DaySim

Activity-Based Modelling Symposium

Research Centre for Integrated Transport and Innovation (rCITI)
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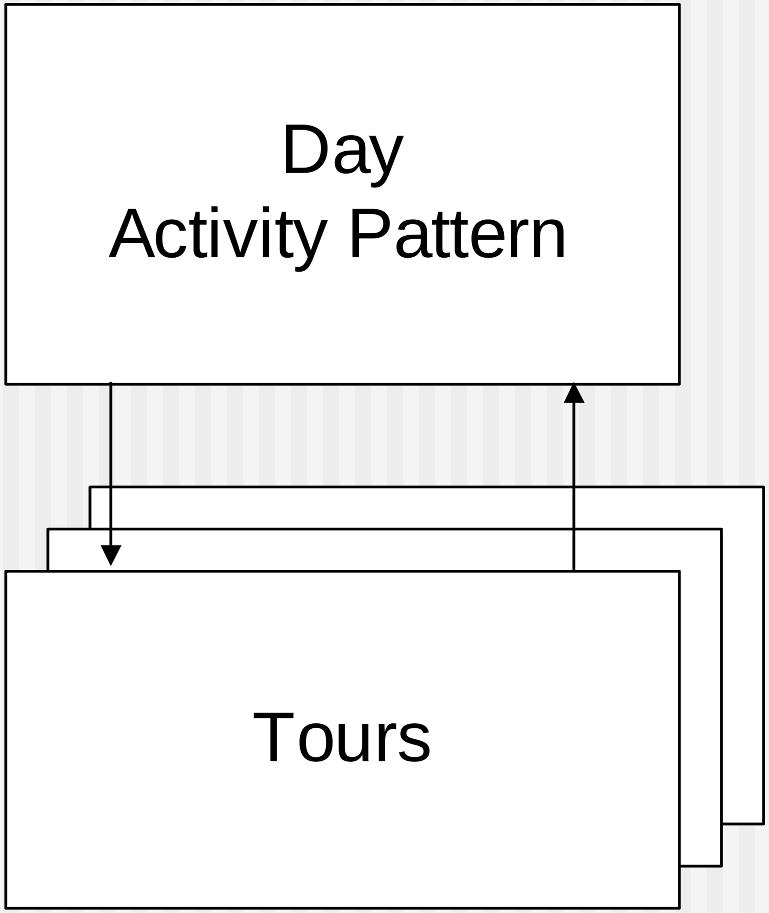
John L Bowman, Ph.D.

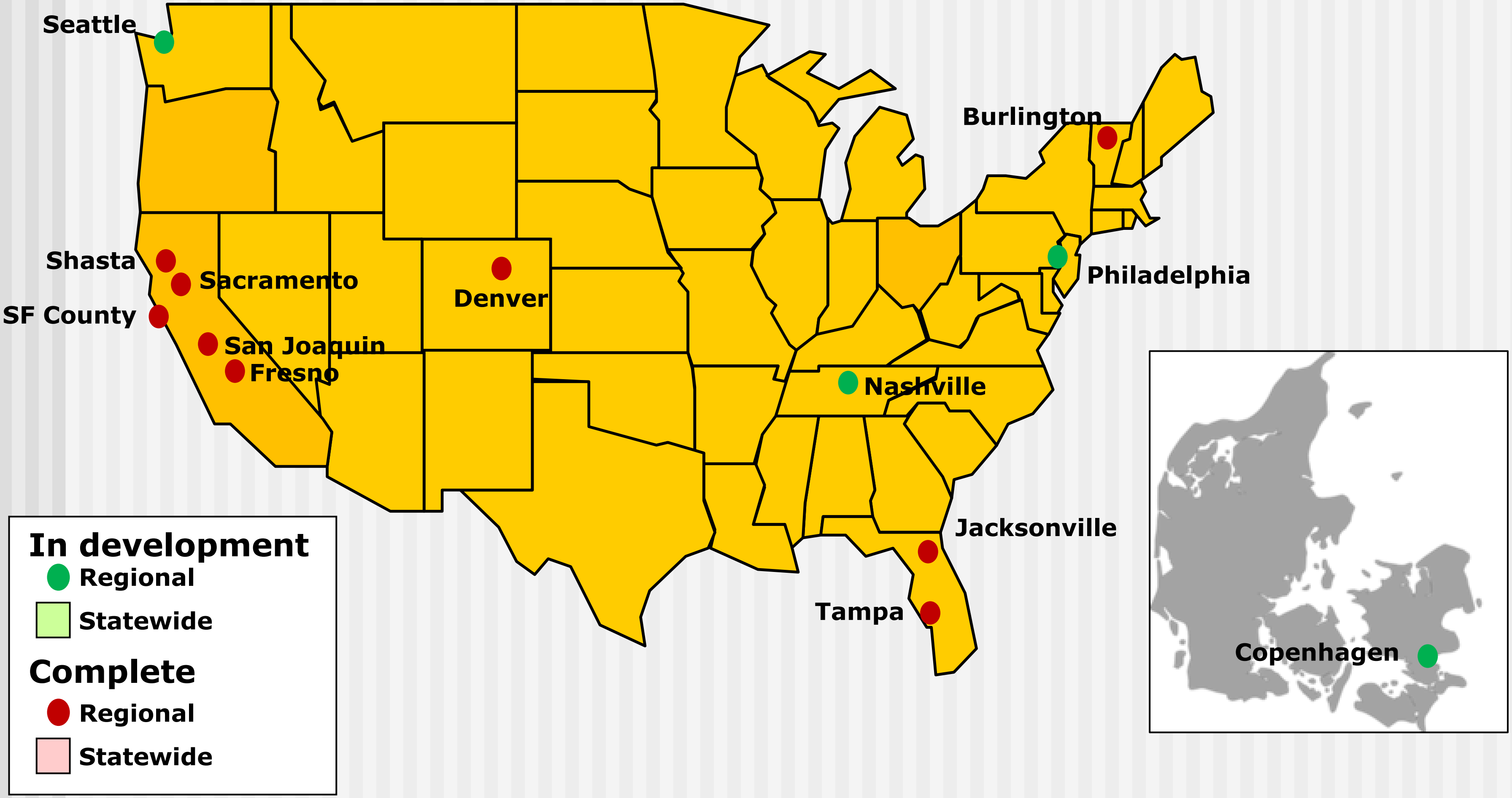
John_L_Bowman@alum.mit.edu

JBowman.net

DaySim's Roots
The Day Activity Schedule
(TRB January 1994)



DaySim and related models 2014



Outline

- Basic Features
- Model structure and associated features
- Software

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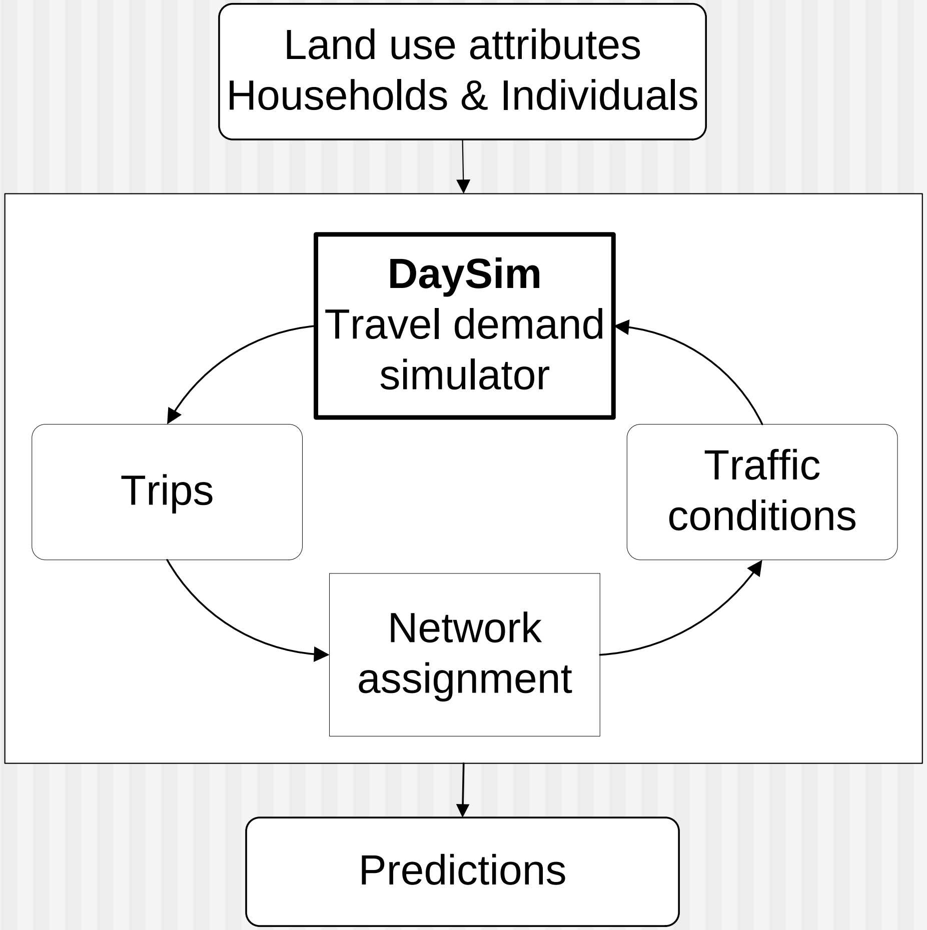
- Software

DaySim is a travel demand simulator that equilibrates with network assignment models



DaySim uses primarily discrete choice models of the logit family

$$P_n(i) = \frac{\exp(\beta' X_{in})}{\sum_j \exp(\beta' X_{jn})}$$

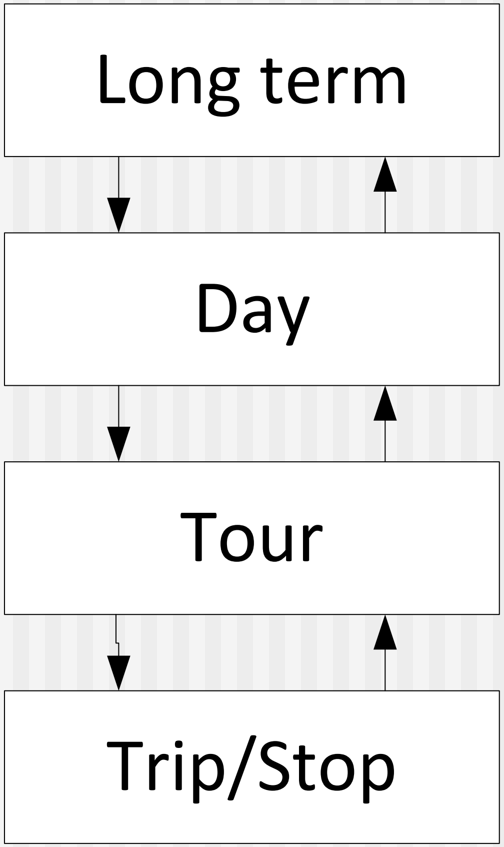
Where i and j index discrete alternatives

$P_n(i)$ is the probability that person n chooses alternative i

X_{in} is a vector of explanatory variables

β is a vector of coefficients

DaySim is an integrated system of choice models

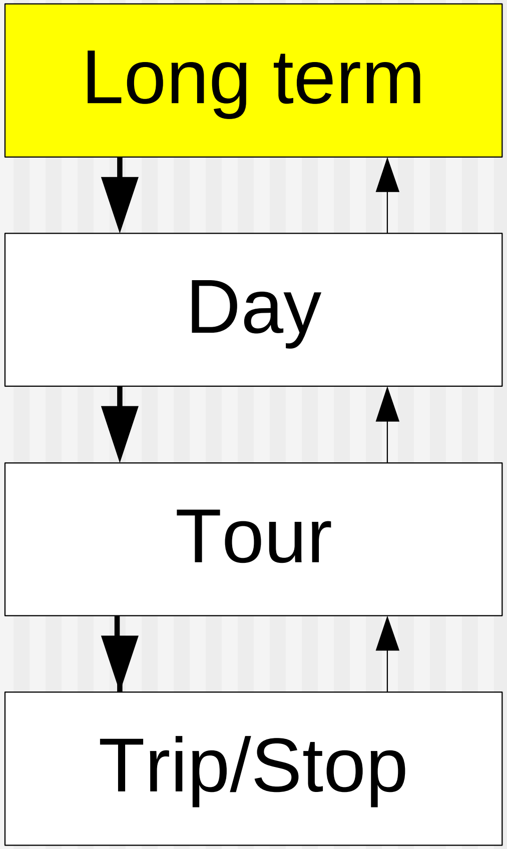


Within **DaySim**, model integration is important

- Downward (conditionality)
- Upward (accessibility)

Downward Integration

Lower models take upper outcomes as given



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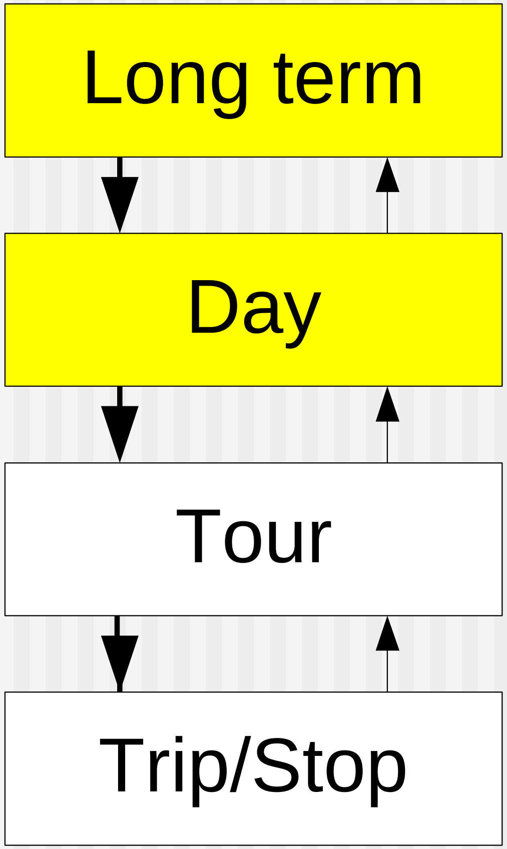

