The Transition to Activity Based Models: What, why, when, where, how?

presented to

Panel on Activity-Based Models

presented by

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May 26, 2010

FLORIDA MODEL TASK FORCE

What is different about activity-based models compared to typical four-step models?

- **Units of decisions**
  - Trips >> Tours >> Person-days >> Household-days >> Longer term choices
- **Method of predicting choices**
  - Top-down aggregate shares >> Bottom-up microsimulation
- **Amount of detail that can be accommodated**
  - Socio-Demographic: A few segmentations >> Many variables
  - Temporal: Broad time periods >> Hours or half-hours
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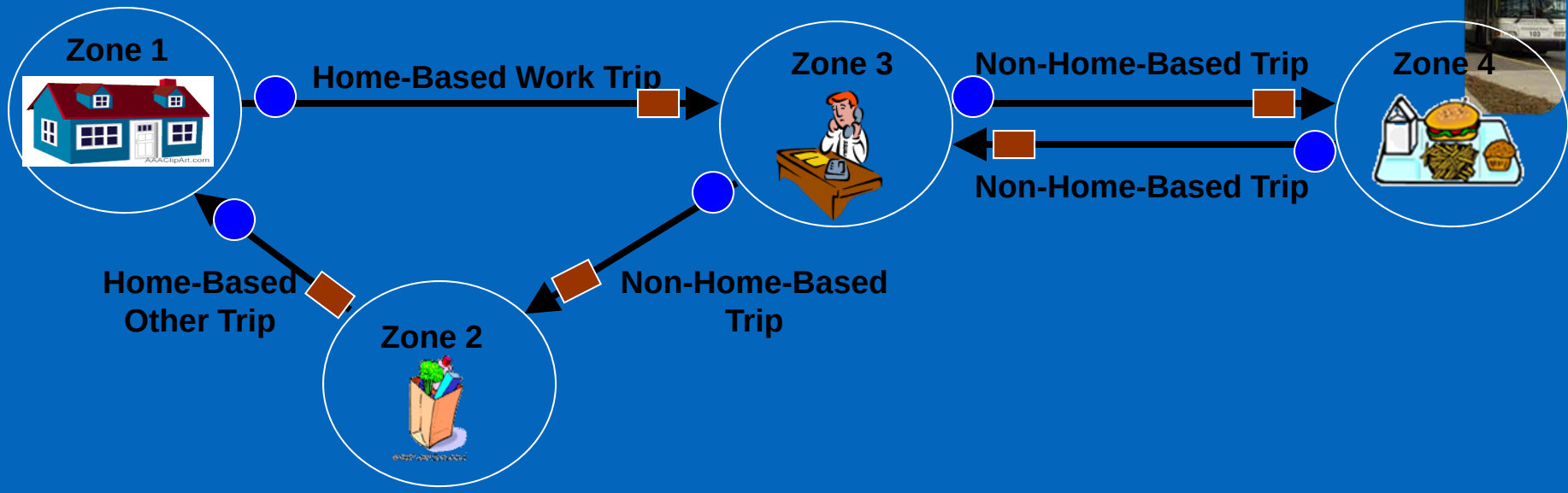
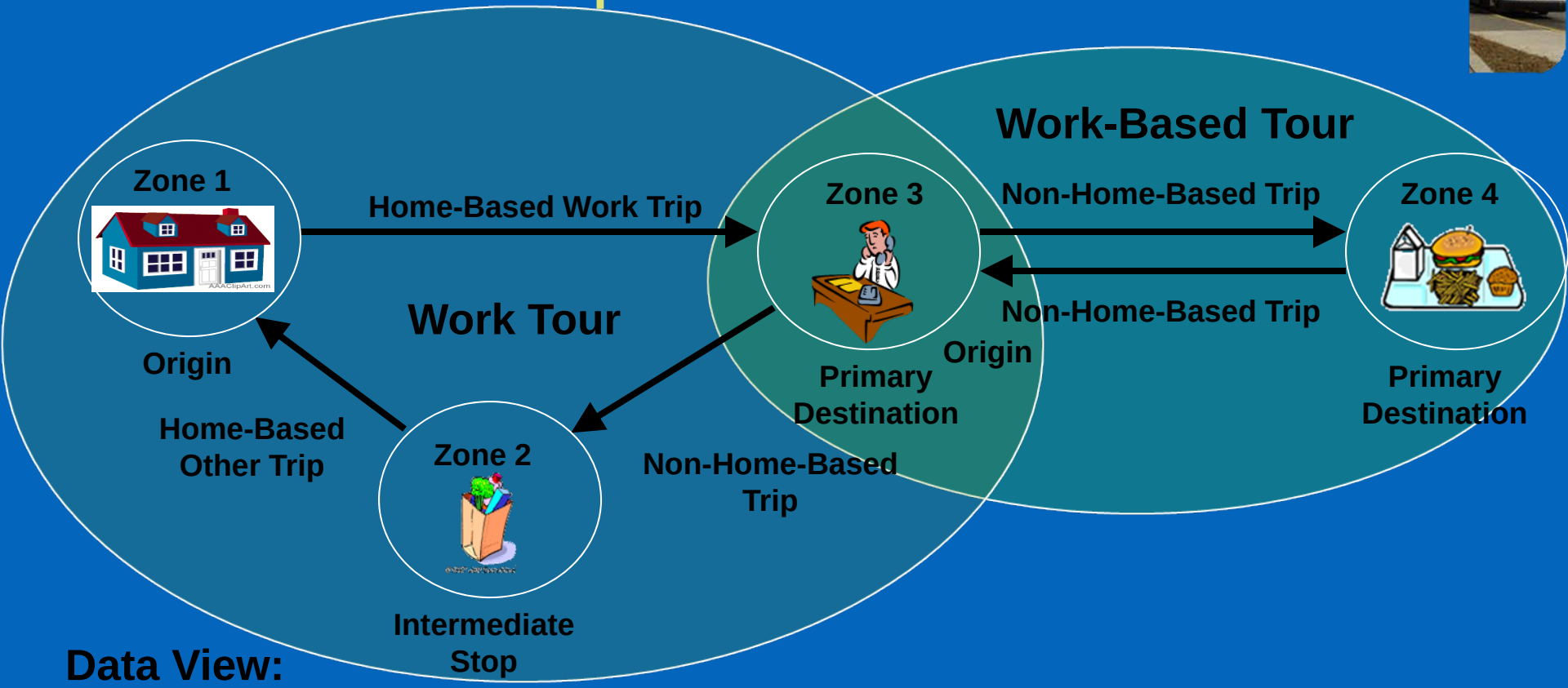
Using home-based tours as a second unit of behavior

