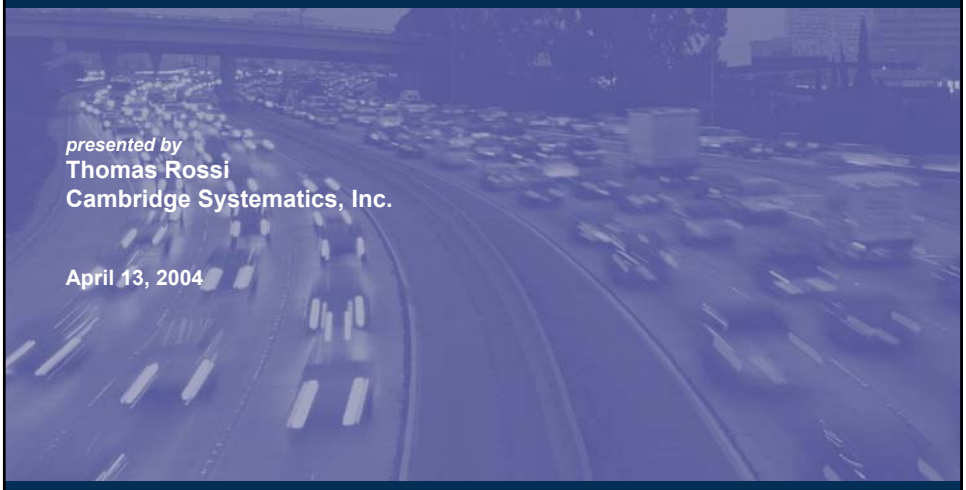
# Activity and Tour Based Modeling Seminar



*presented by*
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## Seminar Objectives

- Understand the limitations of traditional trip based models
- Learn about existing activity and tour based modeling procedures
- Understand the concepts behind such models
- Identify the ways in which these models are estimated and the data requirements
- Discuss how activity and tour based models can be applied

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# What Do You Know About Activity and Tour Based Modeling?

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## Two "New" Types of Models

- Tour based models
  - Unit of travel is tour (beginning/ending at home) rather than trip
  - Characteristics (mode, destination, time of day) of trips in a tour are modeled as related
- Activity based models
  - Demand is assumed to be for trip making, rather than activities
  - Activity patterns with locations converted to tours

*All activity based models are tour based, but not all tour based models are activity based*

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## The Role of Modeling in Transportation Planning

- Development of transportation plans
- Analysis of proposed transportation improvement projects
- Analysis of proposed transportation policies
- If conformity issues exist, needed for air quality analysis
- Land use planning

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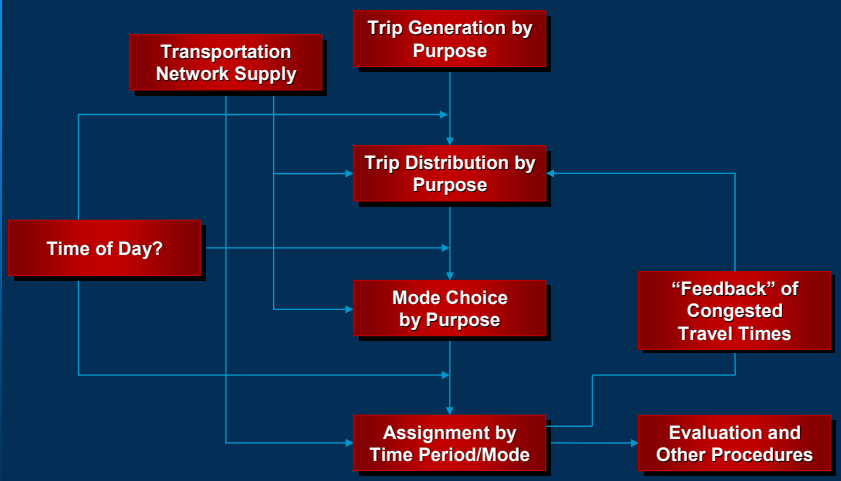
## The Four-Step Modeling Process
### An Old Friend?

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# What Types of Models Do You Use Now?

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## What are the Limitations of Your Trip Based Models?

- Analytical
- Data

## What Assumptions Do You Make?

- How comfortable are you with them?

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## Some Limitations of Trip Based Models

- Aggregation errors, many caused by the use of zones
- Trips are treated as independent of one another
- Sequential nature of four-step process

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## Some More Limitations of Trip Based Models

- Behavior modeled in earlier steps unaffected by choices modeled in later steps
- Effects of changes in transportation system not modeled in all steps
- Lack of sensitivity of trip generation to accessibility/cost (no induced travel)

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## Even More Limitations of Trip Based Models

- Demand is assumed to be for trip making, rather than activities
- Limited number of segmentation variables can be considered
- Limitations on types of policy analyses that can be considered

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## Analyses That Cannot Be Done Using Conventional Models

- Effects of level of service changes for one trip on other trips in a tour
- Effects of level of service changes for one person on others in household
- Identification of specific persons/households affected by policy actions

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## The Four-Step Modeling Process
### An Old Friend?