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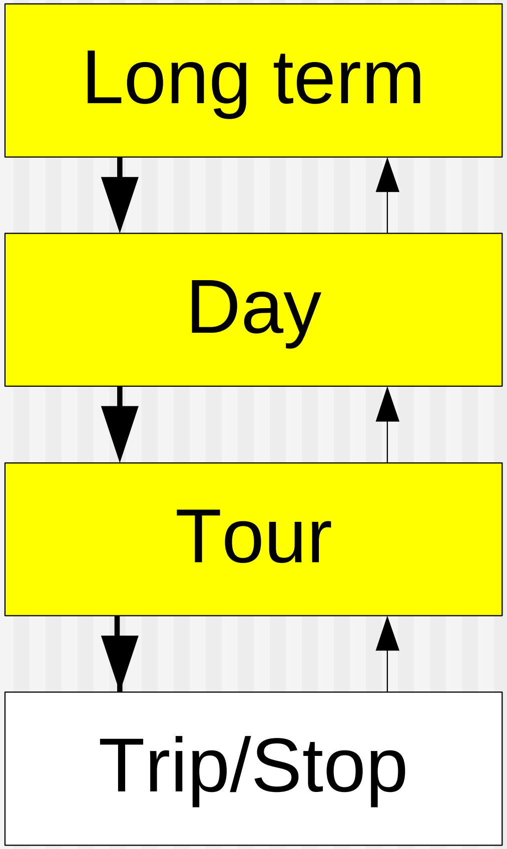

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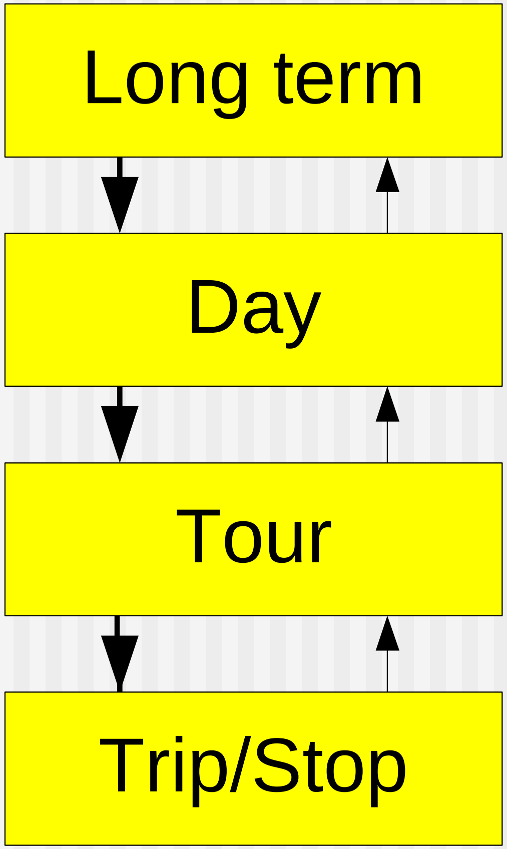
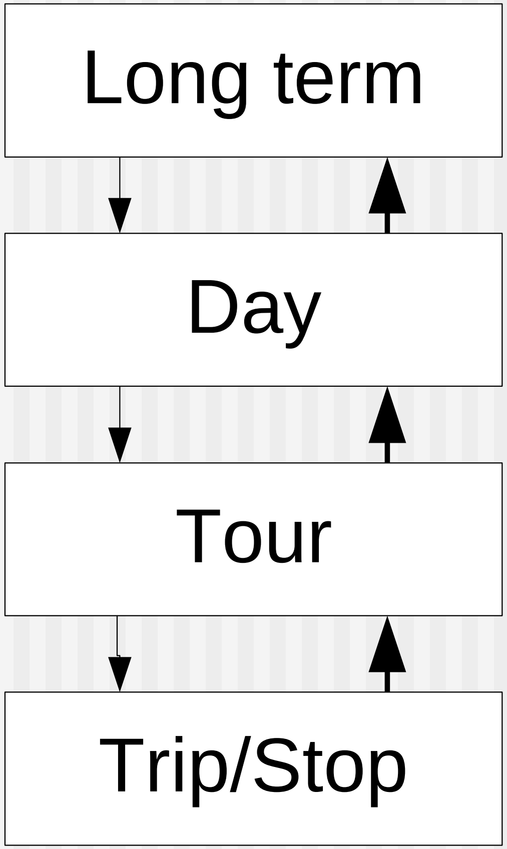


Upward Integration

Upper models should be sensitive to conditions affecting lower models



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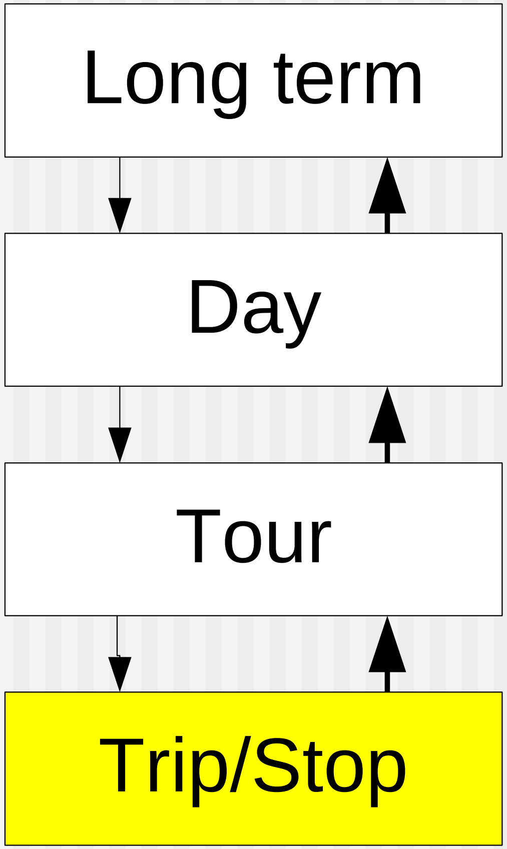

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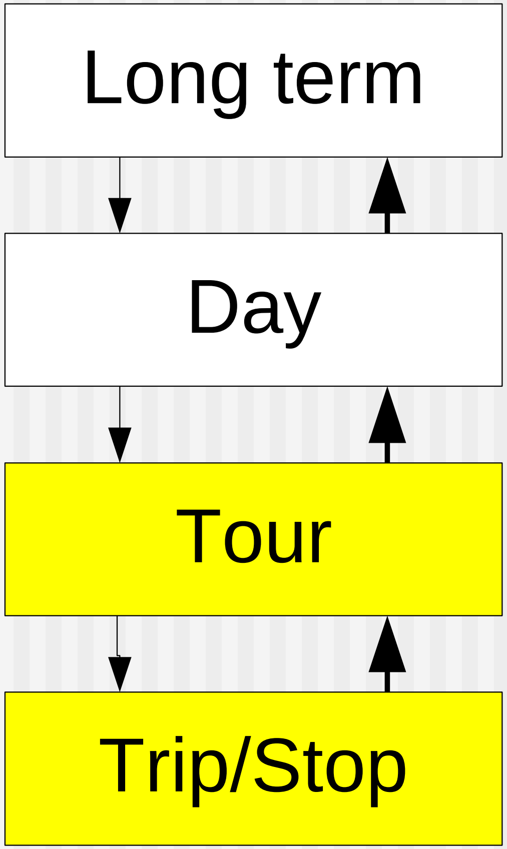

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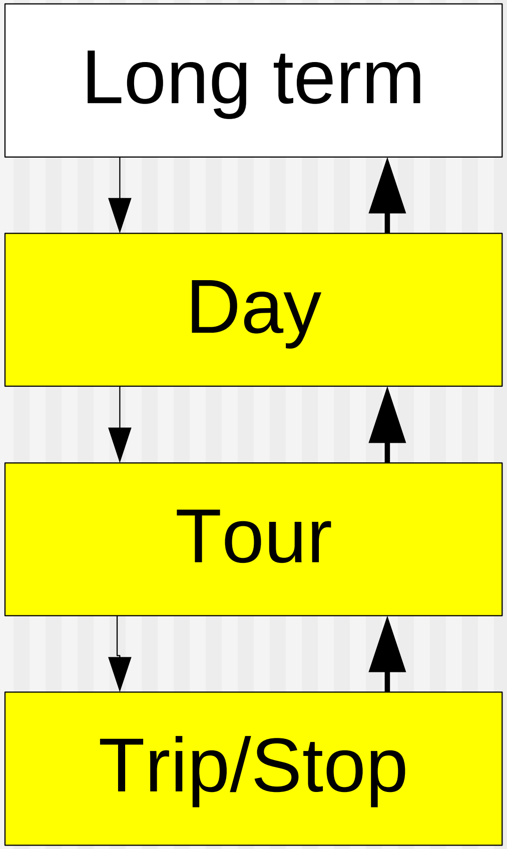

Upward Integration

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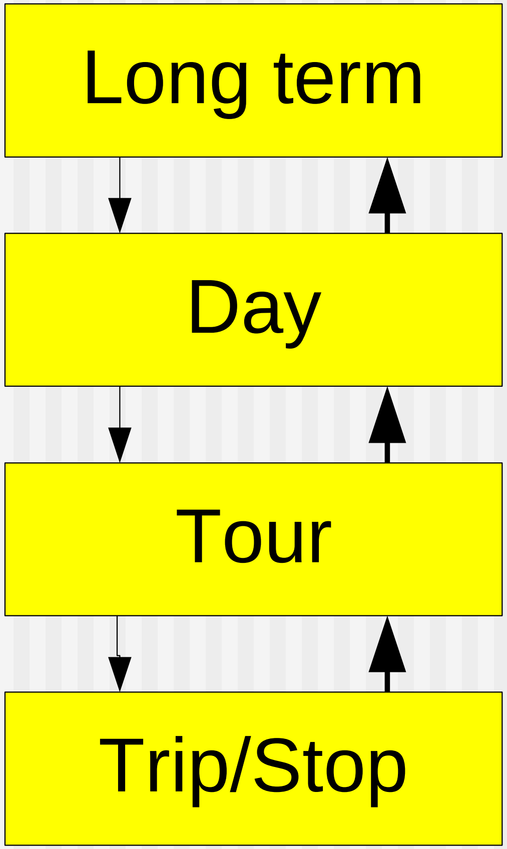


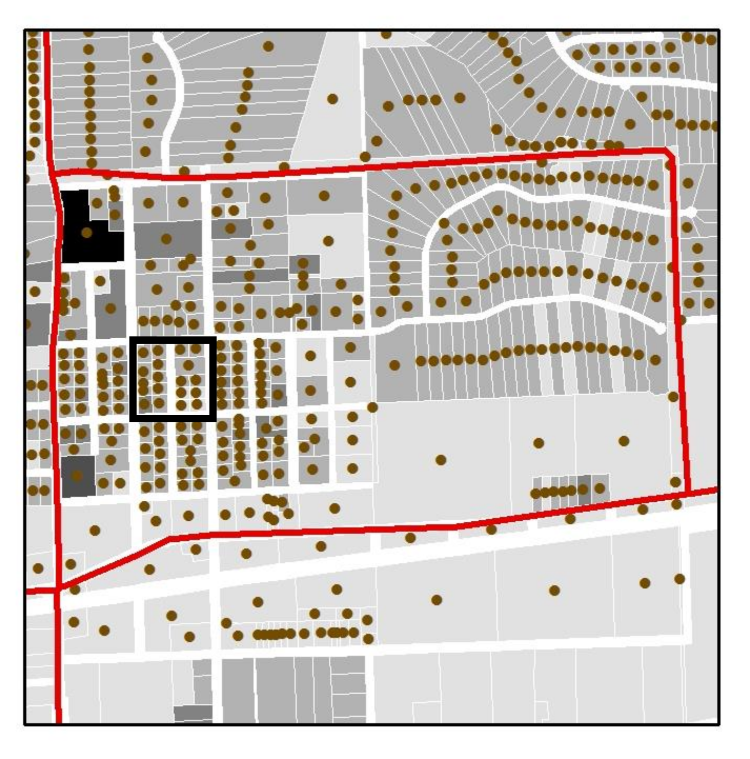
Within **DaySim**, model integration is impotant

- Downward (conditionality)
- Upward (accessibility)

DaySim uses fine spatial detail

Parcels or Microzones

- Attributes include:
  - Location
  - Area
  - Housing units
  - Enrollment by school type
  - Employment by sector
  - Transportation network access
  - Urban form measures
  - Offstreet parking



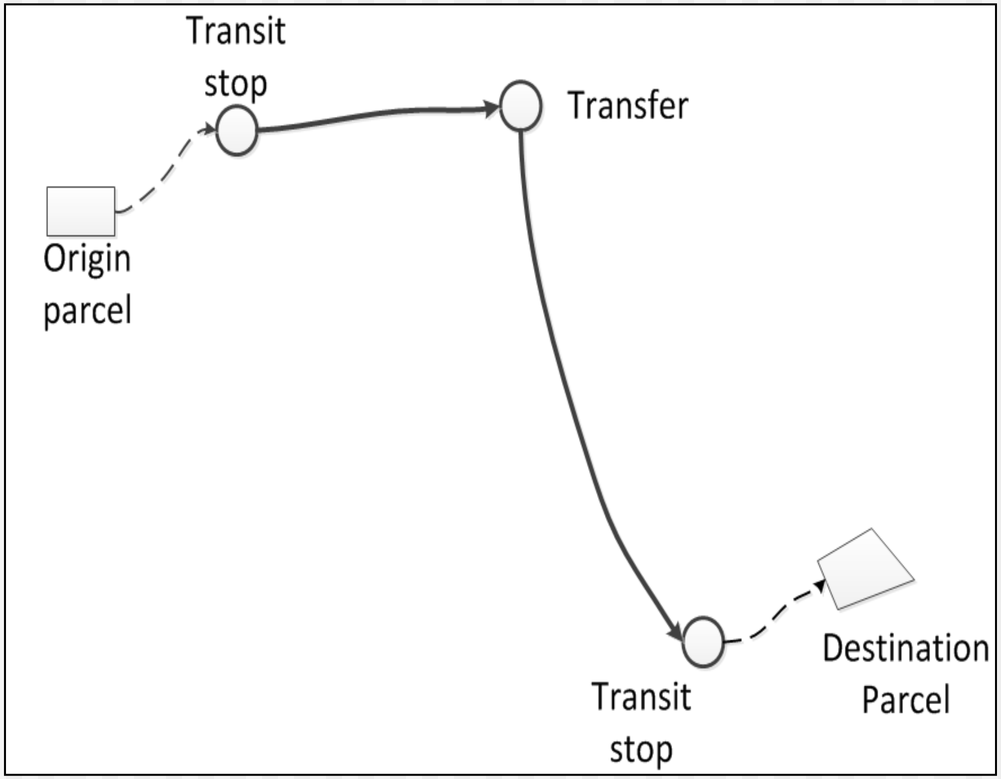
Ex. TAZs, microzones and parcels

Why use a fine-grained representation of space?