- **Why?**
  - Mode, timing, destination of trips on a tour are highly related
  - Current models do a poor job predicting NHB trips
- **When and where?**
  - Netherlands National and Regional Models (mid-1980's)
  - CS models in Idaho, New Hampshire (mid-1990's)
  - A feature of all ABM since (Portland, San Francisco, NYC, Columbus, Sacramento, Tahoe, Atlanta, Bay Area, Seattle, Denver, San Diego, Los Angeles, Phoenix, Jacksonville, …)
- **How?**
  - Original implementations were modified four-step
  - Realistic treatment of intermediate destinations is only feasible in a microsimulation framework (Portland)



	Home-Based Work (HBW)		Home-Based Other (HBO)		Non-Home-Based (NHB)	
Zone	Prod.	Attract.	Prod.	Attract.	Prod.	Attract.
1	1		1			
2				1		1
3		1			2	1
4					1	1
Total	1	1	1	1	3	3

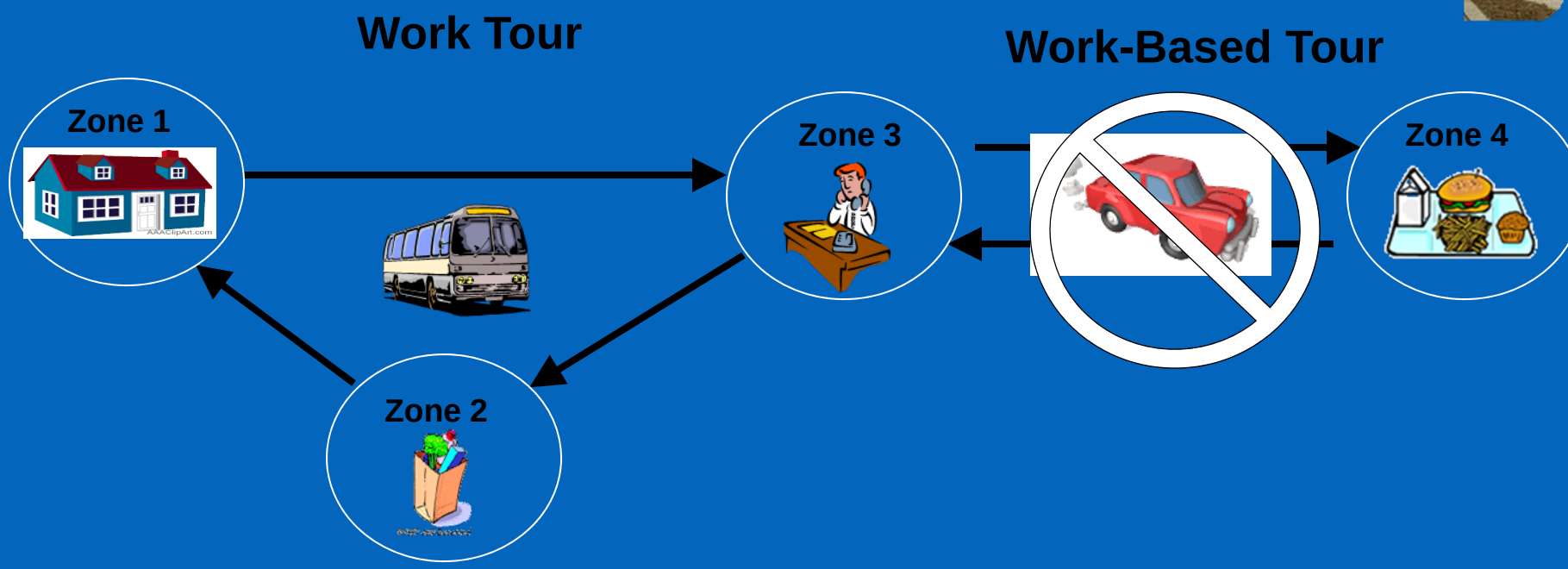
ABM: Tours and Trips



Data View:

HH #	Per #	Tour #	Purp	Origin TAZ	Destin. TAZ	Outbound Stop1 TAZ	Return Stop1 TAZ	Mode	Sub-tour	Sub-Tour Destin.
1023	1	1	Work	1	3	0	2	Transit	Yes	4