How Old

How Friendly

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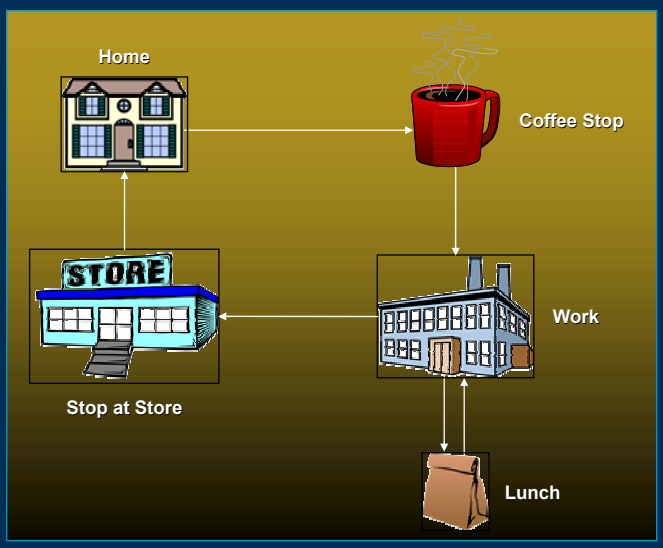
## Concept of Tours

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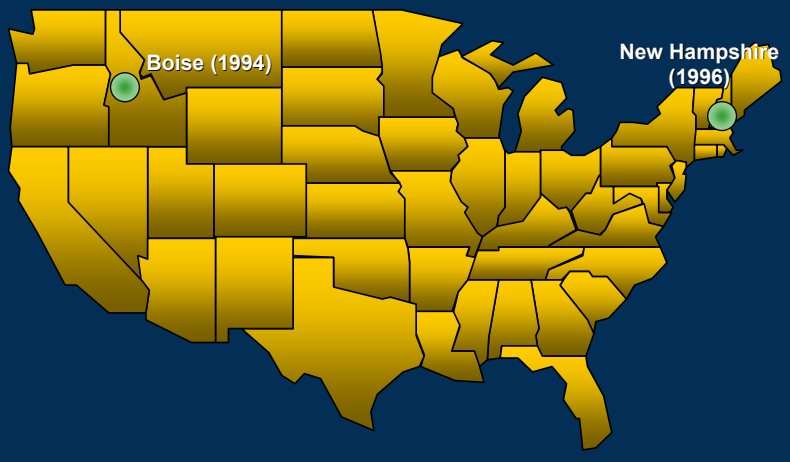
## First United States Tour Based Models

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## First United States Tour Based Models

- Boise
  - Developed by Cambridge Systematics for Ada County
- New Hampshire
  - Developed by Cambridge Systematics for New Hampshire Department of Transportation

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## Early Tour Based Models
### Prior to United States Implementation

- Dutch national model
- Stockholm, Sweden

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## Features of First Working Tour Based Models
### Tour Level

- Number of tours by type/purpose
- Number of intermediate stops for each tour
- Tour primary destination choice
- Tour level mode choice

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## Features of First Working Tour Based Models
### Trip Level

- Location of intermediate stops (trip destination choice)
- Trip level mode choice

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## Correspondence Between Four-Step and Tour Based Models
### Trip Generation

- Number of trips by purpose could be derived from
  - Number of tours by purpose
  - Number of intermediate stops for each tour
- Home based work trips
  - "Half tours" between home and work with no intermediate stops
- Home based non-work trips
  - All other initial and final legs of tours
- Non-home based trips
  - Trips between primary destinations/intermediate stops

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## Correspondence Between Four-Step and Tour Based Models
### Trip Distribution

- Primary destination choice for tour
- Destination choice for intermediate stops (dependent on locations of home and primary destination)

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## Correspondence Between Four-Step and Tour Based Models
### Mode Choice

- Mode choice for tour (whether automobile is brought)
- Mode choice for intermediate stops (dependent on tour level mode choice)

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## Tour Generation Models

- Models for each defined tour purpose
- Multinomial logit specification
- Inputs
  - Primary destination choice utility logsum (induced travel)
  - Socioeconomic characteristics of traveler/household
- Output
  - Number of tours by purpose

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## Tour Generation Model Example
### New Hampshire Model – Work Tours
### One and Two Person Households

| Variable | Zero Tours | One Tour | Two Tours | Three Tours |
|---|---|---|---|---|
| Constant | 0 | -2.345 | -7.840 | -12.60 |
| Workers | 0 | 3.018 | 6.070 | 7.555 |
| Income Category | 0 | 0.08215 | 0.1702 | 0.1702 |
| Summer Dummy | 0.7535 | 0 | 0 | 0 |

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## Tour Stops Models

- Models number of stops and work subtours
- Multinomial logit specification
- Inputs
  - Intermediate stop destination choice utility logsum
  - Socioeconomic characteristics of traveler/household
- Output
  - Number of stops and subtours

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## Tour Stops Model Example
### New Hampshire Model – Work Tours

| Variable | Zero Stops Zero Sub | Zero Stops One Sub | One Stop Zero Sub | One Stop One Sub | Two Stops Zero Subs | Two Stops One Sub |
|---|---|---|---|---|---|---|
| Constant | 0 | -3.695 | -1.534 | -3.738 | -2.554 | -4.378 |
| Vehicles | 0 | -0.0957 | 0 | -0.0957 | 0 | -0.0957 |
| Workers | 0 | -0.2377 | -0.2377 | -0.2377 | -0.2377 | -0.2377 |
| ln (Income) | 0 | 0.5966 | 0.3521 | 0.5573 | 0.5996 | 0.9116 |
| SF Dummy | 0 | -0.3018 | 0 | -0.3018 | 0 | -0.3018 |

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## Destination Choice Models

- Combine trip attraction and trip distribution components of four-step models
- Multinomial logit specification
- Models estimated/applied at two levels
  - Tour level
    - The location of the primary activity of tour
  - Trip level
    - The locations of intermediate stops on tour
- Singly constrained models (as are trip based logit destination choice models) although artificial constraints can be used if there is feedback

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## Primary Destination Choice Models

- Separate models by tour purpose
- Alternatives are the destination zones
- Other inputs
  - Socioeconomic characteristics of traveler/household
  - Land use data (employment, etc.)
  - Travel impedance captured using the mode choice utility logsum