- measure attractiveness better for location choice
- capture neighborhood effects on location choices
- include the impact of true walk distances in travel choices
- model short intra-zonal travel choices better
- represent transit alternatives more accurately in mode choice
- Handle bicycle and walk modes as effectively as cars and transit

Measure walk access and egress more accurately (Philadelphia)

- Walk access and egress impedance: parcel-to-stop using Enhanced short distance calculation
- Transit impedance from boarding stop to alighting stop
- AB model chooses best combination of transit stops



…improves work mode choice estimation results (and prediction)

	TAZ-based		Link-based	
Log-likelihood	-4637		-4607	
Values of time	$/hr	(T)	$/hr	(T)
Car- drive alone	2.2	(1.2)	4.6	(2.5)
Transit- in vehicle	1.4	(1.4)	1.9	(1.9)
Transit- wait	5.9	(3.5)	5.3	(3.3)
Transit- walk	0.9	(0.2)	**12.2**	**(6.1)**

From Portland Metro (Bowman, et al, 2001)

Use similar techniques for other mode combinations

- Auto park and ride
- Auto park and walk
- Auto kiss and ride
- Bicycle park and ride
- Bicycle on board transit

Outline

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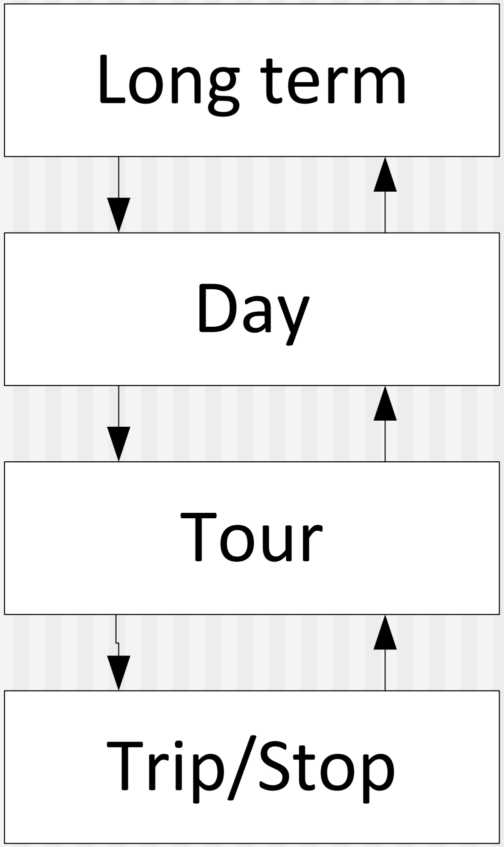
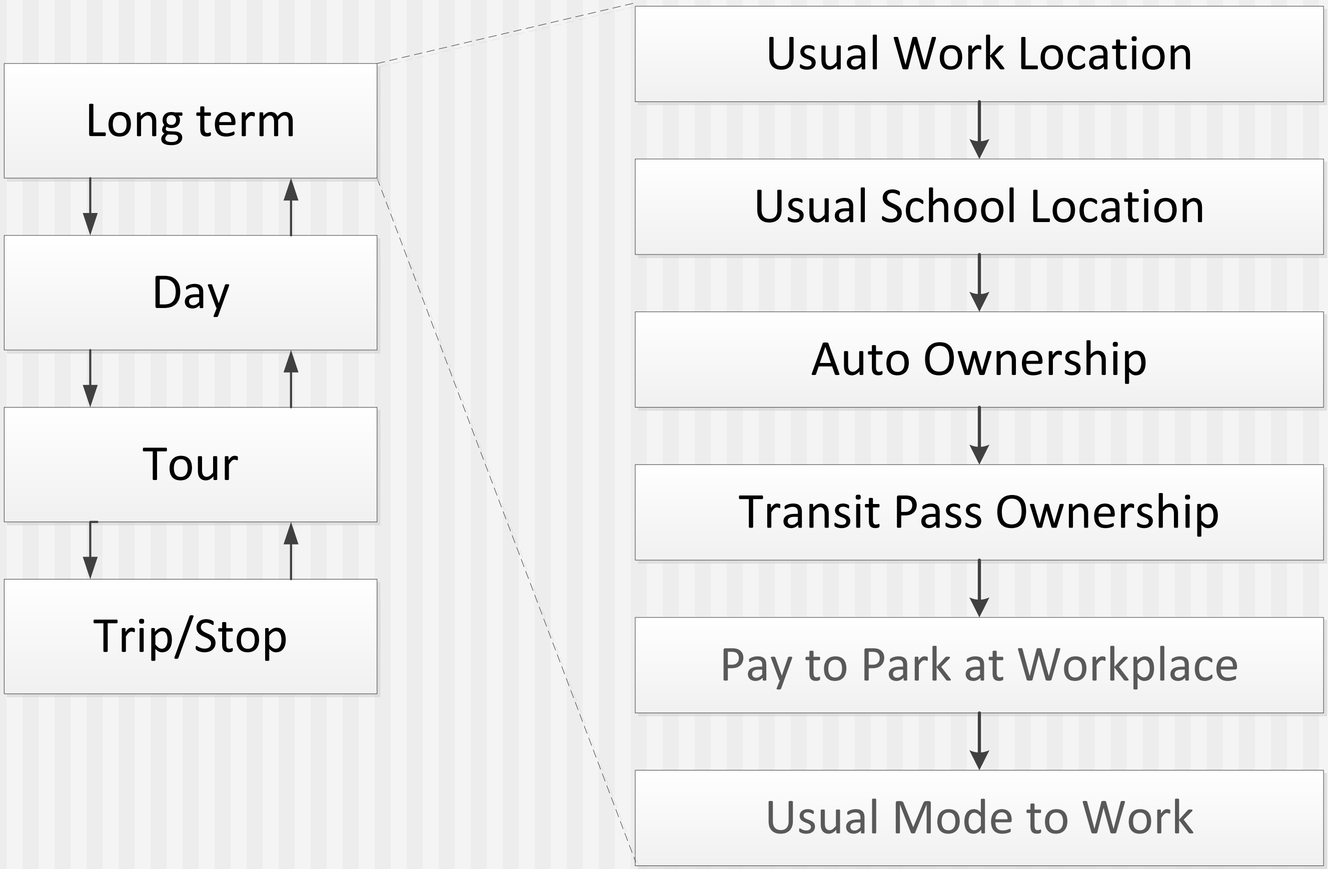
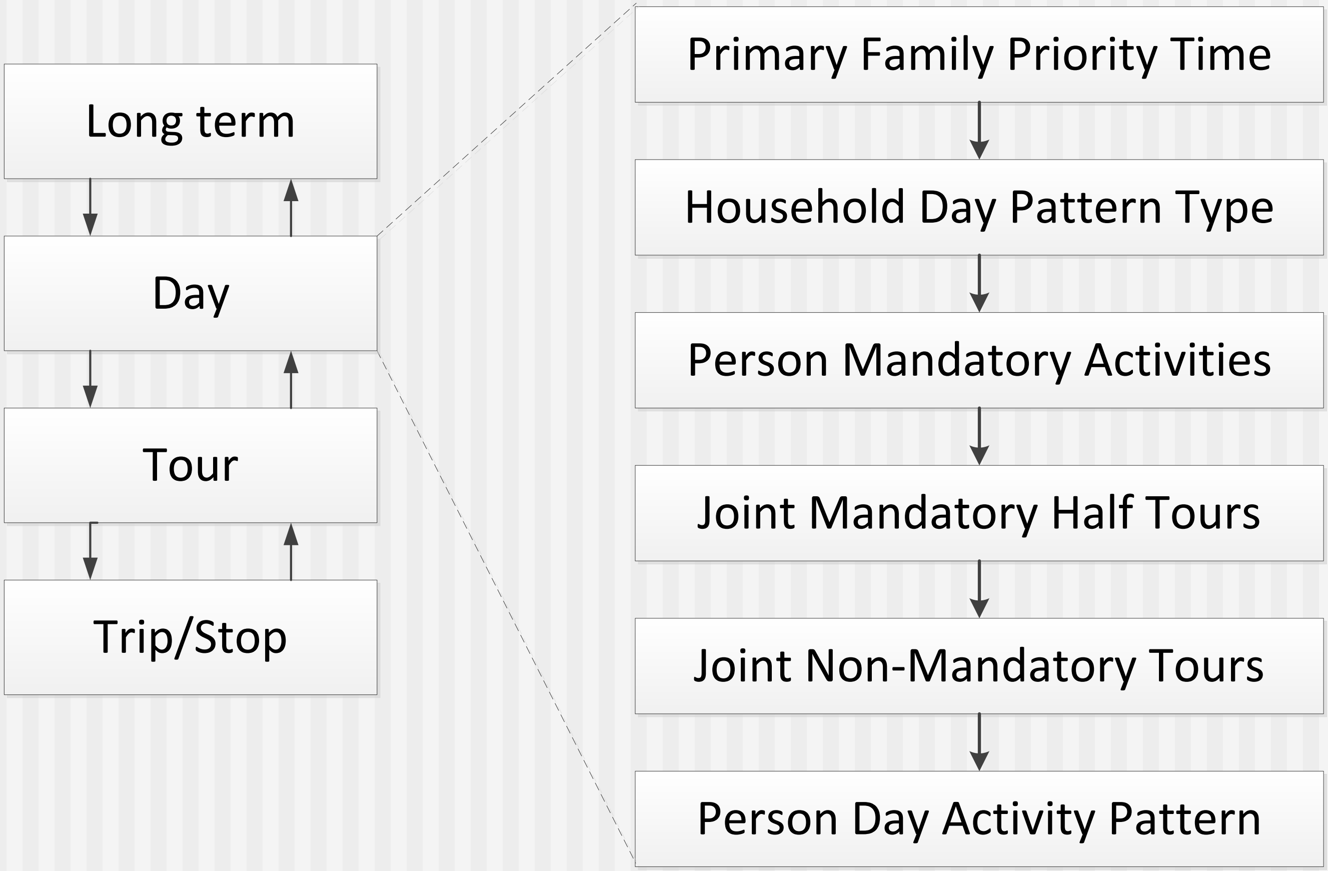
DaySim Model Structure



Long term models



Day models



Long term

Day

Tour

Trip/Stop

Primary Family Priority Time

Household Day Pattern Type

Person Mandatory Activities

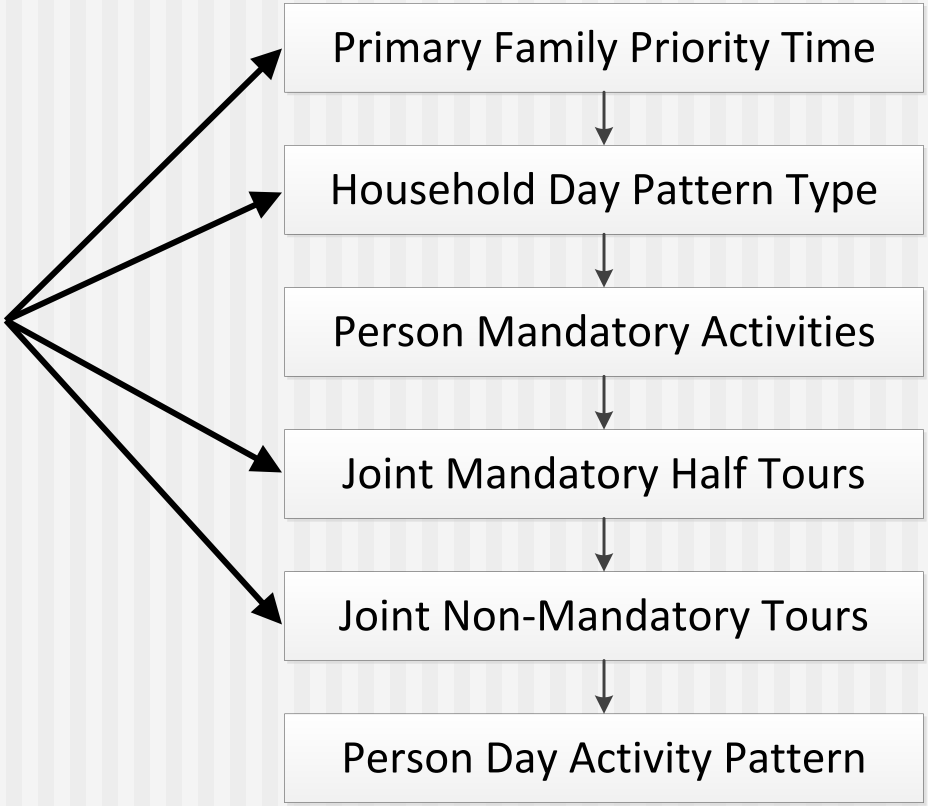
Joint Mandatory Half Tours

Joint Non-Mandatory Tours

Person Day Activity Pattern

Day models

Models with explicit household interactions



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Why model joint intra-household interactions?

