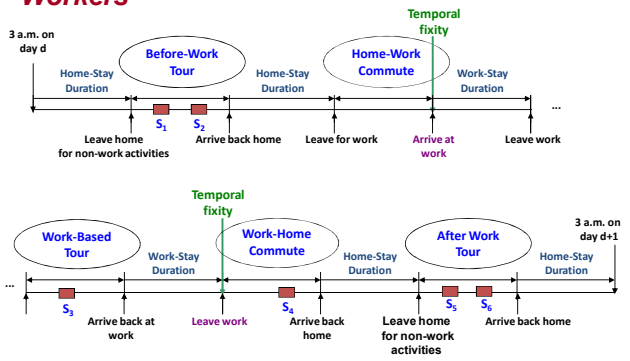
Workers



COLLABORATE. INNOVATE. EDUCATE.

Representing Activity-travel Patterns

Workers



COLLABORATE. INNOVATE. EDUCATE.

Representing Activity-travel Patterns

Workers

- Start and end times of the work activity
- For the Work-Home and Home-Work commutes:
  - Mode(s)
  - Number of stops
  - Duration
- Number of tours
  - Before work, based at work, and after work

COLLABORATE. INNOVATE. EDUCATE.

Representing Activity-travel Patterns

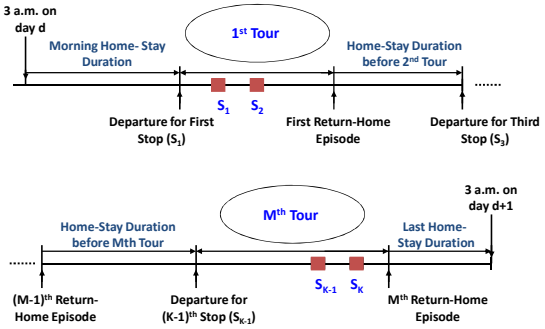
Workers

- For each tour:
  - Mode(s)
  - Number of stops
  - Duration
  - Home-stay duration before tour
  - Work-stay duration before tour
- For each stop:
  - Activity type
  - Activity duration
  - Travel time to activity
  - Location of activity

COLLABORATE. INNOVATE. EDUCATE.

Representing Activity-travel Patterns

Non-Workers



COLLABORATE. INNOVATE. EDUCATE.

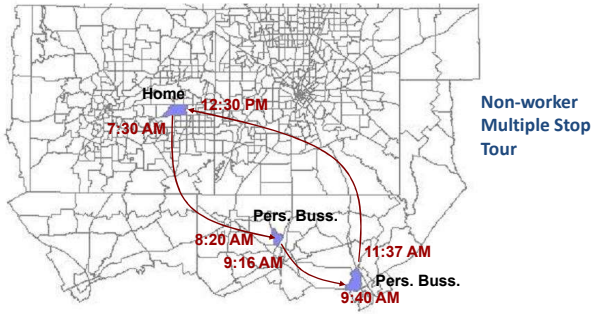
Representing Activity-travel Patterns

Non-Workers

- Number of tours during the day
- For each tour:
  - Mode(s)
  - Number of stops
  - Duration
  - Home-stay duration before tour
- For each stop:
  - Activity type
  - Activity duration
  - Travel time to activity
  - Location of activity

COLLABORATE. INNOVATE. EDUCATE.

A Graphical Illustration



COLLABORATE. INNOVATE. EDUCATE.

IMPORTANT ASPECTS

COLLABORATE. INNOVATE. EDUCATE.

Important Aspects of Activity-Based Approach

- Time and Space
  - The Time Dimension
    - Activity time-use
    - Activity-travel timing
    - Time frame of analysis (multi-day and weekly analysis)
  - Space in activity-based analysis
- Inter-personal Interactions
  - Intra-household interactions
  - Role of children
  - Social networks
  - Workplace interactions

Time: Activity Time-Use Analysis

- Central basis of activity-based approach
  - Individuals' activity-travel patterns are a result of their time-use decisions
  - Time is a limited resource
    - Individuals have to decide how to use the available time for various activities and travel
- Analytic approaches
  - Resource allocation formulation
    - Theoretically driven microeconomic theories of time allocation (e.g. works of Becker, Gronau, Mincer, and DeSerpa)
    - Random utility maximization approaches have been particularly popular (Bhat, 2005; Meloni etal., 2007, Jara-Diaz and Guavera 2003)
    - Empirically-driven efforts to better understand activity-travel behavior (Bhat and Koppelman, 1999; Pendyala and Goulias, 2002; Arentze and Timmermans, 2004)
  - Statistically oriented modeling approaches (Lu and Pas, 1999; Meka et al., 2002; Fujii etal., 1999; Ye and Pendyala, 2005)
- Substantive focus of previous research
  - Activity purpose: Most studies focus on discretionary time-use, few include maintenance as well
  - Trade-off and substitution effects between in-home and out-of-home activity time-use
  - Recent research: Interpersonal dependencies, multiday/weekly time-use