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## Intermediate Stop Destination Choice Models

- Alternatives are the zones for intermediate stops
- Inputs to multinomial logit
  - Socioeconomic characteristics of traveler/household
  - Land use data (employment, etc.)
  - 'Additional' time (impedance) to each sampled destination
- Output
  - Zone for trip destination

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## Tour Level Mode Choice Models

- Nested logit mode choice models, one per tour purpose
- Alternatives
  - Auto, transit, sometimes non-motorized, and park-and-ride
- Inputs
  - Socioeconomic characteristics of traveler/household
  - Land use data
  - Number of stops on tour
  - Level of service skims by time period (best available transit path)
  - Considers both Origin (O) → Destination (D) and D → O level of service
- Output
  - Mode for tour

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## Trip Mode Choice Models

- Nested or multinomial logit models, one per tour purpose
- Inputs
  - Socioeconomic characteristics of traveler/household
  - Land use data
  - Mode of tour
  - Level of service skims (for O-D trip leg) by time period
- Output
  - Mode for each trip on tour

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## Trip Assignment

- Basically the same as for trip based models
- O-D trip table matrices must be created from information on tours and stops

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## Time of Day

- Early United States models did not include time of day
- Tour level time of day
  - Departure time from home
  - Arrival time back at home
  - Information on timing/duration of primary activity
- Trip level time of day (for each stop)
- Multinomial logit models
- May be modeled before destination or mode choice

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## Other Tour Model Components

- Auto ownership model
- External travel model
  - Usually treated as trip based for non-residents (no data for tours)
  - Can be treated as either trip or tour based for residents, but no data on external destinations
- Commercial vehicle model
  - Usually treated as trip based

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## Tour Based Modeling
### Data Requirements

- Basically the same as for trip based models
  - Household/traveler characteristics
  - Origin, destination, mode, etc. for all trips
  - Which tours comprise trips (available from household surveys)
- Data preparation
  - Arrange travel into tours and trips within tour
  - Classify households by structure/lifecycle
  - Classify persons by age, worker status, household structure/lifestyle

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## Tour Based Modeling
### Model Estimation

- Same type of estimation process as four-step models (logit estimation software)
- Many more models to estimate compared to four-step
- Data can be stretched thin – be careful with specification

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## Tour Based Modeling
### Model Application

- Could use aggregate, sample enumeration, or microsimulation approach
- Some modeling software beginning to incorporate tour based approach
- Probably need custom software (can draw on existing tour based models)
- Run times can be significantly longer, depending on efficiency of programming

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## Tour Based Modeling
### Model Validation

- Most validation tests of trip based models can (and should) be performed for tour based models:
  - Volume/VMT/screenline comparisons to counts
  - Trip length frequencies
  - Mode shares
  - Tests of input data
  - Comparisons of base and forecast years
- Other tests should also be performed:
  - Trips per tour by purpose
  - Tours per household by purpose, etc.

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## Tour Based Modeling
### Summary

- Model structure
  - Generally known
- Model estimation procedures
  - Generally same as trip based models
- Data requirements
  - Generally same as trip based models
- Data processing
  - Significantly greater than trip based models
- Run times
  - Significantly greater than trip based models
- Analytical capabilities
  - Greater than trip based models

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## Definition of Activity Based Modeling

- Treatment of travel as a demand derived from the desire to participate in other activities
- Focus on sequences/patterns of behavior
- Households as decision-making units
- Examination of timing and duration of activities and travel
- Incorporation of spatial, temporal, and interpersonal constraints
- Recognition of interdependence of events
- Use of household/person classification schemes based on differences in activity needs, commitments, and constraints

*Source: Kitamura (1996).*

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## Activity Based Modeling
### Relation to Tour Based Modeling

- All activity models are tour based, but not all tour based models are activity based
- Daily activity patterns have related travel patterns, which are expressed as tours
- Tours, as sequences of trips, can be modeled without modeling the underlying activity patterns (although most modern models are activity based)

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## Two Types of Activity Based Models

| Model Type | Econometric | Hybrid Simulation |
|---|---|---|
| Search Stage | Exhaustive (Feasible) or Simple Heuristic | Complex Search Heuristic |
| Choice Stage | Utility Maximization | Utility or Satisfaction |
| Application | Probabilistic | Rule Based |
| Implementation | Calculated Probabilities or Realization | Realization |

*Source: Based on Bowman and Ben-Akiva (1996).*

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## Activity Based Models
### Terminology

- In-home activities
- Activity opportunity
  - Location in time and space where an activity can be pursued
- Duration
  - The length of time an activity is performed (excluding travel to/from the activity)
- Daily activity schedule
  - A listing of activities to be pursued by an individual during the day along with their locations in time and space

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## Activity Based Models
### Early Research

- Oi and Shuldiner (1962)
  - Introduced concept of travel as a derived demand
- Hagerstrand (early 1970s)
  - Delineated systems of constraints on activity participation
- Chapin (early 1970s)
  - Identified patterns of behavior across time and space
- Jones/Heggie (late 1970s/early 1980s)
  - In depth interviews with small samples
  - Gaming simulation

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## Activity Based Models
### Concepts up to the Early 1990s

- Bowman and Ben-Akiva
  - Classified as econometric
  - Introduced the concept of the daily activity pattern model
  - Incorporated time of day decision
  - Identified daily activity pattern, primary activity, primary tour type, and number/purpose of secondary tours
  - Implemented as system of nested logit models

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## Activity Based Models
### Concepts up to the 1990s