- Yields coherent travel choices among household members

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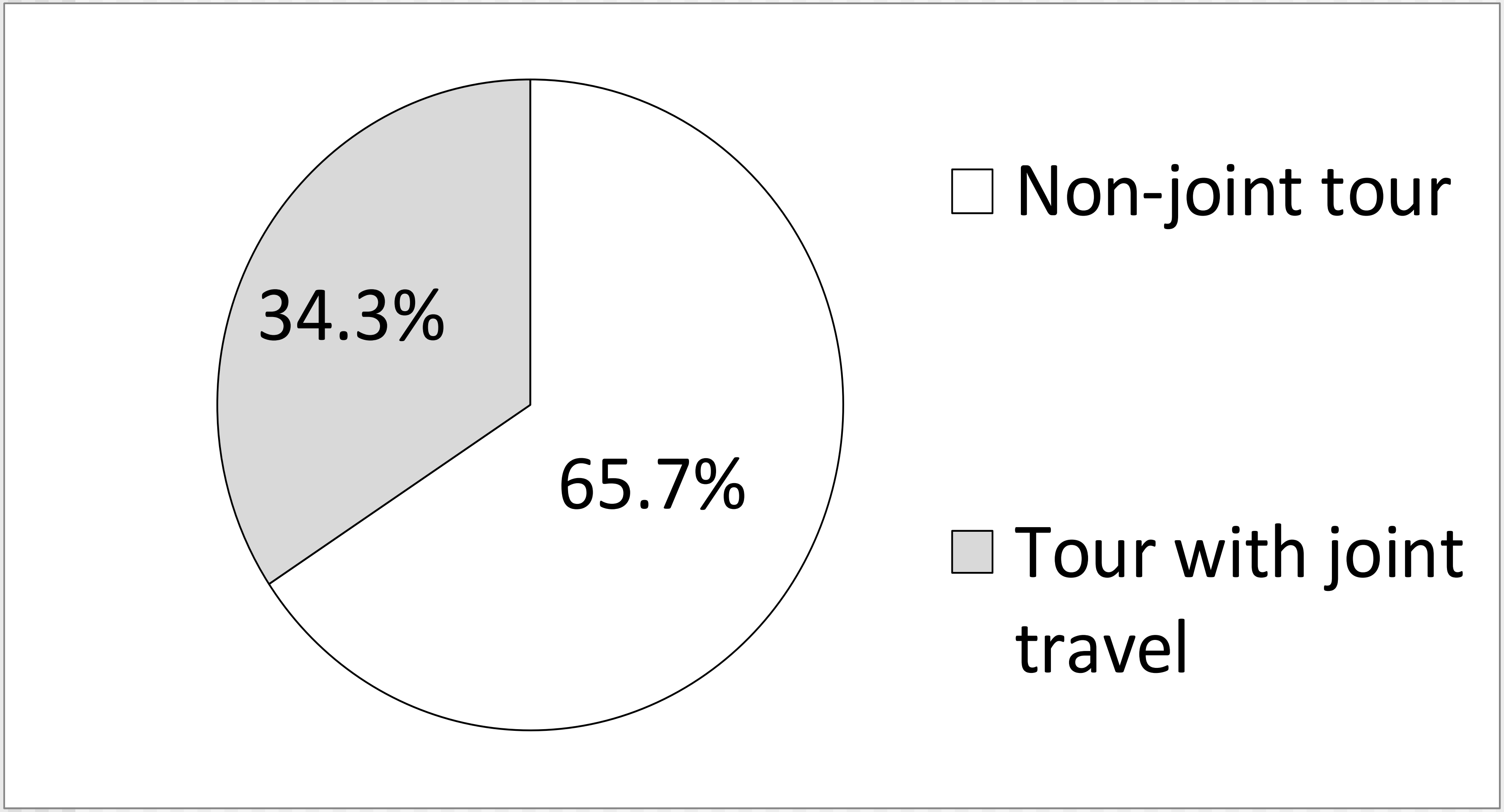
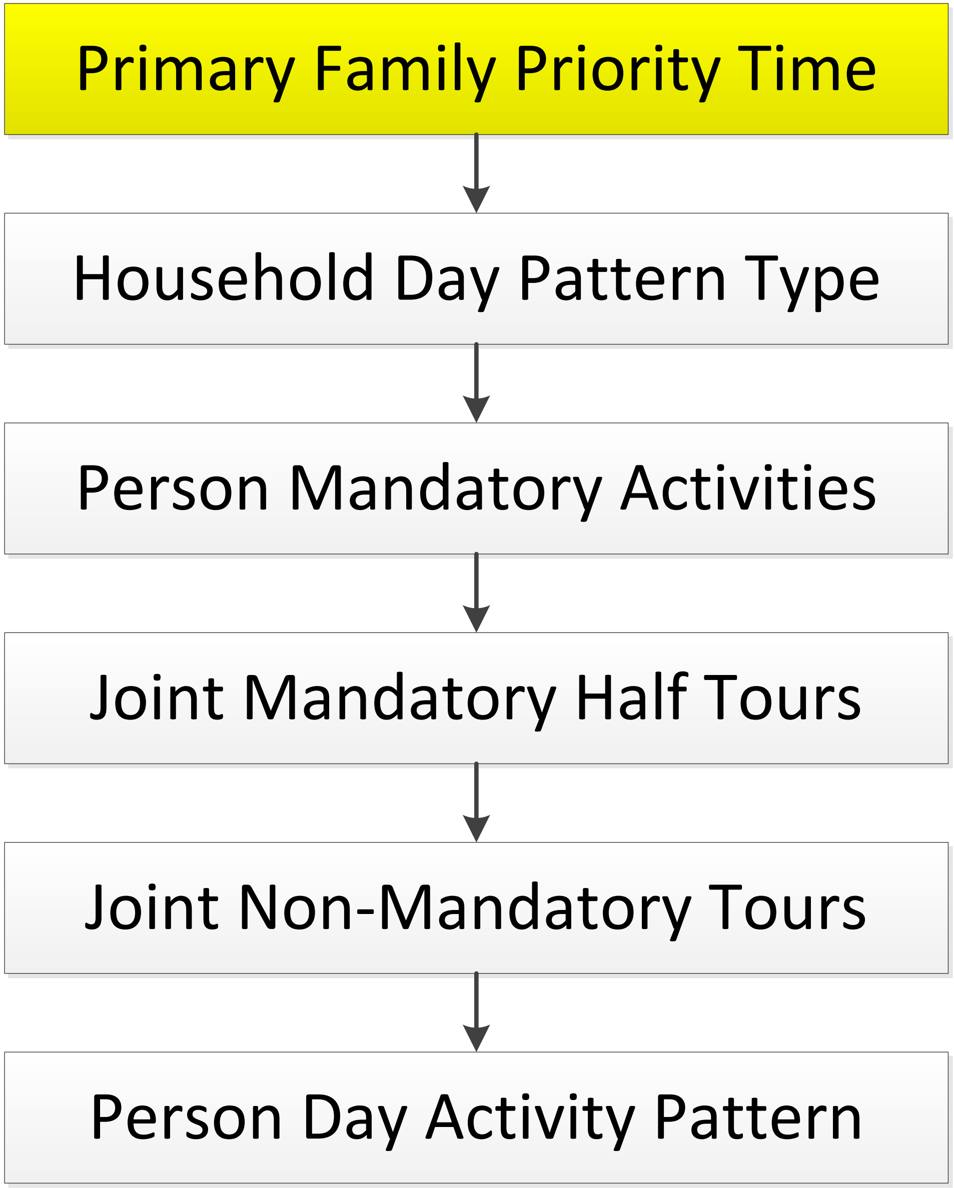
Why model joint intra-household interactions?

- Yields coherent travel choices among household members
- Joint travel impacts responsiveness to transport policies
- At-home family activities correlate with travel choices
- Joint decisions constrain and influence individual choices

Many tours have joint travel (Seattle example)





Primary Family Priority Time

Household Day Pattern Type

Person Mandatory Activities

Joint Mandatory Half Tours

Joint Non-Mandatory Tours

Person Day Activity Pattern

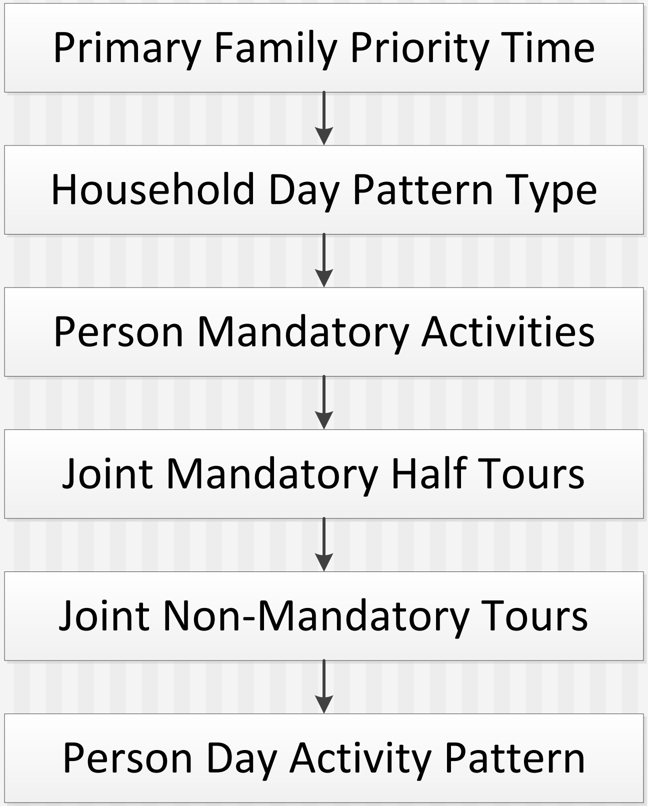
- Copenhagen
- Vuk et al (2013)
- Participation Model
  - Shared at-home activity
- Schedule Model
  - Start minute and duration minutes

Logsums—accessibility to workplaces and at home affect likelihood of PFPT

Variable (PFPT alternative)	Coeff	T Stat
Work tour mode choice logsums for up to two workers	0.134	1.58
At-home non-auto mode-destination logsum	-0.031	-2.38