- Research needs:
  - Incorporation of activity time-use models into operational travel demand models
  - Integrated analyses of activity time-use and activity episode settings (i.e., the spatial, temporal, scheduling, sequencing, and social contexts of activity participation)
  - Weekly and longer-term activity time-use analyses
  - Application of economic theory-based formulations for the empirical analyses of activity time allocation, consumption, and travel
  - Time and Money in activity-analysis

Time: Activity-Travel Episode Timing (or Time-of-Day)

- Activity-travel episode timing (or time-of-day) analysis
  - At the heart of several activity-based travel model systems
  - Important to analyze the temporal variations in activity-travel demand
- Earlier research:
  - Largely focused on individuals' trip departure time choice
  - Discrete time modeling approaches
- Recent developments:
  - Tour-based travel timing (e.g. departure and arrival timing) models
  - Continuous time modeling approaches (e.g., hazard-based, fine resolution discrete choice models)
  - Activity-based approach
    - Recognition that activity episode participation and timing decisions govern travel timing decisions
    - Joint time-use and activity episode timing studies
- Continuing work: Incorporation of the impact of time-varying level of service and dynamic congesting pricing policies

Time: Time Frame Analysis

- Importance
  - One-day analysis assumes uniformity in behavior from one day to the next
  - Several activities (shopping, discretionary) have longer time cycle of participation
  - Several policies (e.g. tele-working) result in multi-day shifts in activity-travel patterns
- Recent research provides evidence of
  - Substantial day-to-day dependence and variation (Axhanusen et al., 2002; Bhat et al; Pendyala and Pas, 1997; Hanson and Huff, 1988)
  - Weekly rhythm in shopping and discretionary activities (Bhat et al., 2004; Habib and Miller, 2008)
  - Week-to-week variations (Spissu et al., 2008)
- Current research needs
  - More weekly and multi-week activity scheduling and time-use data collection
  - Integrated weekly-level activity scheduling and time-use and daily-level activity time-use and participation models
  - Activity-travel may be associated with multiple time horizons. It is important to determine the appropriate time frame of analysis.

Space in Activity-Based Analysis

- Spatial analysis in activity-travel analysis refers to:
  - Activity episode location choice
  - Impact of spatial (or location specific) elements on activity-travel patterns
- Current research issues
  - Modifiable Area Unit Problem (MAUP)
    - Sensitivity of analytic results to the definition of spatial units
    - Fundamental reason behind MAUP is the inconsistency between individuals' **spatial perception** and analysts' **spatial representation** in analytic models
  - Spatial Perception and Cognition
    - Not adequate research has focused on understanding people's mental perceptions of the spatial attributes of the environments in which they live in, work at, and travel to.

Space in Activity-Based Analysis

- Spatial effects
  - Quite ubiquitous in urban and economic data, whether the data is in aggregate form or in disaggregate form.

(1) Spatial dependency (spatial auto-correlation) refers to the tendency of the data points to be similar when closer in space.

- Diffusion effects, social interaction effects, or unobserved location-related effects influencing the level of the dependent variable.

(2) Spatial heterogeneity refers to differences in the data-generating urban process over space due to location-specific effects.

- Intrinsic behavioral differences in the process across spatial units.
- Lack of information (on the part of the analyst) regarding some process-related or spatial-unit related attributes.

(3) Spatial heteroscedasticity refers to heterogeneity in the variance of the unobserved process across spatial units.

Space in Activity-Based Analysis

- Spatial configuration issues in activity-based models
  - Since 1950s the spatial configuration of a region has been represented in the form of spatial units, labeled as Traffic Analysis Zones(TAZs)
  - However, the shift to activity-based paradigm has been accompanied by the consideration of finer spatial resolution of areal units (e.g. parcels)
  - Advantages:
    - More accurate representation of spatial elements and network attributes (transit stop accessibility etc.)
    - Potentially improved accuracy and high resolution forecasts
  - Challenges:
    - Increased data collection, storage, and computation requirements
    - Is finer resolution necessarily better?
    - A single spatial scale may not be appropriate for all activity-travel decisions
  - Future work
    - Determine the appropriate spatial configuration
    - Move toward person-specific spatial representation

Inter-Personal Interactions

- Since the turn of the century, and in recent years, the role of inter-personal interactions has started gaining increasing attention
- Four important sources of inter-personal interactions
  - Household members (Intra-household interactions)
  - Children
  - Social networks
  - Work-place

COLLABORATE. INNOVATE. EDUCATE.