Activity-Based Models: Mode Consistency

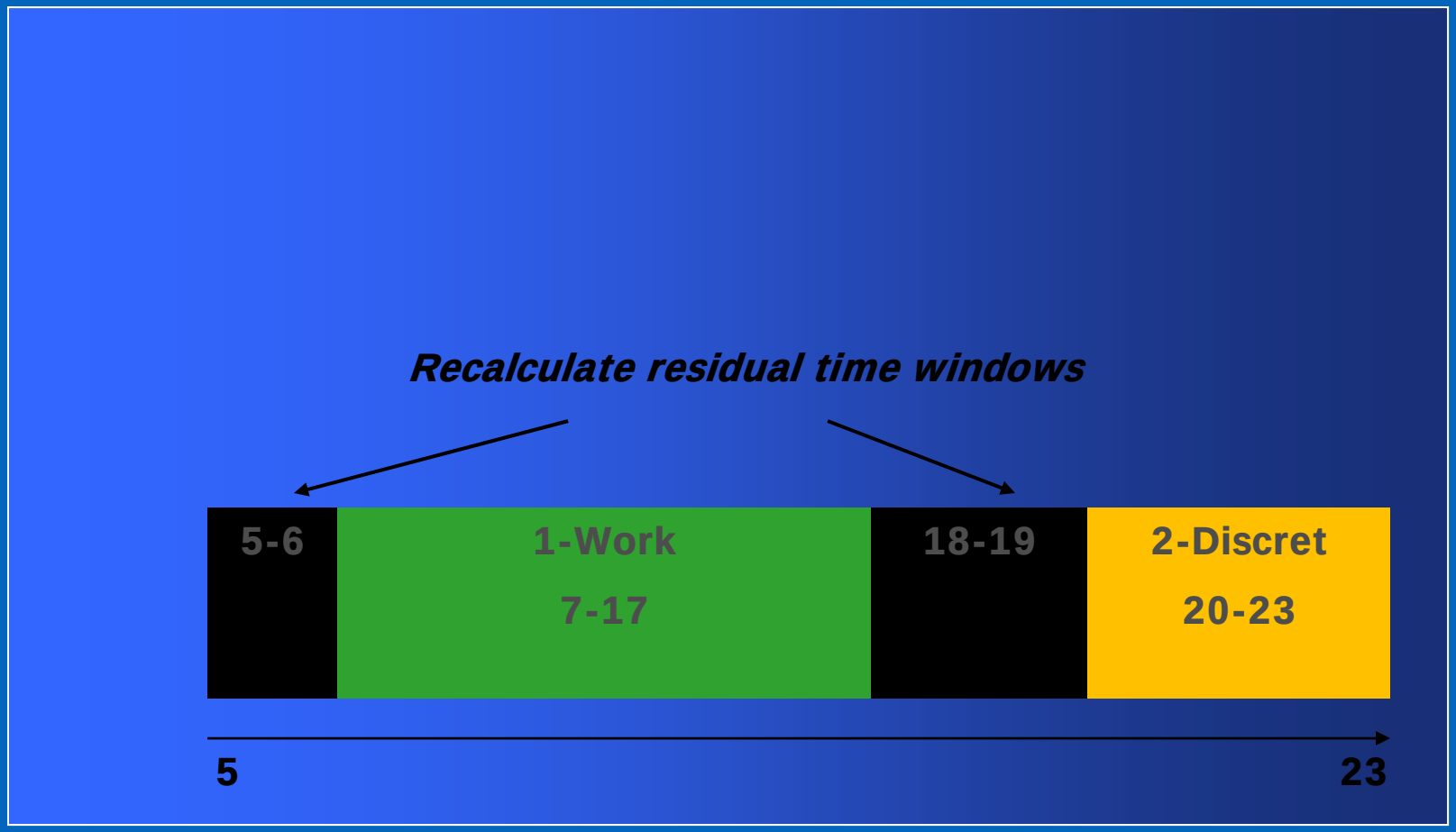


Bus to Work = Drive alone not available for lunch

Using person-days as a third unit of behavior

- **Why?**
  - Tours in a day are related because of time-space constraints
    - substitution among tours
    - substitution between more trips on tours versus more tours
    - affected by travel conditions
  - Model time of day choices realistically
- **When and where?**
  - Boston (Bowman and Ben Akiva, mid-1990's)
  - Portland, San Francisco implementations (late 1990's)
  - A feature of all ABM since (but with various assumptions)
- **How?**
  - Requires another level of choice hierarchy in microsimulation frameworks, plus good travel diary data.