- Satisficing approaches
  - STARCHILD (1986 – Recker, McNally, Root)
  - MIDAS (1992 – Goulias and Kitamura)
  - SMASH (1993 – Ettema, Borgers, Timmermans)
  - AMOS (1995 – Kitamura, Pendyala, Pas et al)
  - FAMOS (Ongoing – Pendyala, Kitamura et al)

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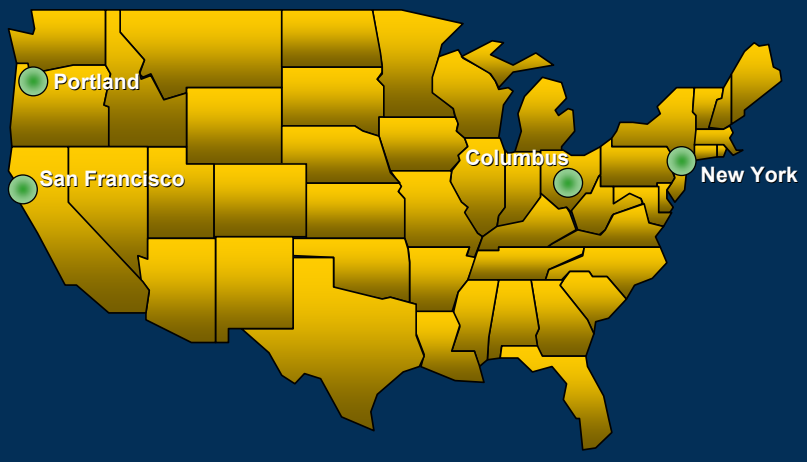
## Examples of Activity Based Models

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## Examples of Activity Based Models

- Portland
  - Developed by Portland Metro, Mark Bradley, John Bowman, Cambridge Systematics
- San Francisco
  - Developed by Cambridge Systematics, Parsons Brinckerhoff, and Mark Bradley for San Francisco County Transportation Authority

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## Examples of Activity Based Models

- New York
  - Developed by Parsons Brinckerhoff with AECOM, Cambridge Systematics, Urbitran, Urbanomics, Alex Anas, NuStats, George Hoyt for New York Metropolitan Transportation Council
- Columbus
  - Developed by Parsons Brinckerhoff and Mark Bradley for Mid-Ohio Regional Planning Commission

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## Other Examples of Activity Based Models

- ALBATROSS (Netherlands) – Arentze, Timmermans, Hofman
- TRANSIMS – Developed by Los Alamos National Laboratories for U.S. Department of Transportation

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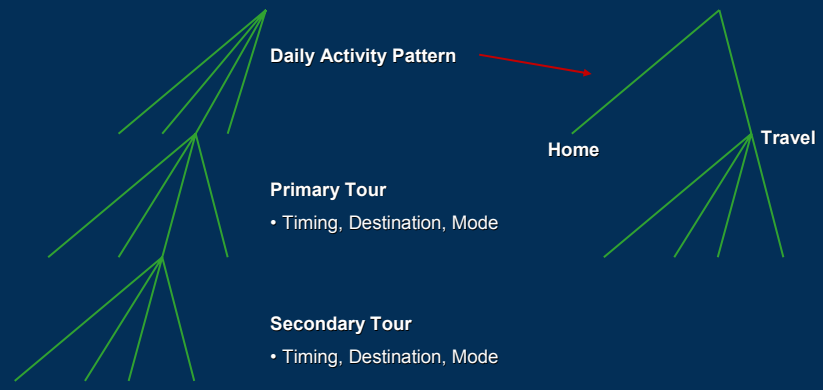
## Daily Activity Schedule




*Source: Bowman and Ben-Akiva (1996).*

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## In-Home Activities

- Choice between in-home and out-of-home activities may be affected by transportation system
- HOWEVER, to model this choice, need survey data on in-home activities
- Note that in-home includes not only technology driven activities (telecommuting, shopping on-line, etc.) but more "traditional" activities such as recreation

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# Activity Based Models
## Time of Day Modeling

- As in tour based modeling, need to jointly model start/end times of tours and of intermediate stops
  - Start time of activity = arrival time of trip
  - End time of activity = departure time of trip
- Since activities are being modeled, activity durations are being modeled
- Tours can take a long time!
  - Cannot assign (as is done with trips) tours to individual time periods
  - Start/end time period combination defines alternatives

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# Example Time of Day Model
## Portland

| Time Periods | |
|---|---|
| EA | 3:00 A.M.-6:59 A.M. |
| A.M. | 7:00 A.M.-9:29 A.M. |
| MD | 9:30 A.M.-3:59 P.M. |
| P.M. | 4:00 P.M.-6:59 P.M. |
| LA | 7:00 P.M.-2:59 A.M. |

EA = Early
MD = Midday
LA = Late

| Definitions of Alternatives | | | | |
|---|---|---|---|---|
| (1) EA-EA | (2) EA-A.M. | (3) EA-MD | (4) EA-P.M. | (5) EA-LA |
| | (6) A.M.-A.M. | (7) A.M.-MD | (8) A.M.-P.M. | (9) A.M.-LA |
| | | (10) MD-MD | (11) MD-P.M. | (12) MD-LA |
| | | | (13) P.M.-P.M. | (14) P.M.-LA |
| | | | | (15) LA-LA |

*Source: Bradley, Cambridge Systematics, and Portland Metro, 1998.*

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# Example Time of Day Model
## Portland (continued)

- Conditional on tour type, purpose, importance, person/household variables
- Logit models with logsums from mode/destination choice