Inter-Personal Interactions: *Intra-Household Interactions*

- Intra-household interactions play a major role in shaping individuals' activity-travel decisions
  - Sharing and allocation of responsibilities and resources
  - Facilitation of activity participation and travel needs of mobility dependent household members (children, elderly, etc)
  - Joint activity engagement and travel
- Since the turn of the century, increasing number of empirical studies on
  - Activity/task allocation
  - Joint activity-travel engagement
  - Children's activity travel arrangements
- Future work:
  - Better understanding of vehicle allocation among household members
  - Negotiation and altruistic processes leading up to observed activity-travel patterns
  - Joint /Group decision making modeling frameworks

COLLABORATE. INNOVATE. EDUCATE.

Inter-Personal Interactions: *Children*

- Children's activity-travel needs affect adult's activity-travel patterns through:
  - Generation of baby-sitting and/or day-care needs
  - Generation of serve passenger (or escorting) trips
  - Joint activity engagement (shopping, going to park, walking together, etc.)
- Current approach is to include children related exogenous variables (e.g. presence of children) in activity models
- Ongoing research:
  - Impact of children on adult activity and travel patterns
  - Reverse impact of adult activity-travel patterns on children's activity-travel patterns
  - Non-school activity-travel modeling: Non-school travel mode choice, Joint non-school activity-travel engagement
  - Need travel representation frameworks that explicitly recognize adult-children, and children-children interactions

COLLABORATE. INNOVATE. EDUCATE.

Inter-Personal Interactions: *Social Networks*

- Recently emerging field, likely to gain more importance in coming years
- Examples of social networks
  - Friends, Relatives, Neighborhoods, Virtual acquaintances, etc.
- Importance and advantages
  - Social networks shape individuals' activity-travel patterns, including:
    - Activity-travel generation, scheduling, route, & location choices
  - Behavioral realism:
    - For example, understanding the dynamics of social networks (formation of new social links & dissolution of old links) can inform the activity-travel engagement dynamics
  - Potential decrease in computation time due to potential winnowing down of the number of feasible spatial activity location alternatives
- Immediate Needs
  - Design and administer surveys to capture social network data
  - Exploratory analyses of the influence of social networks in activity-travel patterns

COLLABORATE. INNOVATE. EDUCATE.

Inter-Personal Interactions: *Work Place*

- Work-related interactions arise due to :
  - Interactions with co-workers, and
  - Interactions at the professional network-level (e.g., this workshop)
- Importance
  - People spend a significant amount of time at work place (8 hours = 1/3rd of a day)
  - Work place and related interactions may have a significant role in activity-travel engagement
  - Important to analyze the effectiveness of travel demand management policies
- Current approach
  - Work place treated as a mere "trip attractor" or a "spatial peg"
  - Work flexibility, weekly work duration, etc., are used as exogenous variables
- Research needs
  - Exploratory and descriptive analyses of work place-based interactions
  - Work-based activity generation and scheduling frameworks
  - Integrated household and work place-based activity-travel surveys, representation, and modeling frameworks

COLLABORATE. INNOVATE. EDUCATE.

ACTIVITY-BASED TRAVEL FORECASTING SYSTEMS

COLLABORATE. INNOVATE. EDUCATE.

Classification

- Most activity-based travel forecasting models developed to date can be classified into:
  - Econometric modeling-based forecasting systems
  - Rule-based computational process model systems
  - The above modeling approaches have not been mutually exclusive
- Further, along with econometric utility-based and/or rule-based frameworks, other modeling frameworks or approaches used include:
  - Time-space prisms and constraints (e.g. FAMOS, CEMDAP)
  - Hazard-based duration models (e.g. CEMDAP)
  - Psychometric methods (e.g. SCHEDULER)
  - Cellular automata (e.g. TRANSIMS)
  - Agent-based (TRANSIMS, MATSIM, ALBATROSS)
  - Operations research (e.g. HAPP)

COLLABORATE. INNOVATE. EDUCATE.

- Modeling hierarchy in modeling systems
  - Population synthesis
  - Long-term choice models
    - Work/school location
    - Vehicle ownership
  - Activity/tour generation
    - Person-day pattern models
  - Tour-level models
  - Trip-level models

See here for example modeling hierarchies

COLLABORATE. INNOVATE. EDUCATE.