Time-Use Concept: Scheduling of Tours in a Day

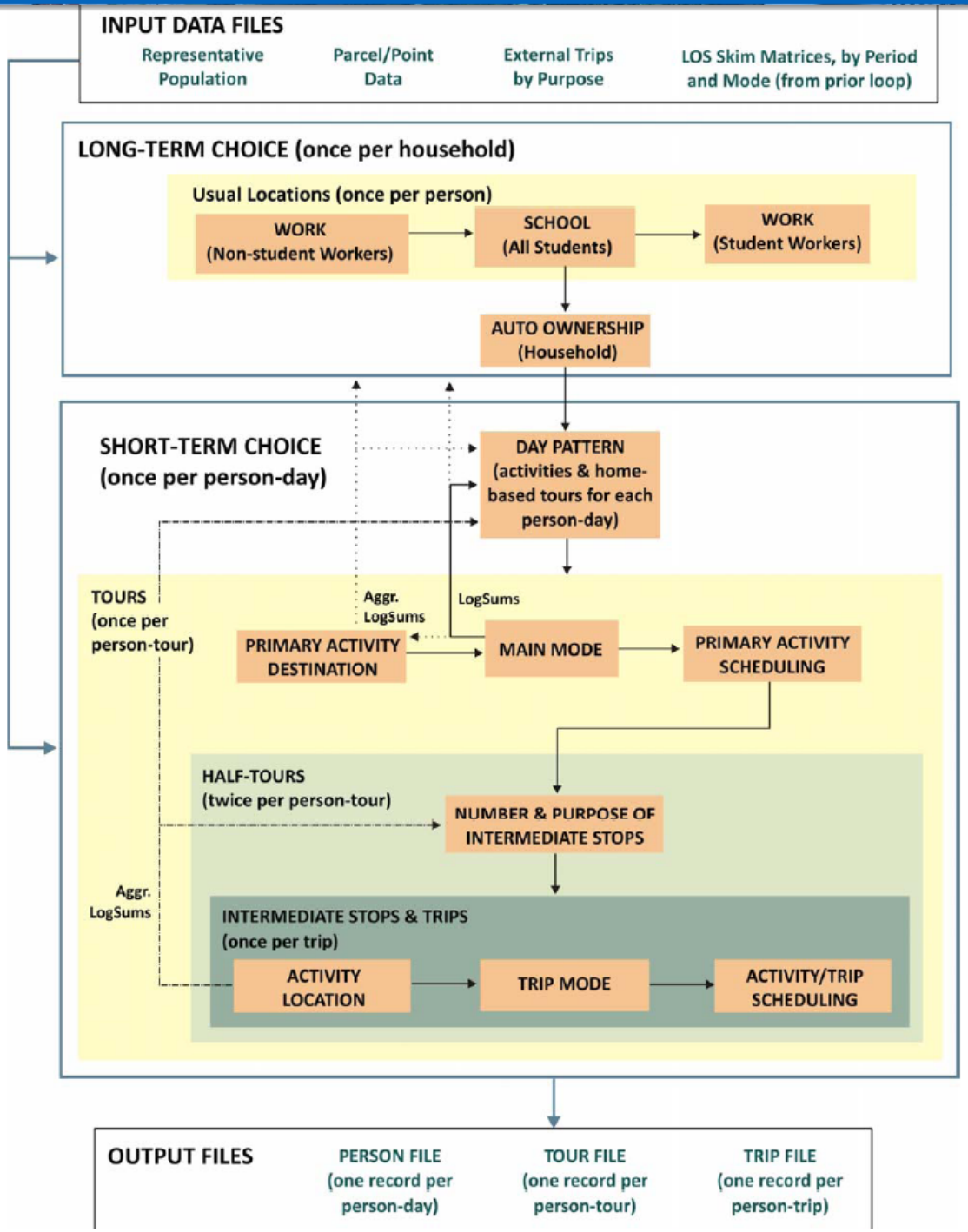


Modeling explicit linkages between household member's activity and travel patterns

- **Why?**
  - Explicit interactions between household members (e.g. parents taking kids to school)
  - Joint travel has different constraints, policy sensitivities
- **When and where?**
  - Joint discretionary tours: Columbus (Vovsha, mid 2000's)
  - Joint work/school half-tours: San Diego, Seattle (2010?)
  - Will be a feature of all ABM soon
- **How?**
  - Requires yet another level of choice hierarchy in microsimulation frameworks, plus even better travel diary data

Modeling some decisions as “longer term” choices

- **Why?**
  - **Choice of regular workplace, school, auto ownership are not day-to-day decisions, and can influence / be influenced by a wide variety of other related travel choices**
- **When and where?**
  - **San Francisco (late-1990’s)**
  - **A feature of nearly all ABM since**
  - **Newest ABM’s may include a wider range (transit pass holding, usual work schedule, usual mode to work)**
- **How?**
  - **Fit naturally into the structure of AB microsimulation models to loop across individual households and persons.**


INPUT DATA FILES
Representative Population
Parcel/Point Data
External Trips by Purpose
LOS Skim Matrices, by Period and Mode (from prior loop)
LONG-TERM CHOICE (once per household)
Usual Locations (once per person)
WORK (Non-student Workers)
SCHOOL (All Students)
WORK (Student Workers)
AUTO OWNERSHIP (Household)
SHORT-TERM CHOICE (once per person-day)
DAY PATTERN (activities & home-based tours for each person-day)
TOURS (once per person-tour)
Aggr. LogSums
LogSums
PRIMARY ACTIVITY DESTINATION
MAIN MODE
PRIMARY ACTIVITY SCHEDULING
HALF-TOURS (twice per person-tour)
NUMBER & PURPOSE OF INTERMEDIATE STOPS
Aggr. LogSums
INTERMEDIATE STOPS & TRIPS (once per trip)
ACTIVITY LOCATION
TRIP MODE
ACTIVITY/TRIP SCHEDULING
OUTPUT FILES
PERSON FILE (one record per person-day)
TOUR FILE (one record per person-tour)
TRIP FILE (one record per person-trip)