*Source: Bradley, Cambridge Systematics, and Portland Metro, 1998.*

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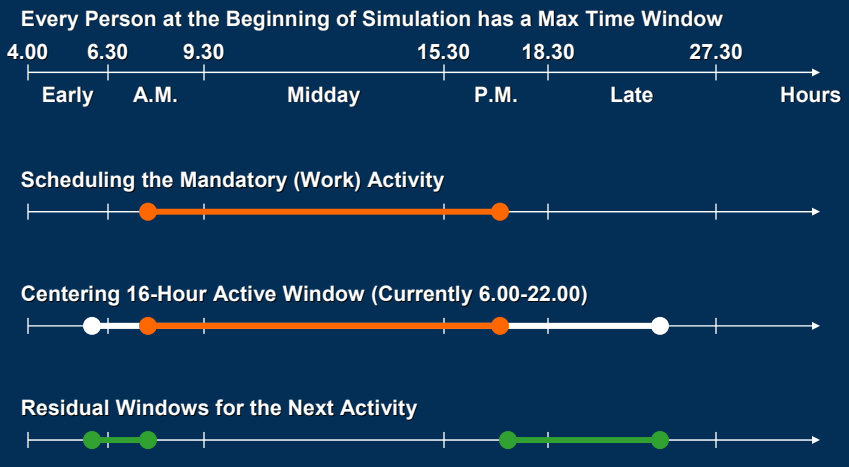
# Example Time of Day Model
## Columbus




*Source: Anderson, Al-Akhras, Gill, and Donelly, 2003.*

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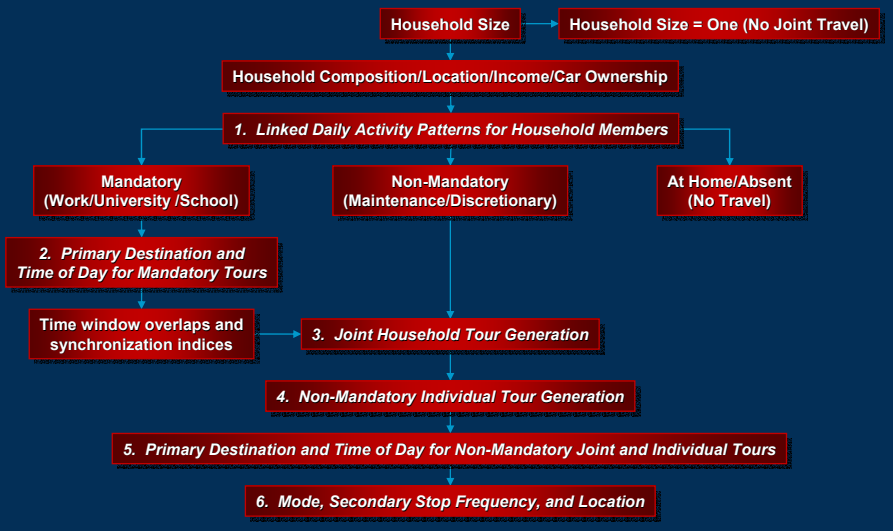
# Joint Activities/Intra-Household Interactions




*Source: Anderson, Al-Akhras, Gill, and Donelly, 2003.*

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# Example of Joint Household Travel Modeling
## Columbus

- Fully joint tours generated by shared non-mandatory activity
- Partially joint tours (pick-ups/drop-offs) generated by synchronized mandatory activities (work/school)
- Fully and partially joint tours generated by altruistic escorting

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## Dynamic Transition and Static Models

- Longer term decisions
  - Dynamic models (panel data)
    - Residential choice
    - Workplace choice
    - Car ownership
    - Household demographic transitions
- Shorter term decisions
  - Daily activity patterns and related travel
- Examples
  - MIDAS, DEMOS

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## Activity Based Modeling
### Data Requirements

- Origin, destination, mode, etc. for all trips
- Activity based household surveys (already used in many MPOs)
- For switching/satisficing models, may need stated preference surveys
- For some types of models (e.g., MIDAS), need panel survey data
- The future – process data?

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## Activity Based Modeling
### Data Requirements – Types of Surveys

- Activity diary
- Location diary
- Longitudinal (panel) survey
- Stated preference survey

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## Activity Based Modeling
### Model Estimation

- Logit models estimated with estimation software
- More models to estimate compared to four-step or tour based
- Data can be stretched thin – be careful with specification

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## Activity Based Modeling
### Model Application

- Could use sample enumeration, but modern models use microsimulation
- Modeling software does not yet accommodate activity based approach – can use for assignment and network and matrix maintenance
- Need custom software (can draw on existing activity based models)
- Run times can be much longer, depending on efficiency of programming
  - Microsimulation requires multiple runs (see next session)

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## Activity Based Modeling
### Model Validation

- Most validation tests of trip and tour based models can (and should) be performed for activity based models:
- Other tests should also be performed:
  - Activities per person and tour
  - Comparison of modeled joint participation to observed
  - Comparison of modeled time at home to observed
  - Checks of activities generated but not satisfied

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## Microsimulation of Households/Persons

- Conventional models are aggregate
- We model groups of "similar" households and attribute *the same behavior to all of them*
- It is possible to model the behavior of individual households and persons

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## Synthetic Population/Households

- How to define households and persons
  - Number of persons
  - Workers
  - Ages
  - Income
- Data sources
  - Census
    - PUMS
    - CTPP
    - SF1, SF3
  - Household survey
- How to derive
  - Iterative proportional fitting
  - Random sampling from survey or PUMS data

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## Application of Microsimulation Approach

- Compute probabilities for each choice
- Apply Monte Carlo simulation, based on the choice probabilities, to determine behavior
- Run models multiple times (varying random number seeds) to obtain reasonable average results

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## Replicability of Results

- In aggregate and probabilistic models applied using probabilities directly, results are the same every time model is run
- When Monte Carlo simulation is used, results differ (unless random number seed is kept constant)
- To obtain "average" results, need to run model several times
  - Castiglione et al suggest that 10-20 runs are needed to stabilize at the zone level, 5-10 runs for neighborhoods
  - Number of runs will vary depending on level of detail
- Are the differences between scenario results within the simulation error?