THE UNIVERSITY OF TEXAS AT AUSTIN CENTER FOR TRANSPORTATION RESEARCH

Activity Models Data Needs: Facts and Myths

- Data needs for model building
  - Activity-travel or travel survey data
    - Household travel surveys
    - On-board transit surveys for mode choice
    - Stated preference data to augment the revealed preference data
  - LOS data (skims by time-of-day and mode)
  - Zonal (or parcel) level land-use data
  - **Data not different from what is readily available and used for trip-based model building process. For example:**
    - MORPC model: Travel survey data of 5500 households
    - CEMDAP: Travel survey data of 3500 households
  - Data processing is different; activity-based models involve intensive processing of the data to construct tours and joint activity-travel engagement patterns.
- Data needs for model application
  - Detailed socio-demographics (each and every individual of the study area)
    - Synthetic population generators are used to generate a prototypical sample
  - LOS and land-use data

COLLABORATE. INNOVATE. EDUCATE.

THE UNIVERSITY OF TEXAS AT AUSTIN CENTER FOR TRANSPORTATION RESEARCH

Data Needs for Estimation of ABMs

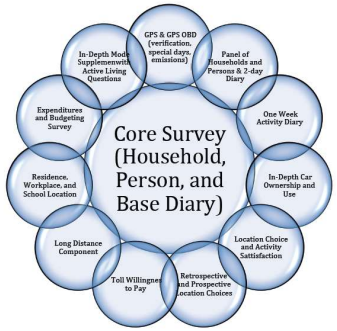


Figure 4 The Data Collection Overall Scheme

COLLABORATE. INNOVATE. EDUCATE.

THE UNIVERSITY OF TEXAS AT AUSTIN CENTER FOR TRANSPORTATION RESEARCH

One Week Activity & Travel Diary

- Account for day-to-day variation in activity scheduling and travel and attempt to
- Identify shifting of tasks and activities from one day of the week to the next
- Design to capture the behavioral processes of scheduling activities, and planning and subsequent re-scheduling modifications

COLLABORATE. INNOVATE. EDUCATE.

THE UNIVERSITY OF TEXAS AT AUSTIN CENTER FOR TRANSPORTATION RESEARCH

Toll Willingness To Pay

- Attitudes and willingness to pay for tolls on highways
- Develop behavioral equations of the willingness to pay
- Large scale regional simulation models to develop pricing strategies
- (Bhat and Castellar, 2002; Bhat and Sardesai, 2006).

COLLABORATE. INNOVATE. EDUCATE.

GPS and GPS OBD

- Develop a database to correlate destinations to routes and identify a typology of different types of routes and stop making patterns
- Develop a route choice model
- Estimate the level and nature of misreported trips by different modes of the main two-day activity diary
- Verify day-to-day behavioral change in other survey components and day of the week effects and provide detailed operating characteristics of the household vehicles

NOTE: This component for persons carrying GPS devices (wearable GPS) can also be supplemented with an online diary and vehicle mounted GPS (week long to capture day to day variation) and On-Board Diagnostics devices (to identify driving patterns and correlate/link them with emissions models).

COLLABORATE. INNOVATE. EDUCATE.

Mode Supplement

- Modes for active living studies.
- The survey objective is to identify situational constraints, attitudes, and predispositions in favor or against modes such as walk, bike and public transportation.
- Create models to study policy actions that go beyond the time cost-comfort analysis.
- Add a stated choice, intentions, and preference component to this module.
- Emphasis on collecting data about walking and biking either as a main mode for each trip or as an access mode to another main mode (e.g., walking from a parking lot to an office, biking to a bus top and then taking the bus).

COLLABORATE. INNOVATE. EDUCATE.

Residence, Workplace, and School Location Choice:

- Critical survey component for behaviorally integrated land use travel demand models
- In-depth survey to identify the determinants for each of the residential, workplace, and school choices (see Kortum et al., 2012)
- Both primary locations and secondary locations should be examined in more detail than typical household surveys and data collected to estimate choice models for each facet
- Examine behavior retrospectively and prospectively
- Possibly add questions about personal biography of each household member using techniques that are not used by typical household surveys (e.g., ethnography)

COLLABORATE. INNOVATE. EDUCATE.