PFPT affects subsequent model components

- ***Time window constraints****—travel activities can’t occur during time reserved for PFPT*
- *PFPT workers more likely to take care of personal business on* ***work-based subtours***
- *PFPT households more likely to* ***travel together to work and school***
- *PFPT households more likely to conduct* ***joint tours for non-mandatory purposes***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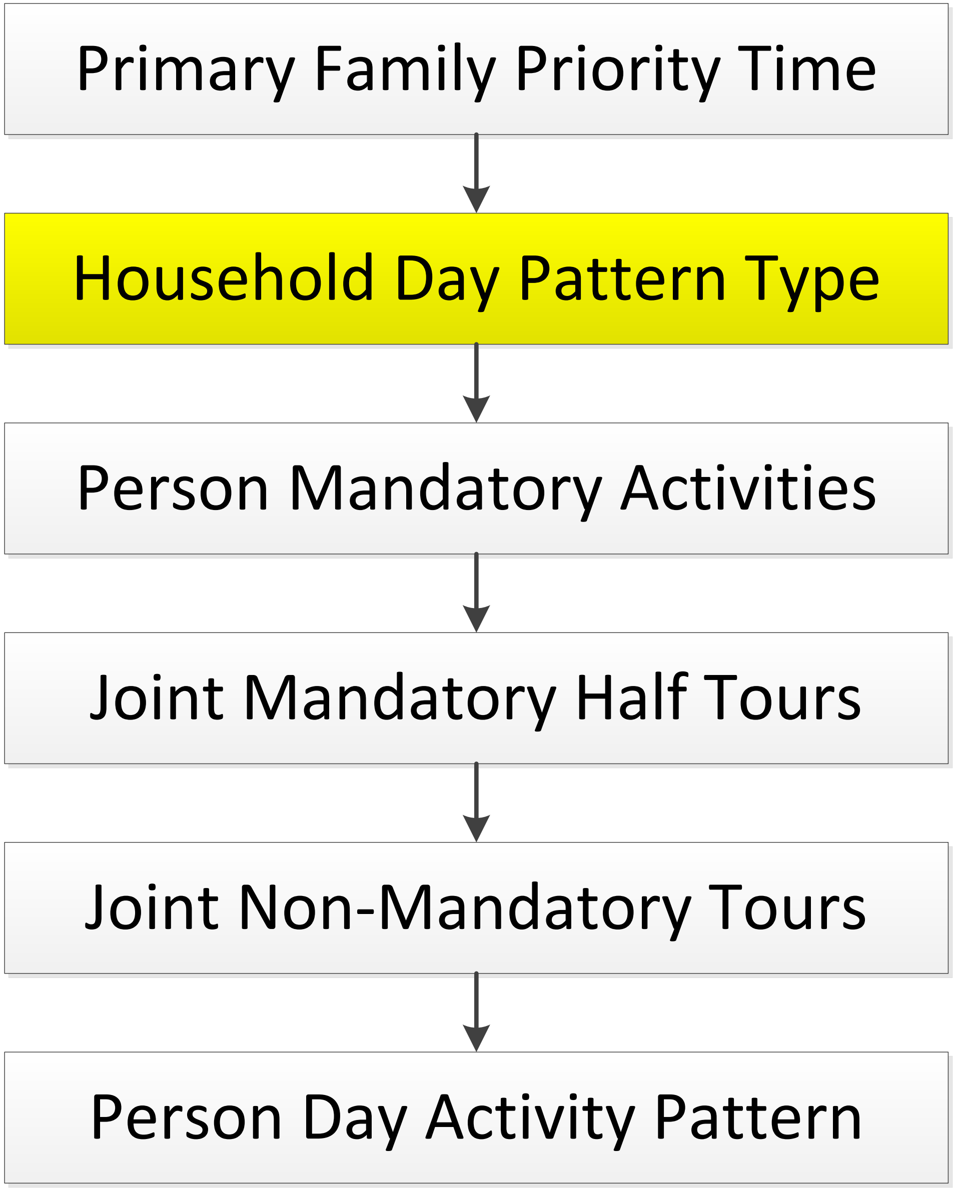
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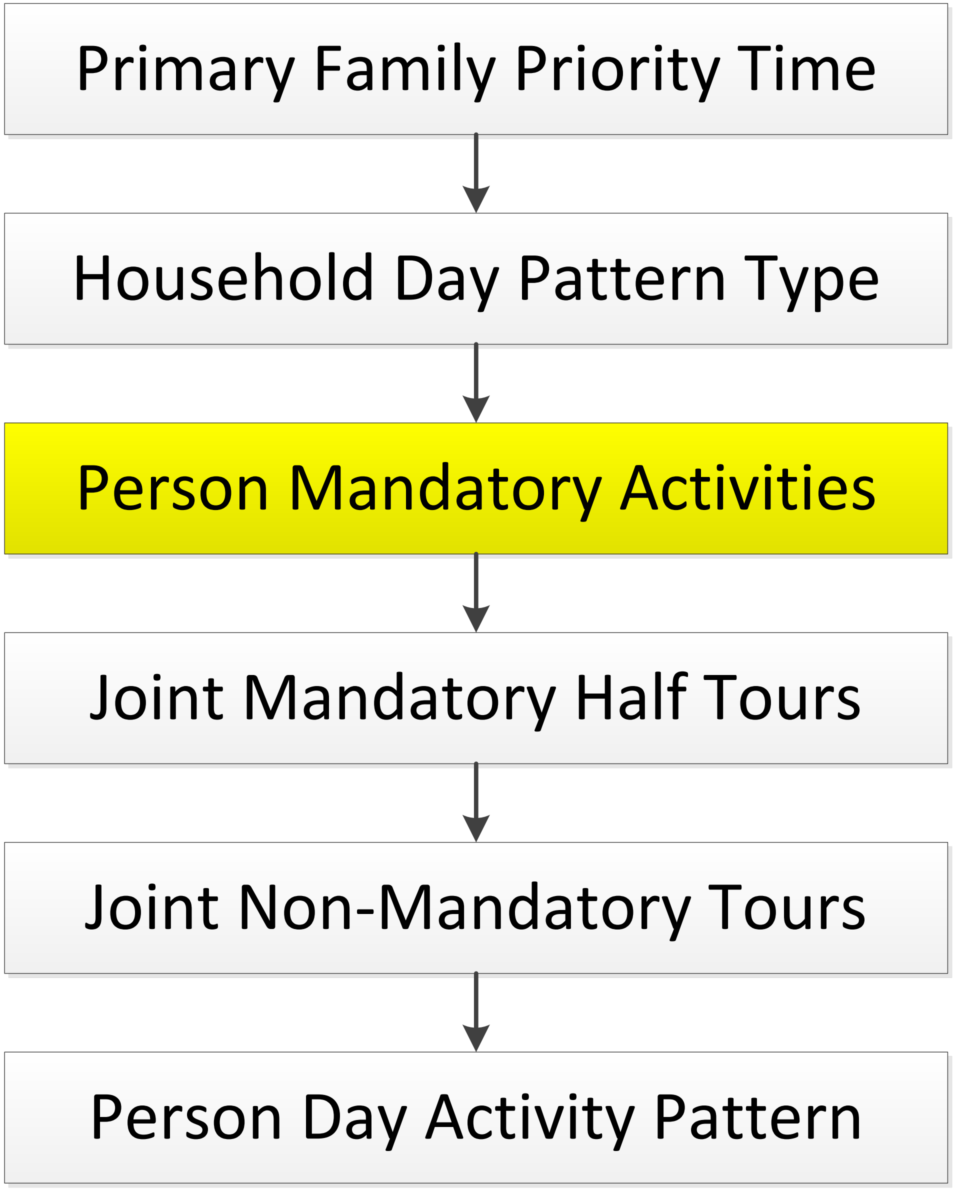
- Based on Bradley & Vovsha (2005)
- Joint for up to five HH members
- Up to three pattern type alternatives per person
  - Mandatory on tour
  - Non-mandatory on tour
  - At home all day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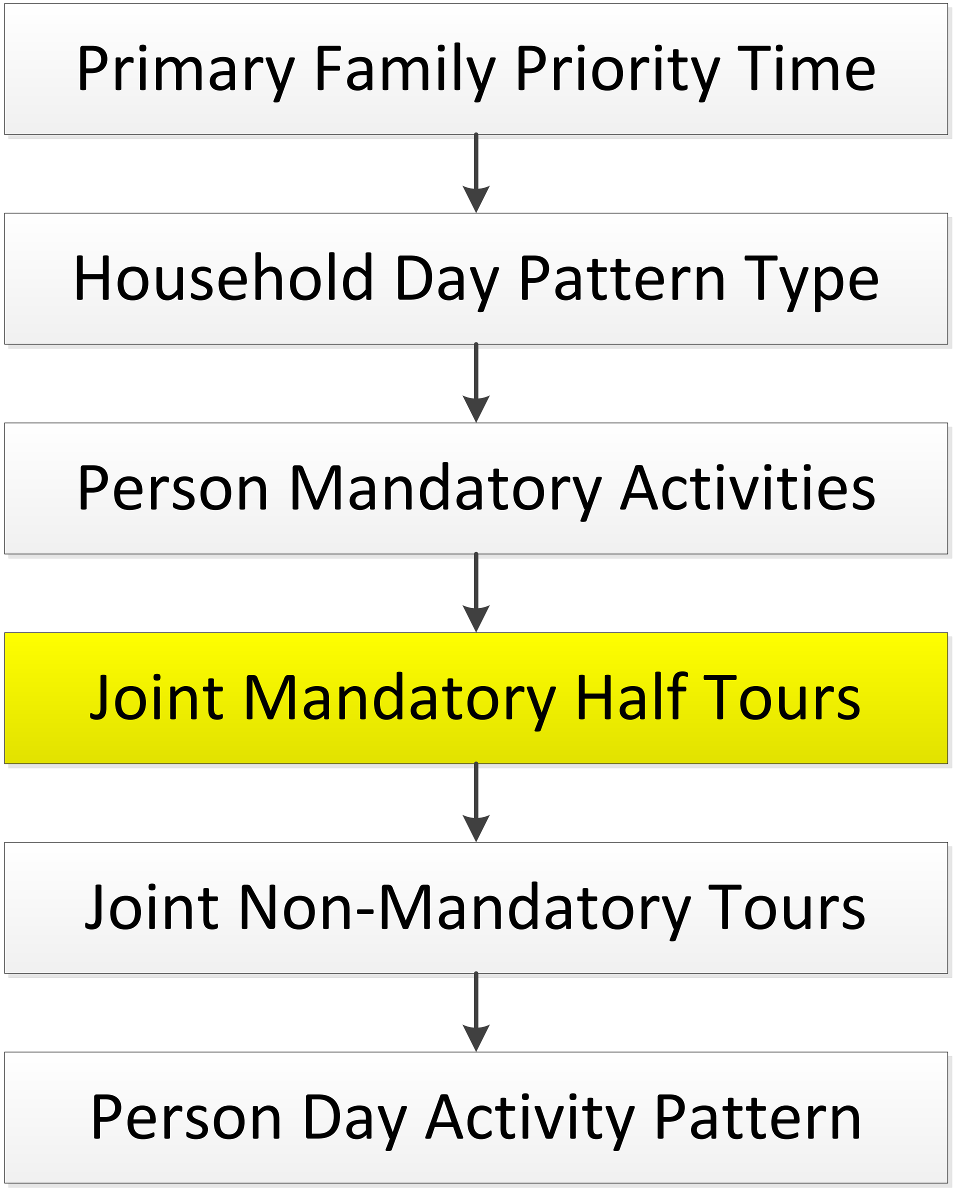
- Work at Home Model
- Mandatory Tour Generation Model
- Mandatory Stop Presence Model



Primary Family Priority Time

Household Day Pattern Type

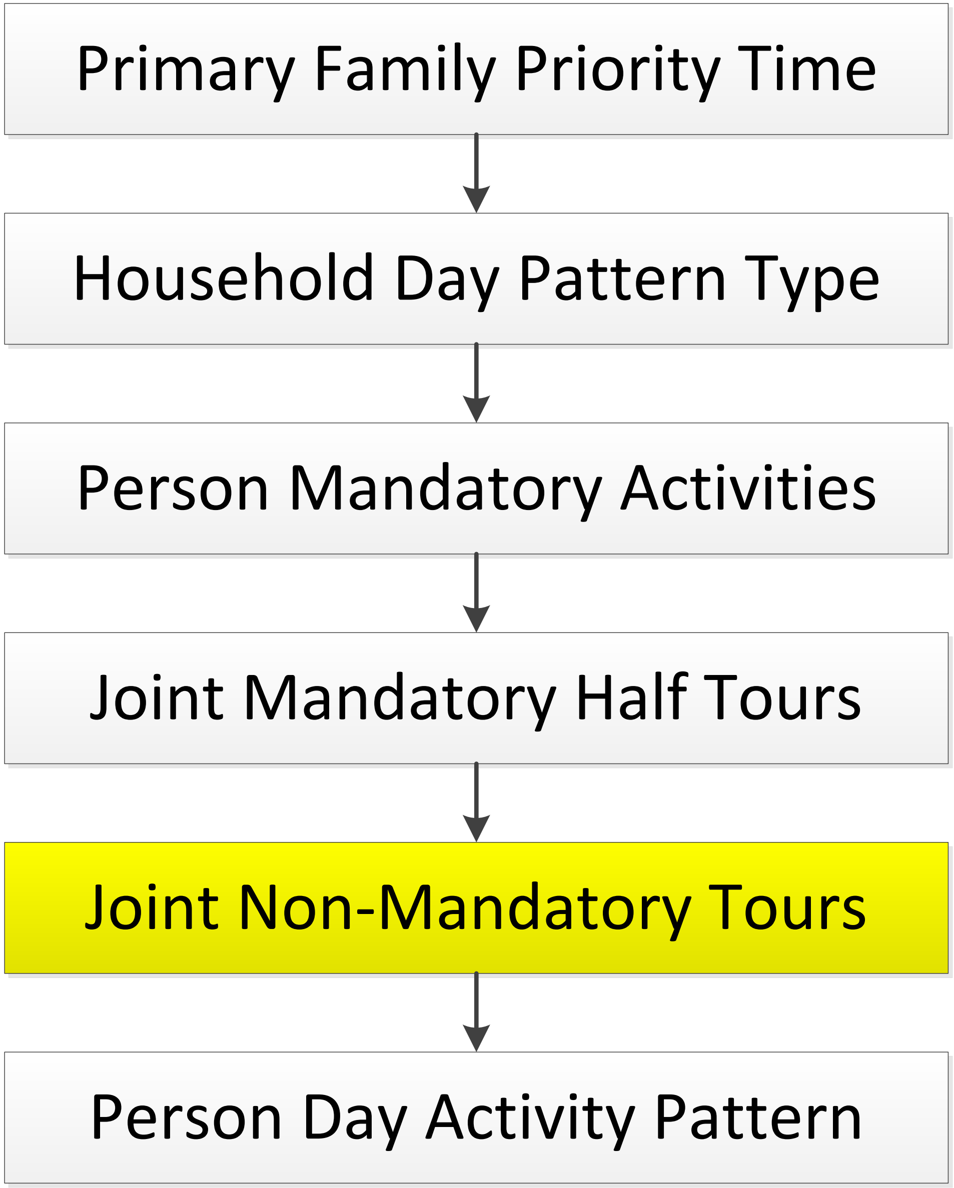
Person Mandatory Activities

Joint Mandatory Half Tours

Joint Non-Mandatory Tours

Person Day Activity Pattern

- Shared travel to work and school
- Joint Half Tour Generation Model
  - Fully joint or partially joint
- Participation Model
  - Jointly for up to five persons