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## Resource Issues

- Run times, even without repeated runs to stabilize results, can be long
  - Simulation of choices of every person (possibly millions) in region
  - Efficiency of custom programs
- Hardware requirements significantly greater than for traditional aggregate models

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## Activity Based Modeling
### Summary

- Model structure
  - Most working United States models are based on either the Ben-Akiva/Bowman daily activity pattern approach or the approach used by Vovsha et al, but other approaches have been successfully tested
- Model estimation procedures
  - Discrete choice models similar to trip based models, rule based approaches
- Data requirements
  - Need activity patterns, in some models may need longitudinal data

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# Activity Based Modeling
## Summary (continued)

- Data processing
  - Significantly greater than trip based models
- Run times
  - Significantly greater than trip based models
- Analytical capabilities
  - Significantly greater than trip based models

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# Stockholm Tour Based Model
## 1994


*Source: Algers et al, 1995.*

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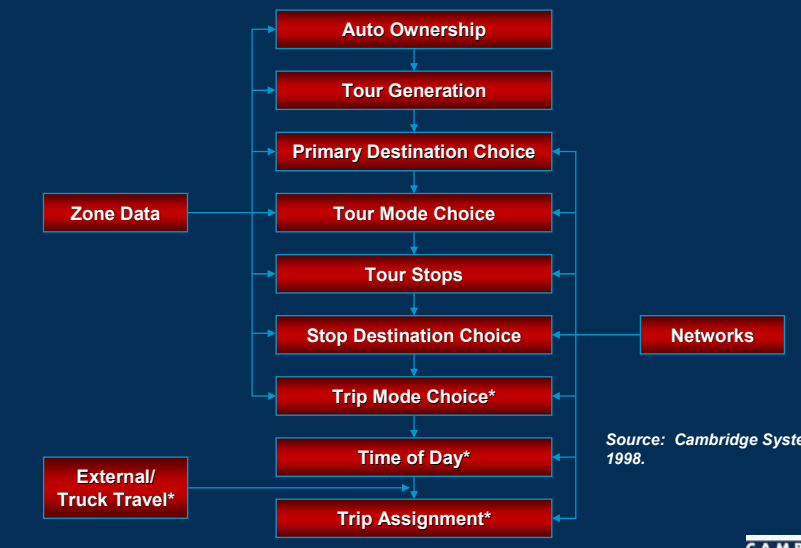
## New Hampshire Statewide Model Structure




*Source: Cambridge Systematics, 1998.*

* Module Run Using EMME/2.

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## San Francisco County Model

- Suite of C++ programs developed for other model components
  - Synthetic sample of households/persons
  - Work location model
  - Vehicle availability model
  - Tour/trip generation and time of day models (full day activity pattern)
  - Tour destination choice/tour mode choice models
  - Intermediate stop destination choice models
  - Trip mode choice models, writes TP+ trip tables
- TP+ software used for skim building, assignment

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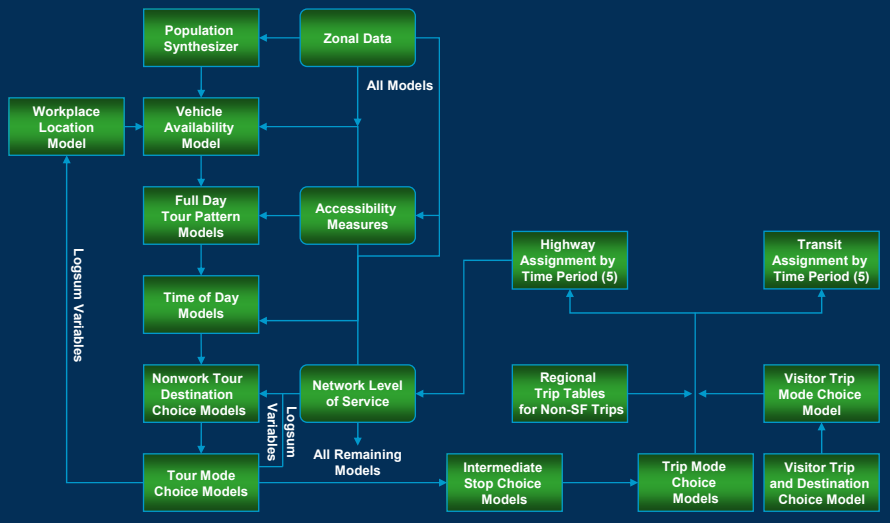
# San Francisco County Model Structure




*Source: Cambridge Systematics et al, 2001.*

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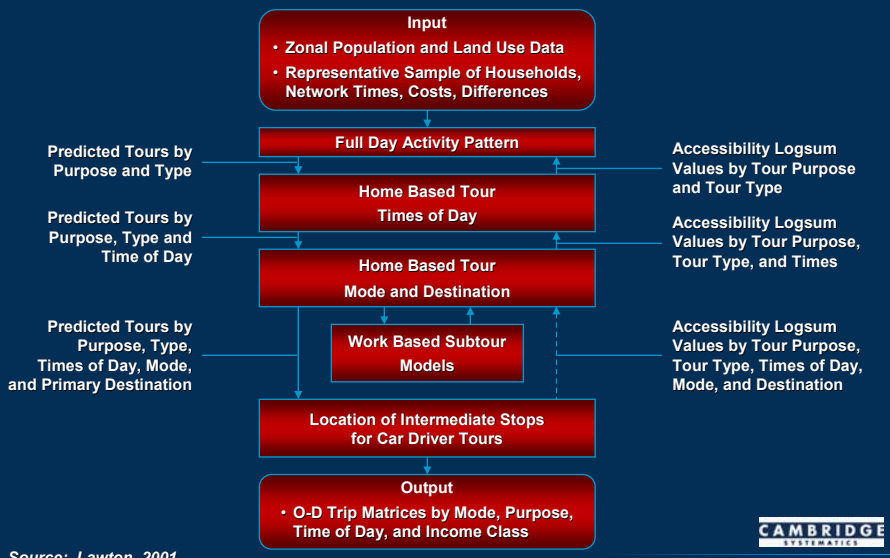
# Portland Model Structure