In Depth Car Ownership Change and Car Assignment

- Identify the determinants for each of the car ownership, car type (e.g., new/used, model, make, and fuel type), and car assignment decisions
- In the car assignment data collection, both the primary and secondary drivers should be identified
- Identify determinants of changes in car ownership, type, and assignment of cars to household members
- Particular emphasis should be given to policy controlled determinants (e.g., taxation, incentives)
- One approach to study this latter part is using combinations of revealed and stated preference surveys.

COLLABORATE. INNOVATE. EDUCATE.

Activity Satisfaction Survey

- Provide a benchmark for the diary instrument
- Create an assessment of activities (including trips) and subjective experiences that is able to capture preferences, satisfaction, and perceived quality of life
- This second set of objectives will enable estimation of choice models with latent variables and classes that are by far richer and more informative than their counterpart observed variable discrete choice models

COLLABORATE. INNOVATE. EDUCATE.

Destinations & Perceptions

- We know that places have symbolic and other meanings that travel behavior models neglect
- This component identifies how destinations are perceived and what role these perceptions play in their selection
- Major aspects = mental maps and sense of place

COLLABORATE. INNOVATE. EDUCATE.

Panel of Households and Persons and Multi-Day Activity

- Undecided: would like a Mobidrive (6 weeks)
- Would also like year to year evolutionary measurement
- Most likely a rotating panel of longer than one week duration

COLLABORATE. INNOVATE. EDUCATE.

Energy Use and Expenditures

- Link housing to transportation demand
- Develop more complete household Greenhouse footprints
- Develop models of comprehensive accounting of energy demand
  - Annual, monthly, or even weekly expenditures for activity participation, travel, and vehicles and housing units maintenance ownership and energy consumption are not collected in typical travel surveys
  - This component will provide the data needed to enable a direct association between travel and at home energy consumption to eventually create models of the type in Fissore et al. (2011).

COLLABORATE. INNOVATE. EDUCATE.

Data Needs for Application of ABMs

- Base year application of these advanced models requires as inputs the information on all individuals and households of the study area for the base year
- Synthetic population generation techniques are used for this purpose, sometimes supplemented with a series of other demographic models
- For a future year forecasting exercise, the inputs should consist of the future year synthetic population and land-use and level-of-service data.
- Thus, advanced travel demand model development should be supported with the development of detailed input data (i.e., the synthetic population, level-of-service and land-use data) for future years

COLLABORATE. INNOVATE. EDUCATE.

Data Needs for Validation of Input Data

- The base year synthetic population inputs can be validated against the census data
- To validate the input work locations, the home-work trip lengths and patterns can be matched against that in the census data
- To validate the vehicle ownership inputs, census data and perhaps other sources such as motor vehicle department estimates of auto registrations can be used

COLLABORATE. INNOVATE. EDUCATE.

Data Needs for Calibration and validation of activity-travel outputs: Base Year Conditions

- The base year synthetic population inputs can be validated against the census data
- To validate the input work locations, the home-work trip lengths and patterns can be matched against that in the census data
- To validate the vehicle ownership inputs, census data and perhaps other sources such as motor vehicle department estimates of auto registrations can be used

COLLABORATE. INNOVATE. EDUCATE.

Data Needs For Calibration and validation of activity-travel outputs: Non-Base Year Conditions

- Can be compared with the observed patterns in those years
- For this purpose, complete input data
  - including the aggregate socio-demographic variable distributions for synthetic population generation
  - the land-use and level-of-service data
  - observed traffic volumes
  - household activity and/travel survey data
  - the Census data (if available) are required for past years and existing "future" years
- Thus, it is important that the regional planning agencies store and document the land-use data and transportation network data of past and existing "future" years

COLLABORATE. INNOVATE. EDUCATE.

INTEGRATION WITH OTHER MODEL SYSTEMS

Integration with Other Models

- Integrated land-use and activity-based travel demand models
- Integrated activity-based travel demand and dynamic travel supply models
- The need for integration
  - Capture interactions among socioeconomic processes, land-use, and travel behavior processes
  - Understand and model all the decision-makers, including individuals and households, businesses, employers, and real estate developers

- Specific needs
  - Generation of socio-demographic, and other decision-maker (businesses, employers, and real estate developers) information over a long-range multi-year time frame
    - Socio-demographic evolution models
    - Evolution of businesses and other players over time
  - Making connections between long-term, medium-term, and short-term decisions
    - Need longitudinal studies to better understand the connections
  - Understand and model interactions between households and other decision-makers
  - Understand and capture demand and supply interactions
    - Integration of activity-based travel demand and dynamic traffic assignment models
    - Development of individual-specific route choice models that take transport system capacity constraints into account
    - Understand the housing and labor market supply and demand interactions

THANK YOU