Primary Family Priority Time
Household Day Pattern Type
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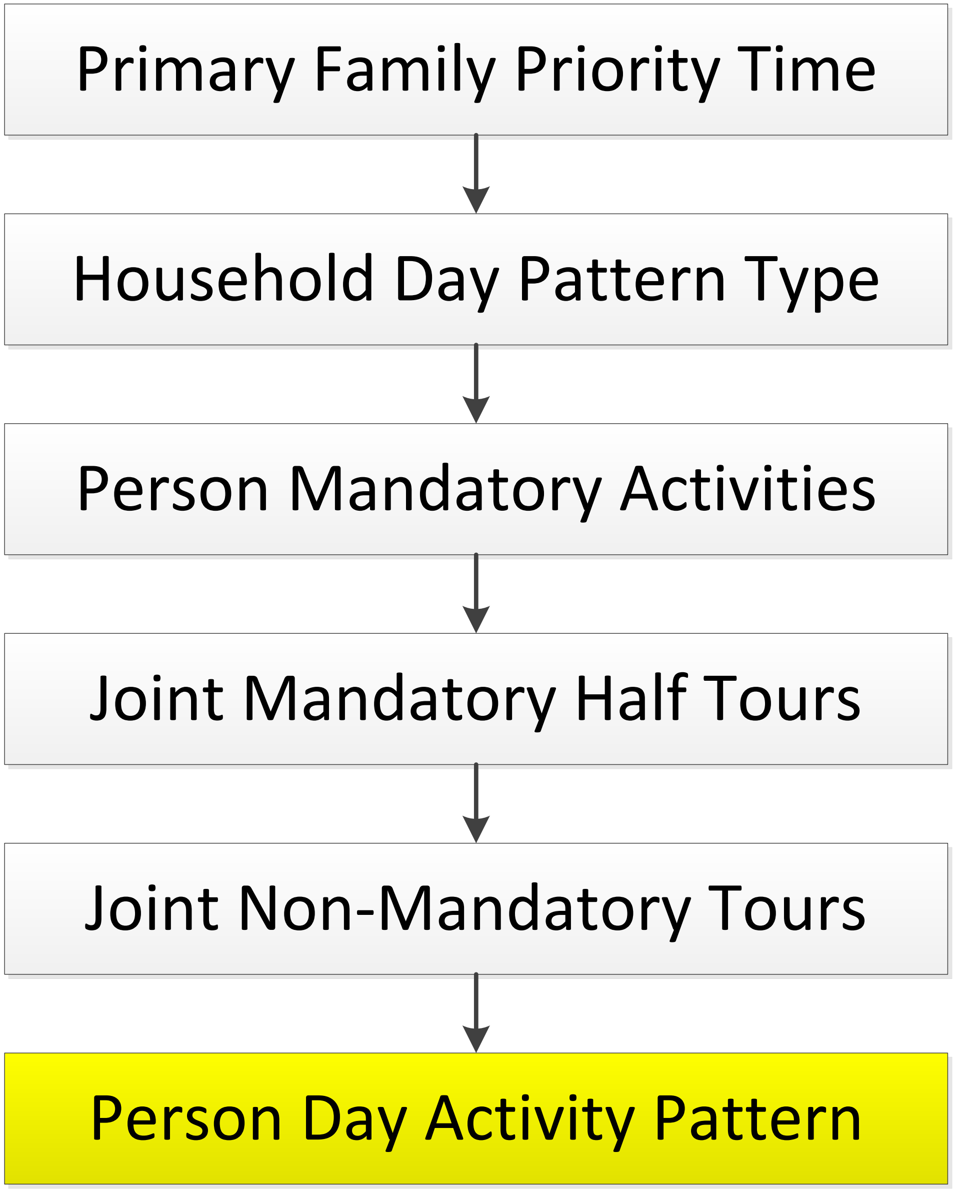
Joint Non-Mandatory Tours
Person Day Activity Pattern

- Shared travel for non-mandatory activity
- Joint Tour Generation Model
- Participation Model
  - Jointly for up to five persons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- Person Day Pattern Model
  - Presence in day of…
    - 9 tour purposes
    - 9 intermediate stop purposes
- Tour Generation Model
  - Exact number of tours for each purpose

Logsums on **work days** (Seattle)

	Patterns with additional tour purpose(s)	Patterns with intermediate stops
	Tour Coeff (T stat)	**Stop Coeff (T stat)**
Work tour mode choice logsum	-0.014 (-0.66)	0.036 (2.13)
At-home mode-destination logsum	0.042 (2.17)	0.033 (2.30)

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Logsums on **school days**

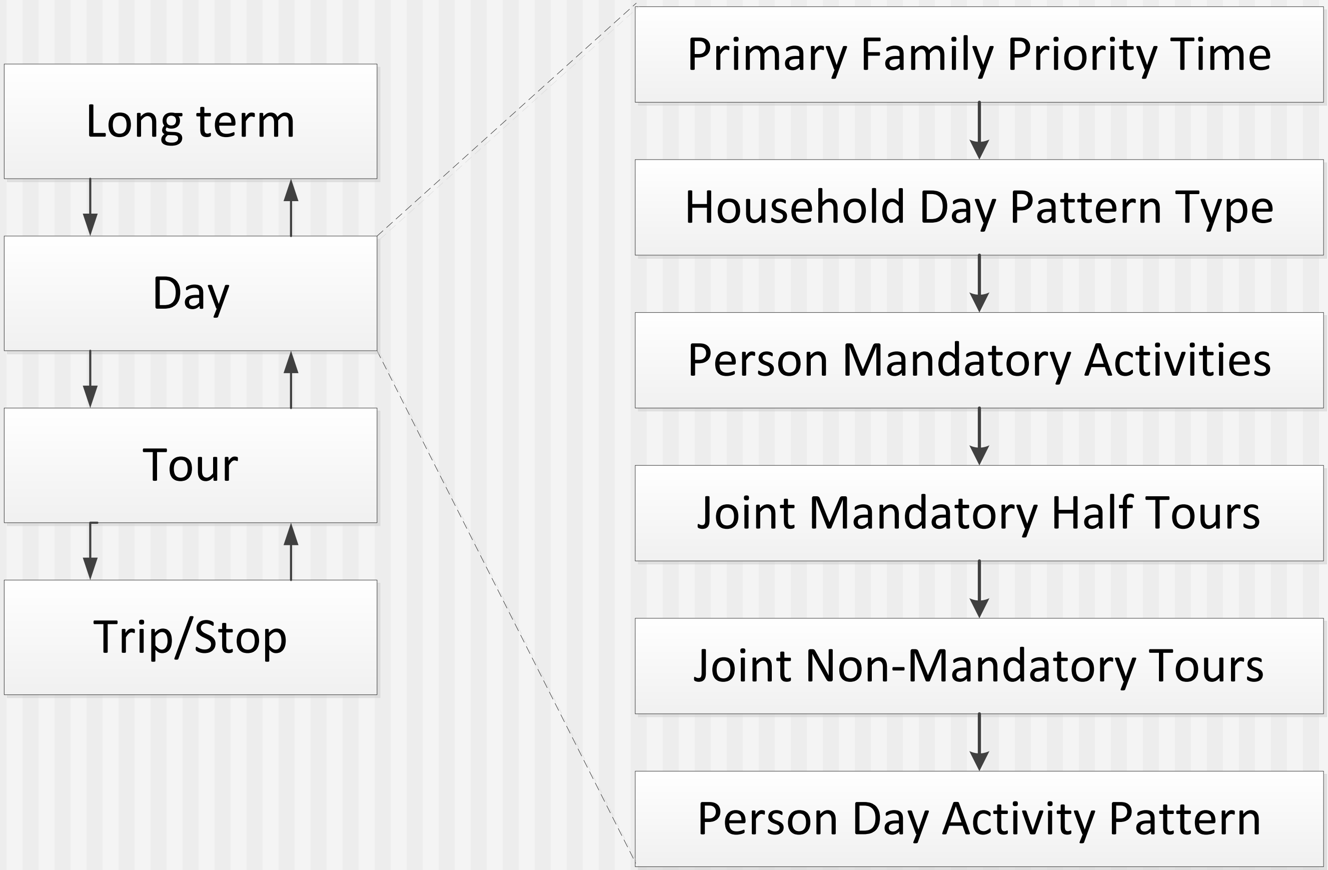
	Patterns with additional tour purpose(s) Tour Coeff (T stat)	Patterns with intermediate stops Stop Coeff (T stat)
School tour mode choice logsum	-0.014 (-0.19)	0.627 (7.74)
At-home mode-destination logsum	0.090 (3.84)	-0.007 (-0.37)

Logsums on
on-tour non-commute days

	Patterns with additional tour purpose(s) Tour Coeff (T stat)	Patterns with intermediate stops Stop Coeff (T stat)
At-home mode-destination logsum	0.077 (4.61)	0.000 (0.02)

Day models

with explicit intra-household interactions



Long term

Day

Tour

Trip/Stop

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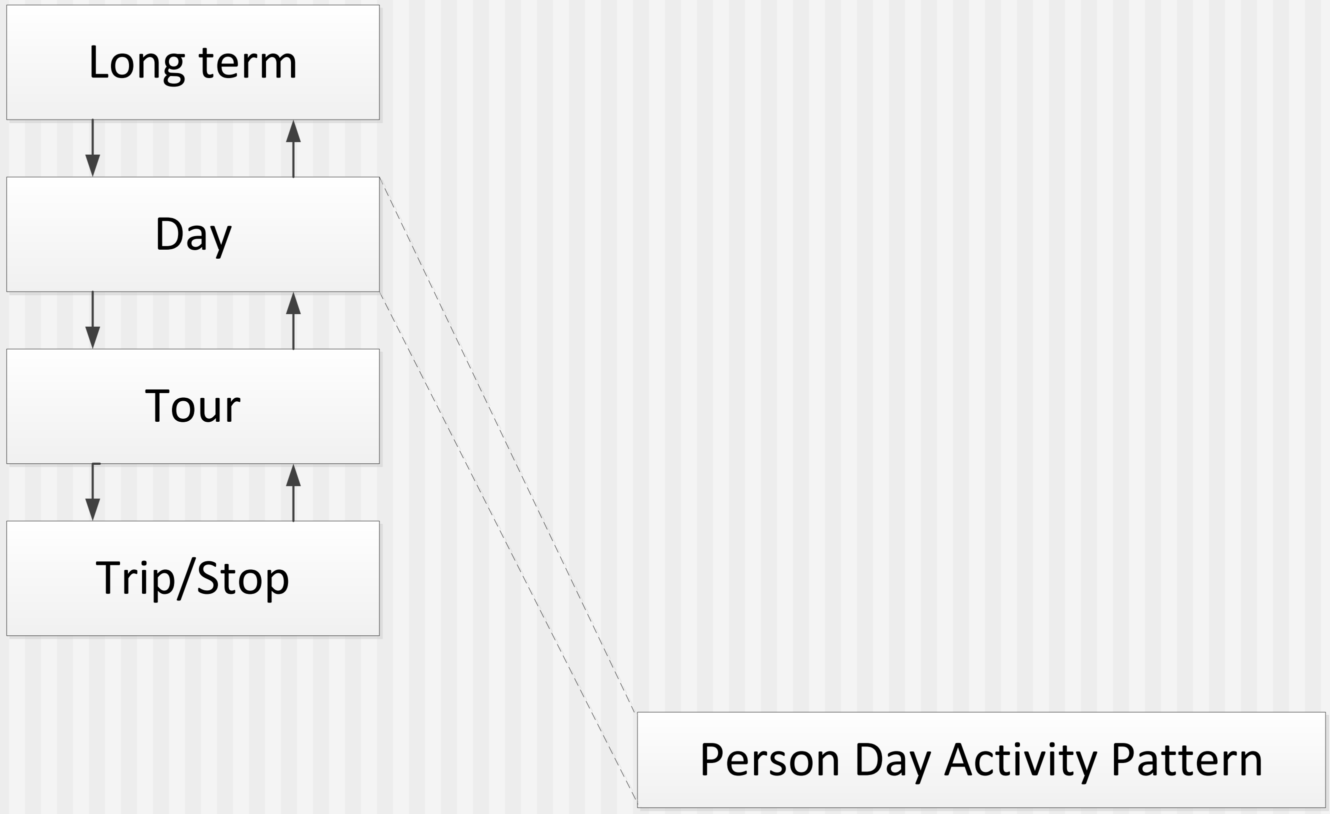
Day models

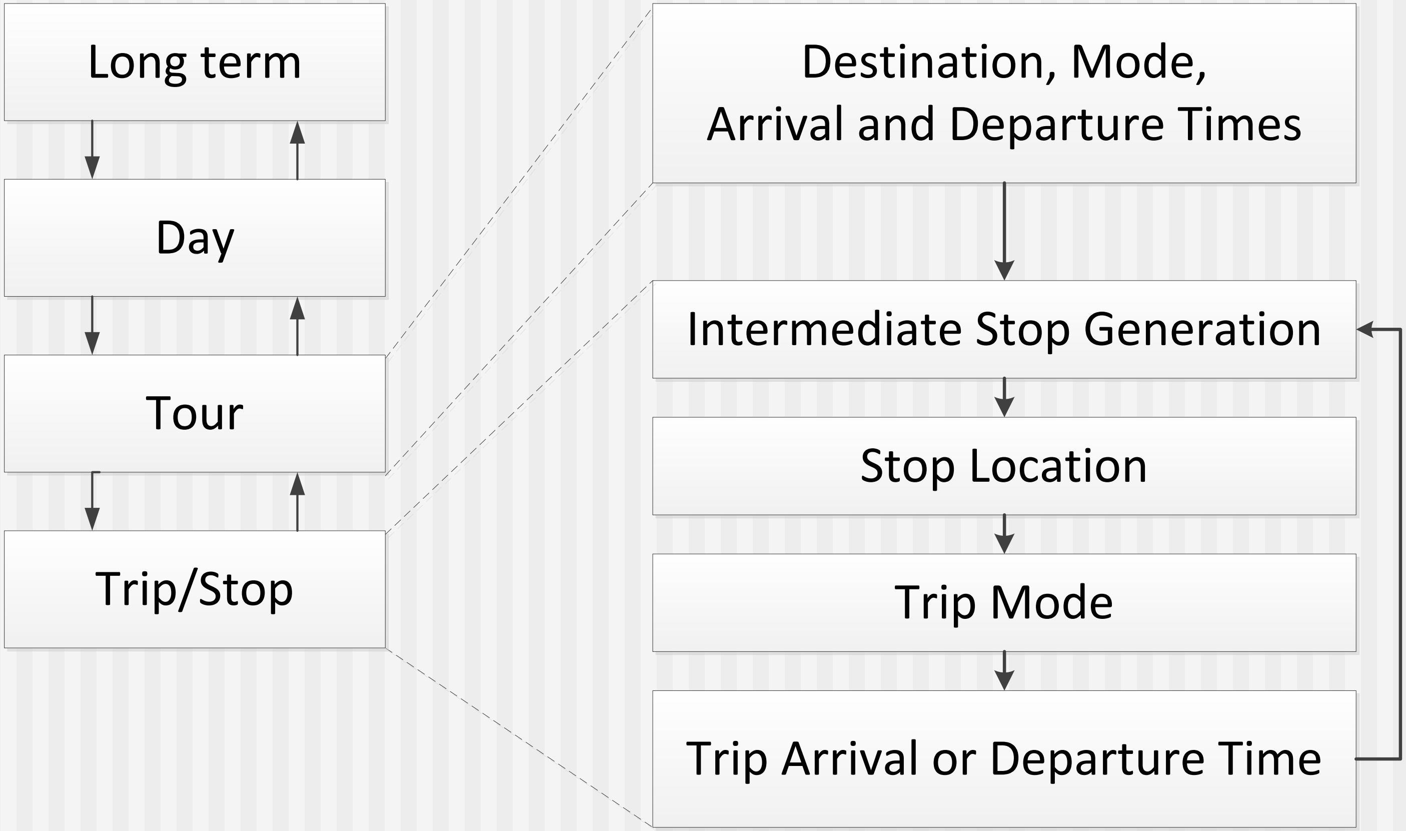
without explicit intra-household interactions