*Source: Lawton, 2001.*

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# Columbus Model

- Household members simulated in priority order
- Choice conditional on choices of other household members
- Work/school tours predicted first, then joint tours, then other individual tours
- Remaining available "time window" influences choices at each stage
- No explicit tradeoff between making stops or additional tours

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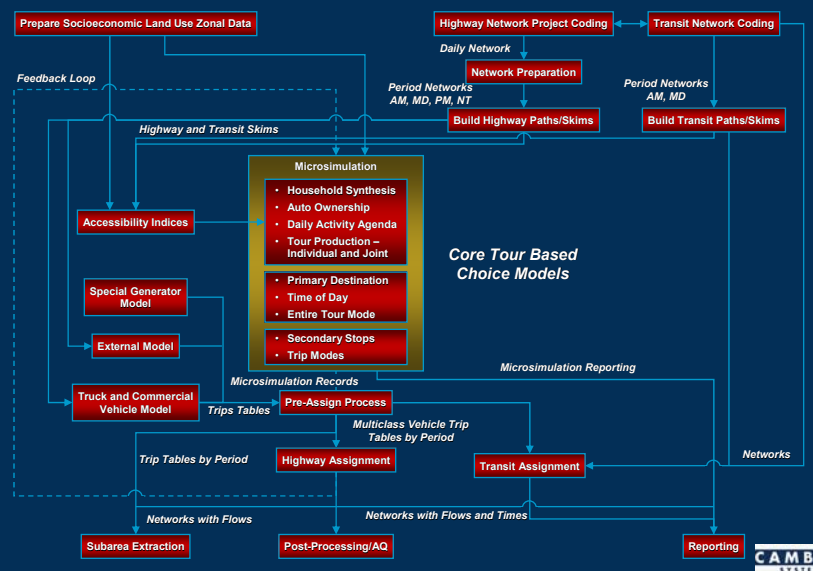
# Columbus Model Structure

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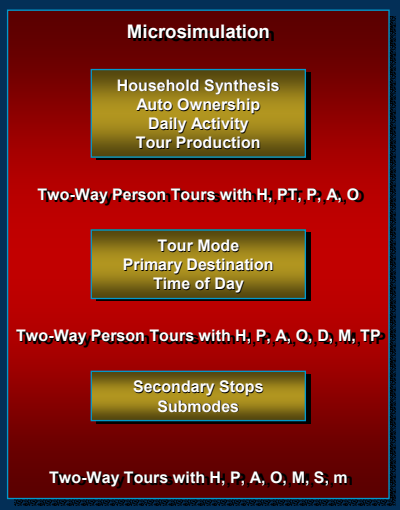
*Source: Anderson, Al-Akhras, Gill, and Donelly, 2003.*

# Columbus Core Models




H = Household Attributes
PT = Person Type
P = Purpose or Category
A = Autos Owned
O = Tour Origin (home)
D = Tour Primary Destination
M = Tour Mode
TP = Time Period
S = Number and Location of Stops
m = Trip Mode

*Source: Anderson, Al-Akhras, Gill, and Donelly, 2003.*

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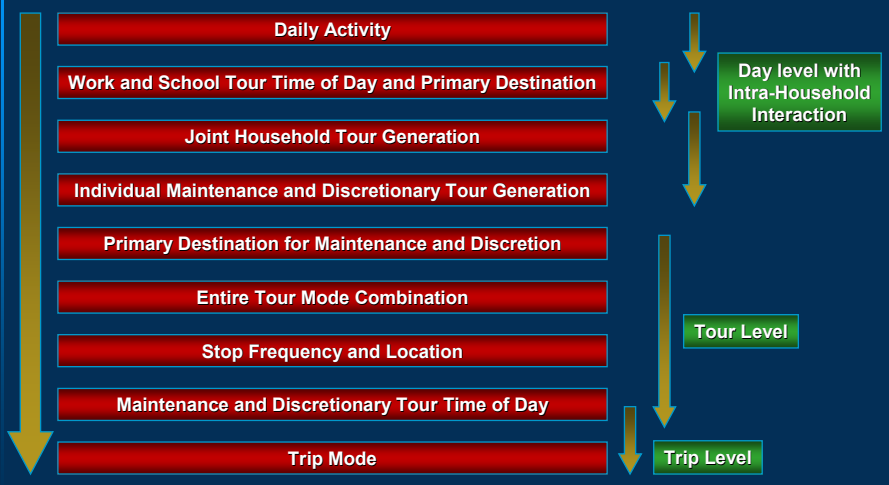
# Columbus Model Hierarchy




*Source: Anderson, Al-Akhras, Gill, and Donelly, 2003.*

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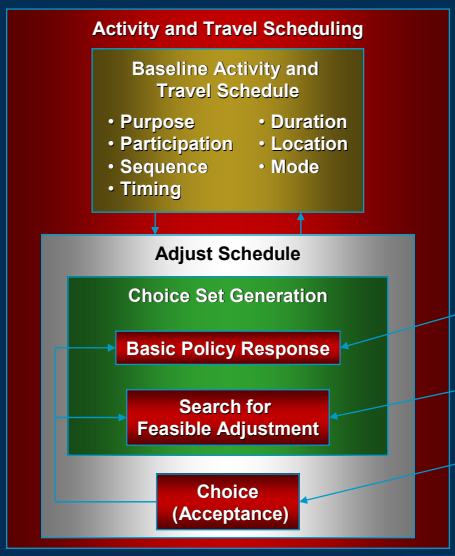
# AMOS
## 1994