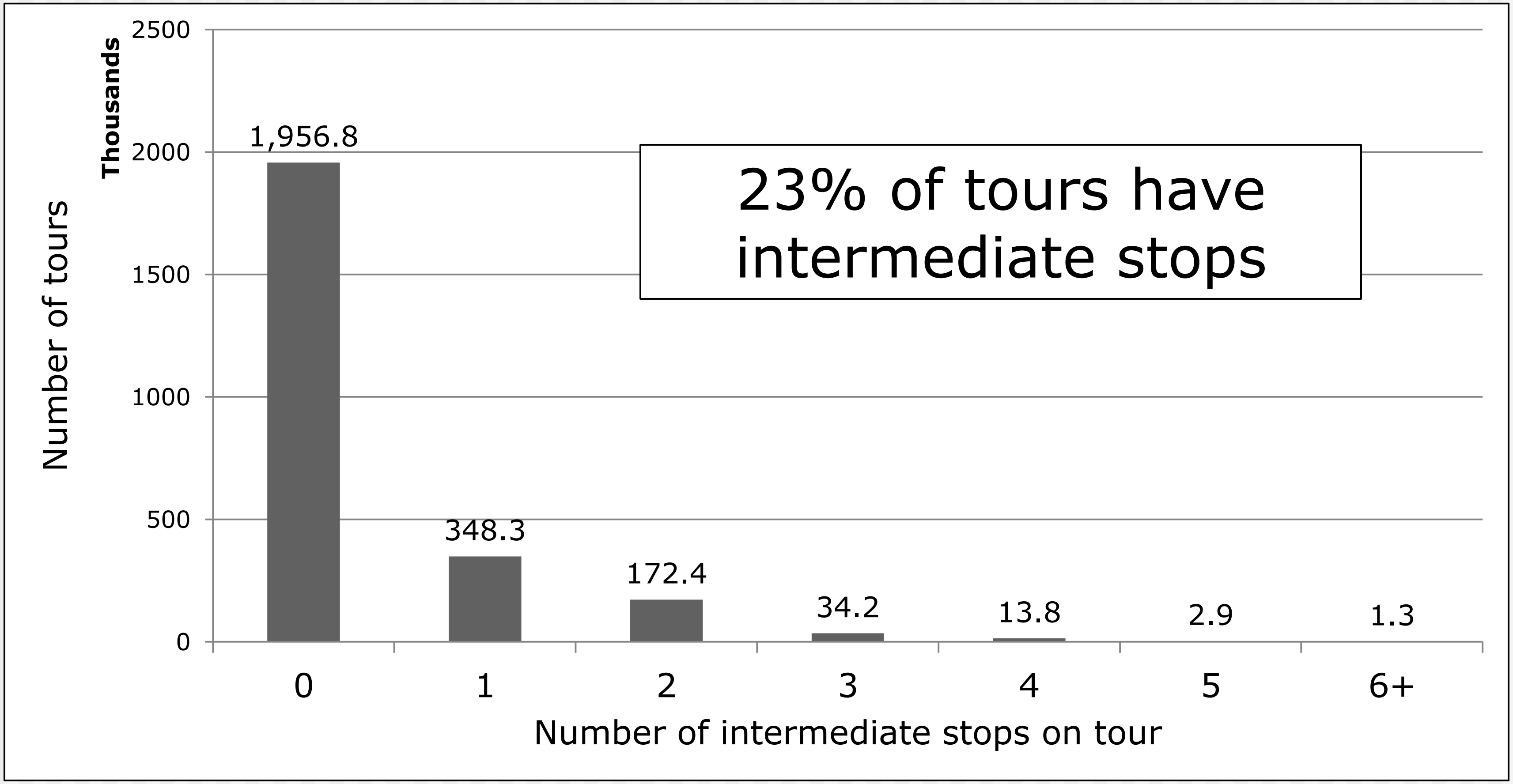
Why NOT model joint intra-household interactions?

- It is a lot simpler
  - Dealing with survey data
  - Estimating models
  - Calibrating and validating
- Not essential for many of the benefits of AB models, e.g.:
  - Time-of-day price sensitivity
  - Induced demand and trip chaining
  - Equity analysis

Tour and Trip Models

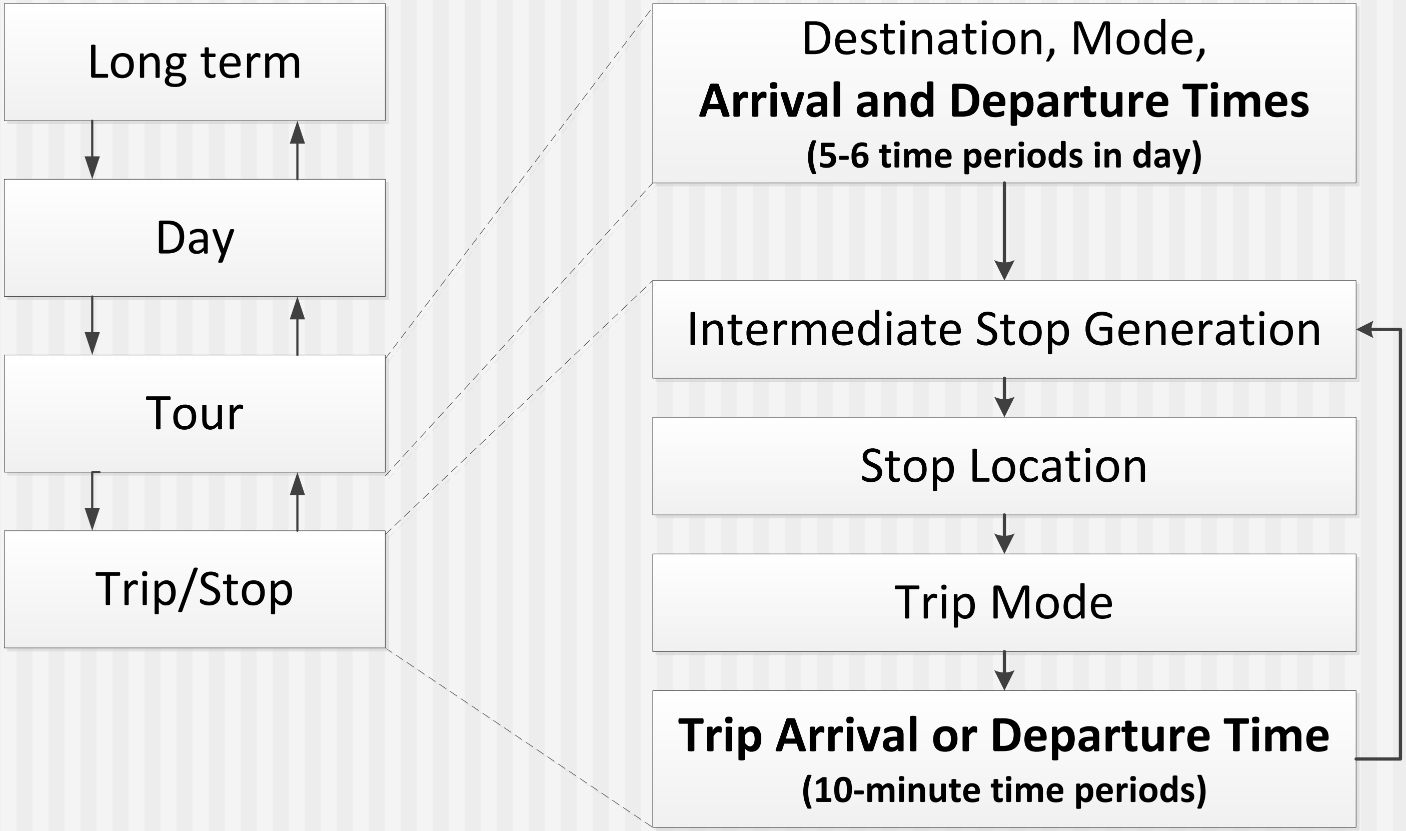

Long term
Day
Tour
Trip/Stop
Destination, Mode,
Arrival and Departure Times
Intermediate Stop Generation
Stop Location
Trip Mode
Trip Arrival or Departure Time

DaySim Base Year Intermediate Stops on Tours (Copenhagen)



23% of tours have intermediate stops

DaySim uses fine temporal detail


Long term

Day

Tour

Trip/Stop

Destination, Mode,
Arrival and Departure Times
(5-6 time periods in day)

Intermediate Stop Generation

Stop Location

Trip Mode

Trip Arrival or Departure Time
(10-minute time periods)

Discrete Choice Model Formulation for Time of Day

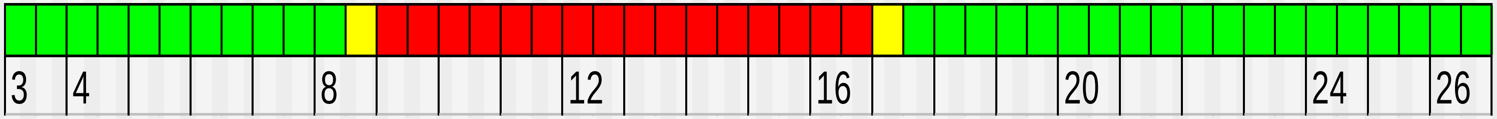
(Vovsha and Bradley, 2004)

- Logit model
- Important effects captured via ‘shift’ variables (analogous to hazard duration models)

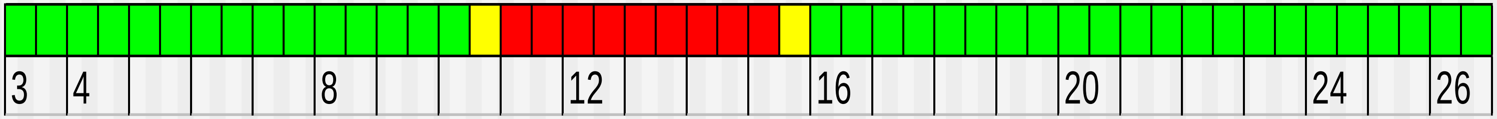
‘Shift’ effects--examples

- part time employees more likely to arrive at work later and have shorter work day

Likely outcome for FT employee:

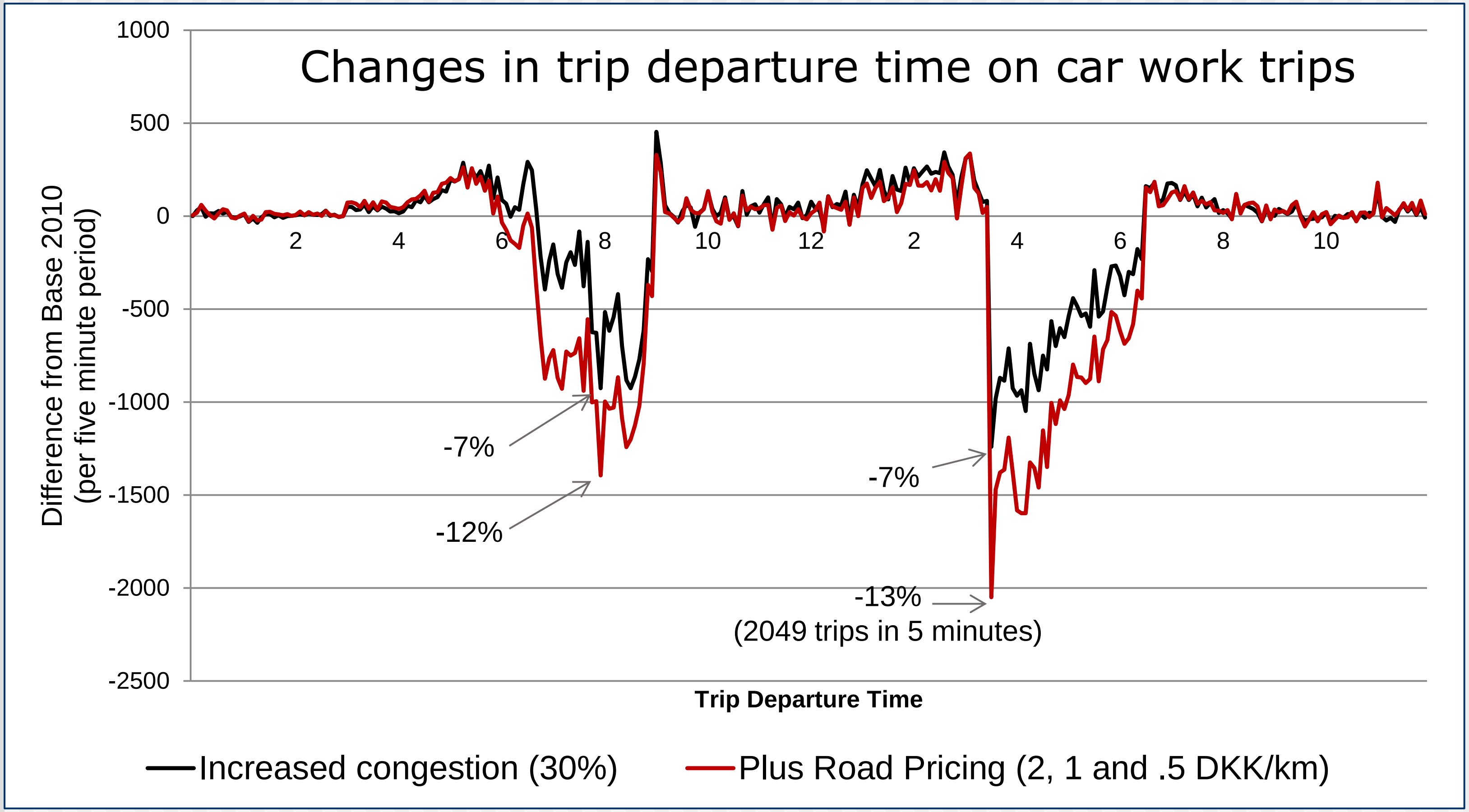


Likely outcome for PT employee:



- People shift travel to periods with lower travel time and cost

Copenhagen:
Congestion and Road Pricing



DaySim uses rigorous time window accounting

- When something is scheduled its time span is occupied
- Tight schedules affect choices
  - Hard constraints: infeasible alternatives are ruled out
  - Soft constraints: feasible alternatives causing tight schedules are less attractive

Simulation Event	Occupied time spans
Work tour scheduled	**7:53 AM to 4:47 PM**
No stop on way to work scheduled	**7:04 AM** to 4:47 PM
Stop on way home scheduled	7:04 AM to **5:30 PM**
No other stop on way home scheduled	7:04 AM to **6:05 PM**
Tour to eat out scheduled	7:04 AM to 6:05 PM **7:30 PM to 9:15 PM**
No stop on way to eat out scheduled	7:04 AM to 6:05 PM **7:15 PM** to 9:15 PM
No stop on way home scheduled	7:04 AM to 6:05 PM 7:15 PM to **9:30 PM**

Sensitivity to pricing via auto path type choice

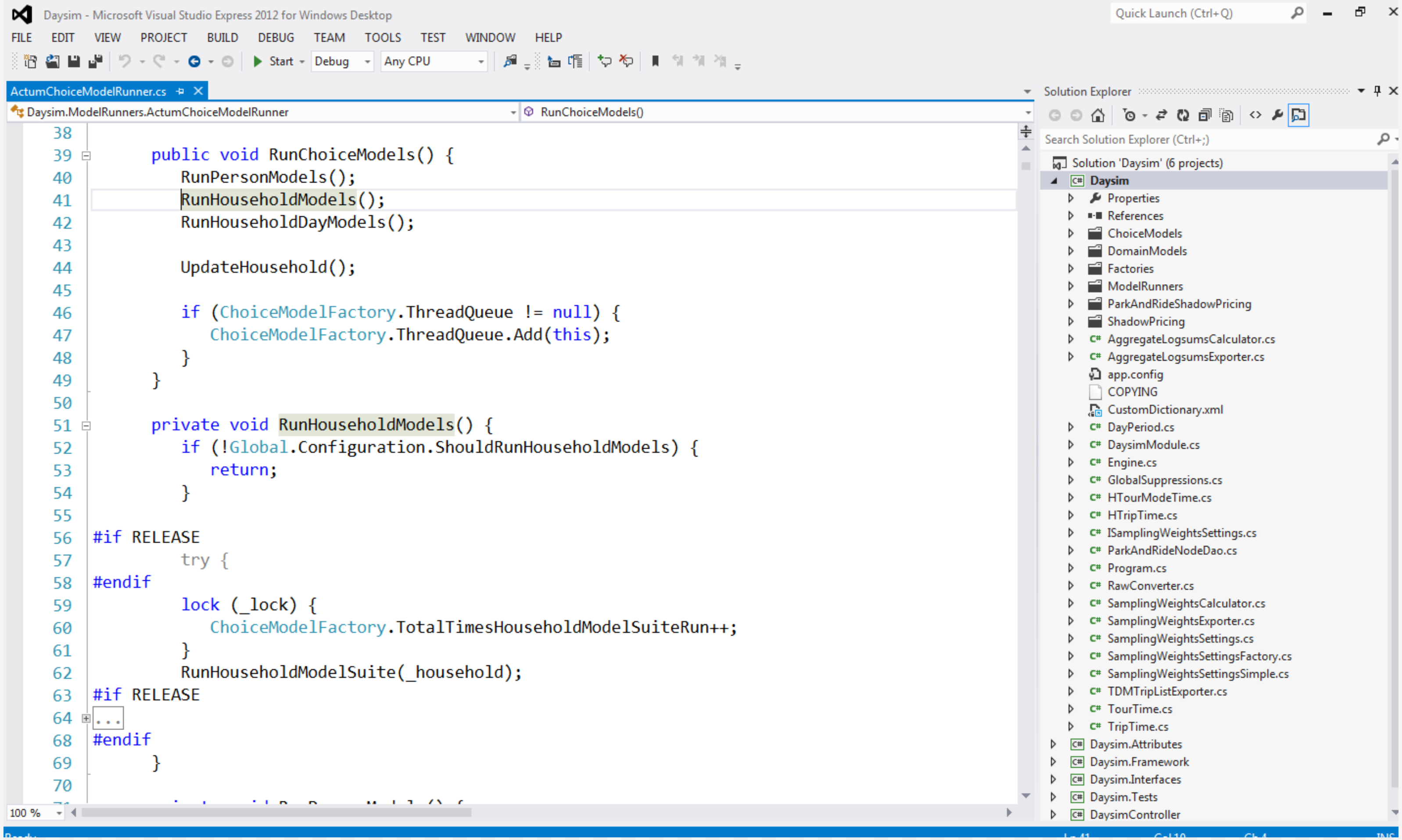
(uses findings of SHRP 2 C04 and C10)

- In some cases, a driver has the choice between a faster tolled path and a slower untolled path.
- Traffic model estimates attributes of both paths
- DaySim chooses between tolled and untolled path
  - Uses random variation in value of time

Outline

- Basic Features
- Model structure and associated features
- Software

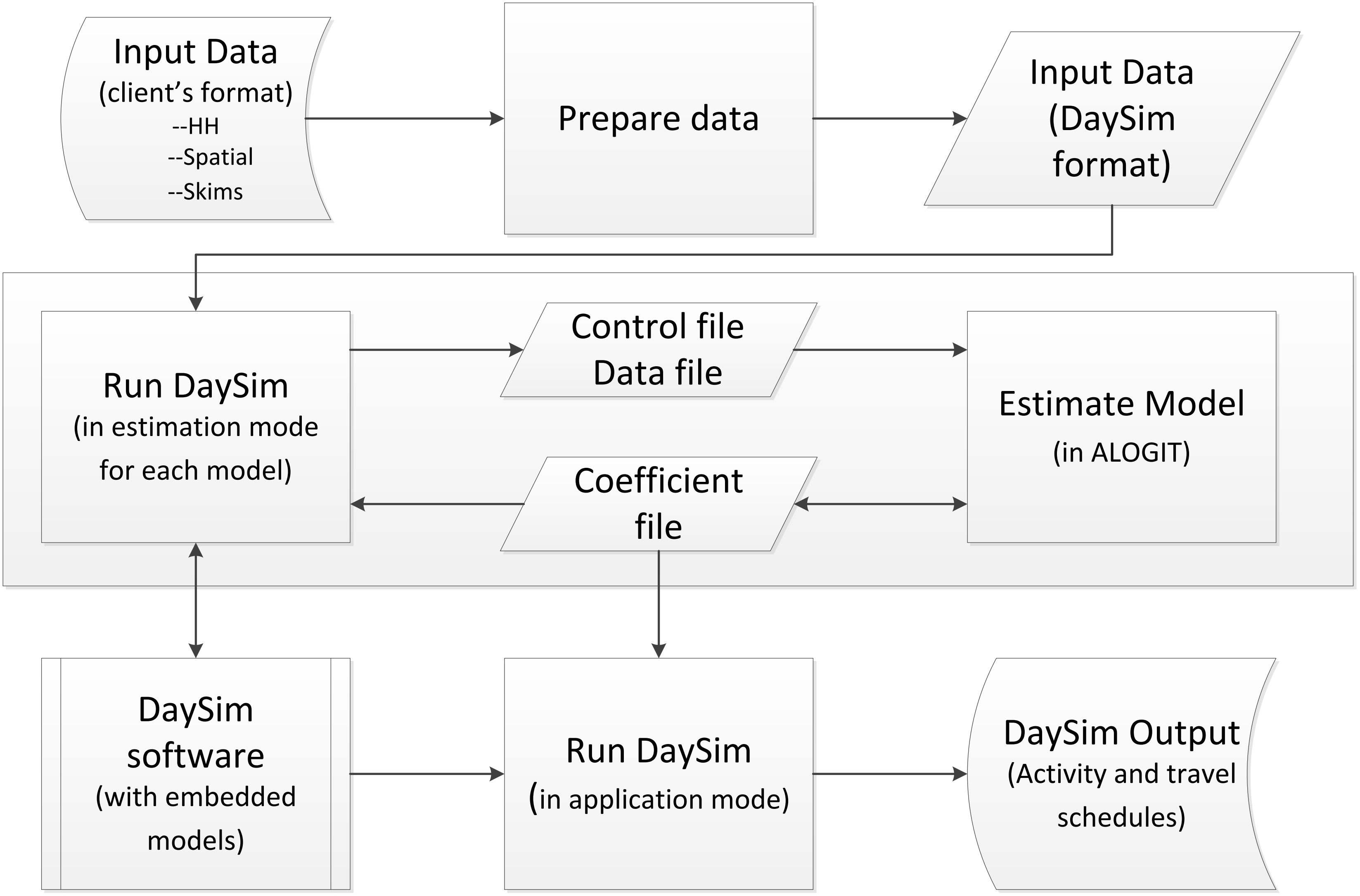
DaySim software: written in C# and distributed with open source license


Daysim - Microsoft Visual Studio Express 2012 for Windows Desktop
Quick Launch (Ctrl+Q)
FILE
EDIT
VIEW
PROJECT
BUILD
DEBUG
TEAM
TOOLS
TEST
WINDOW
HELP
Start
Debug
Any CPU
ActumChoiceModelRunner.cs
Daysim.ModelRunners.ActumChoiceModelRunner
RunChoiceModels()
Solution Explorer
Search Solution Explorer (Ctrl+;)
100 %

```
      public void RunChoiceModels() {
         RunPersonModels();
         RunHouseholdModels();
         RunHouseholdDayModels();

         UpdateHousehold();

         if (ChoiceModelFactory.ThreadQueue != null) {
            ChoiceModelFactory.ThreadQueue.Add(this);
         }
      }

      private void RunHouseholdModels() {
         if (!Global.Configuration.ShouldRunHouseholdModels) {
            return;
         }

#if RELEASE
         try {
#endif
         lock (_lock) {
            ChoiceModelFactory.TotalTimesHouseholdModelSuiteRun++;
         }
         RunHouseholdModelSuite(_household);
#if RELEASE
...
#endif
      }
```

Solution 'Daysim' (6 projects)
- Daysim
  - Properties
  - References
  - ChoiceModels
  - DomainModels
  - Factories
  - ModelRunners
  - ParkAndRideShadowPricing
  - ShadowPricing
  - AggregateLogsumsCalculator.cs
  - AggregateLogsumsExporter.cs
  - app.config
  - COPYING
  - CustomDictionary.xml
  - DayPeriod.cs
  - DaysimModule.cs
  - Engine.cs
  - GlobalSuppressions.cs
  - HTourModeTime.cs
  - HTripTime.cs
  - ISamplingWeightsSettings.cs
  - ParkAndRideNodeDao.cs
  - Program.cs
  - RawConverter.cs
  - SamplingWeightsCalculator.cs
  - SamplingWeightsExporter.cs
  - SamplingWeightsSettings.cs
  - SamplingWeightsSettingsFactory.cs
  - SamplingWeightsSettingsSimple.cs
  - TDMTripListExporter.cs
  - TourTime.cs
  - TripTime.cs
- Daysim.Attributes
- Daysim.Framework
- Daysim.Interfaces
- Daysim.Tests
- DaysimController

DaySim software: supports model estimation and application



DaySim software: runs fast on a PC (e.g. Sacramento)

Problem Size	
Households / persons	.9 M / 2.2 M
Zones / parcels	1533 / 0.7 M
assignment periods / classes	12 / 3

Performance	Threads	Hrs per iteration	Hrs (7 global iterations)	
DaySim	4	**0.7**	4.7	**25%**
Assignment, etc	3	2.0	14.3	75%
Total		2.7	**19**	

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DaySim	4	**0.7**	4.7	**25%**
Assignment, etc	3	2.0	14.3	75%
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DaySim software: runs fast on a PC (e.g. Sacramento)

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Households / persons	.9 M / 2.2 M
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Summary: DaySim…..

- equilibrates with traffic assignment
- is an integrated system of discrete choice models
  - Downward and upward integration are important
- uses fine spatial and temporal detail
- has versions with and without explicit intra-household interactions
- has well-engineered software and runs fast
- is in development or implemented in 11 locations

Collaborators

- Moshe Ben-Akiva (1993-1998)
- Keith Lawton at Metro (1995-2000)
- Mark Bradley (since 1996)
- Gordon Garry & Bruce Griesenbeck at SACOG (since 2001)
- John Gibb & John Long at DKS (since 2005)
- Joe Castiglione (since 2007)
- Resource Systems Group (since 2008)
- Suzanne Childress & PSRC (since 2010)
- Goran Vuk at Danish Road Directorate (since 2011)
- Christian Overgård Hansen & DTU Transport (since 2011)