*Source: RDC Inc., 1995.*

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# ALBATROSS

- For each individual/primary work activity, choose transport mode
- For each individual/flexible activity, add episodes of activity, choose duration/joint participation
- For each individual, define activity sequence and start/end times
- Organize sequences into tours
- Choices are made using a rule based approach

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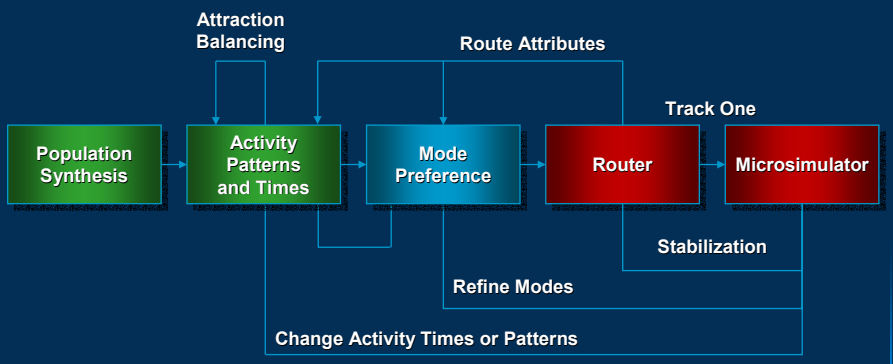
# TRANSIMS
## Model Structure




*Source: PB Consult, 2003.*

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# TRANSIMS
## Activity Generation

- Match each synthesized household with a household from the survey
- Binary classification tree household attributes and urban area type for household matching
- Transfer survey household activity pattern to synthesized household
- Decision rules to “correct” pattern

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## TRANSIMS
### Activity Generation (continued)

- Location choice model
  - Logit formulation
  - Similar to tour based destination choice models for primary activities and stops
- Mode preference
  - Multinomial logit for tour level
  - Secondary binary models for certain sub modes
  - Use of Router for trip mode choice

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## Summary – Tour Based Vs. Trip Based Models

- Tour based models account for trip chaining
- Trip choices not treated as independent of one another in tour based models
- In tour based, easier to limit effects of sequential process
- More analytical capabilities in tour based models
- Data needs are similar (more processing required for tour based models)
- Custom programs needed, run times generally longer for tour based models (for now)

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## Summary – Activity Based Vs. Tour Based Models

- In tour based models, demand is assumed to be for trip making, rather than activities (more realistic behavior)
- Activity based models can account for intra-household effects on travel behavior
- More analytical capabilities in activity based models
- Data needs are similar although more data needed for application of disaggregate (microsimulation) activity based models
- Run times generally longer for activity based models (for now)

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## Future Directions of Activity Based Methods

- Better modeling of household interactions
- Improvements to time of day/activity duration modeling
- Microsimulation as the preferred platform
- Shift from cross-sectional to dynamic models
- Better use of GIS to estimate time/space relationships
- Improvements in model run time/efficiency
- Use of iterative model structures

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## Future Directions of Activity Based Methods

- Finer temporal/spatial resolution
- Integration with land use models
- Additional sensitivity analysis
- Comparisons with traditional models
- More continuous representation of space-time
- Analysis of the day to day variations
- Analysis of decision under uncertainty
- Use of process data and other non-traditional data sources

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## Appendix – More Examples of Tour Based Model Components

(from New Hampshire Statewide Model)

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# Primary Destination Choice Model Example
## New Hampshire Model – Work Tours

| Variable | Coefficient |
|---|---|
| Travel Impedance | -0.0419 |
| Home Zone Dummy | 1.376 |
| CBD Dummy | 0.0545 |
| Airport Dummy | 0.0545 |
| College Dummy | 0.1153 |
| ln (Retail Employment) | 0.0392 |

| Variable | Coefficient |
|---|---|
| ln (Manufacturing Employment) | 0.0467 |
| ln (Private Service Employment) | 0.0779 |
| ln (Fire Employment) | 0.1230 |
| ln (Other Service Employment) | 0.0652 |
| ln (Other Employment) | 0.1404 |
| ln (Households) | 0.1344 |

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# Tour Level Mode Choice Model Example
## New Hampshire Model – Work Tours
## Auto versus Non-Auto

| Variable | Coefficient |
|---|---|
| Travel Impedance | -0.00054 |
| Urban Zone Dummy | -0.3303 |
| Number of Vehicles | 0.4525 |
| Income Category | 0.0167 |

| Variable | Coefficient |
|---|---|
| Single Family Dummy | 0.4899 |
| Number of Work Tours | -0.4799 |
| Number of Persons | -0.1824 |
| Auto Constant | 2.189 |

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# Trip Level Mode Choice Model Example
## New Hampshire Model – Work Non-Auto Tours

| Variable | Non-Motor | Bus | Rail | Auto Passenger |
|---|---|---|---|---|
| Constant | 0 | -3.085 | 0.212 | -2.639 |
| Vehicles | 0 | -0.942 | -0.053 | 0.557 |
| Persons | 0 | 1.021 | 1.085 | 0.487 |
| Distance | 0 | 0.513 | 0.387 | 0.304 |
| Travel Time | 0 | -0.0119 | -0.0119 | -0.0119 |

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