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Top-down forecasting (aggregate four step) Multiplying rates and fractions

- Households by population segment / residence TAZ

  < Trip generation rates >

- Trips by population segment / trip purpose / residence TAZ

  < Trip distribution model >

- Trips by pop. segment / trip purpose / O-D TAZ pair

  < Time of day factors or model >

- Trips by segment / trip purpose / O-D pair / time period

  < Mode choice model >

- Trips by segment / trip purpose / O-D pair / time period / mode

  < = >

- Many millions of numbers, mostly small fractions of trips

Bottom-up forecasting (population microsimulation) Adding up discrete choices

- **Apply a hierarchical series of models to predict behavior at several different levels for each representative household and person in the regional population:**
  - **Work and school locations**
  - **Auto ownership**
  - **Household-days**
  - **Person-days**
  - **Tours**
  - **Trips**
    - Origin and destination locations
    - Departure time and arrival time
    - Mode used

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- **Millions of trip records, each a single trip >> ADD THEM UP**

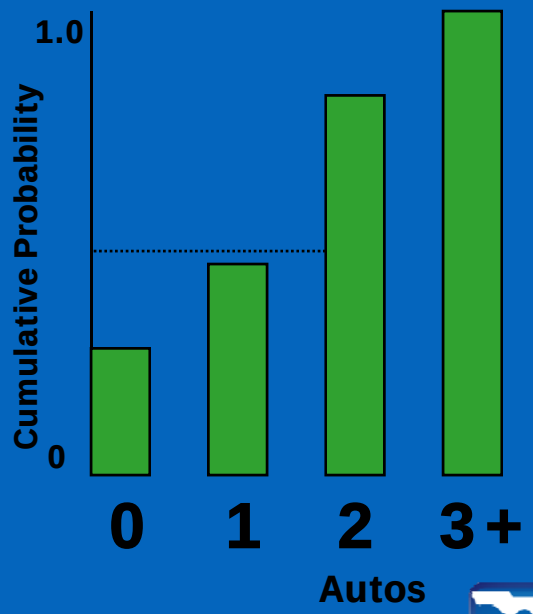
Monte Carlo Simulation Example – Auto Ownership

Autos	Utility	Exp(Utility)	Probability	Cumulative Probability
0	0	1.0000	0.0570	0.0570
1	1.7	5.4739	0.3122	0.3692
2	2	7.3891	0.4215	0.7907
3+	1.3	3.6693	0.2093	1.0000
Sum		17.5323	1.0000	

> 0.3897 ?

Random Number Draw = 0.3897

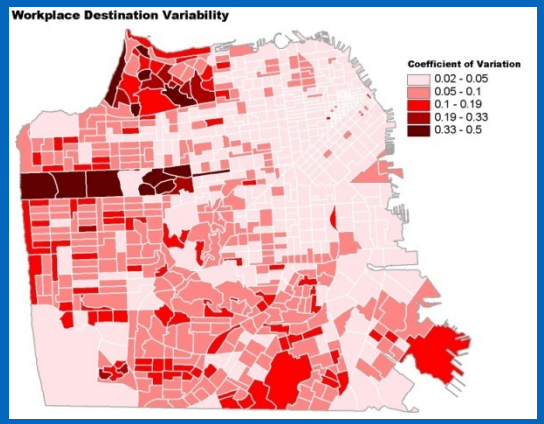
= 2 autos



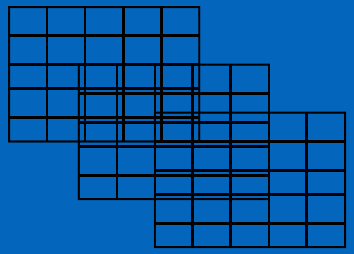
Tour-Based Model Output

Household Data, Person Data, Tour/Trip List

HID	PID	TID	PUR	MOD	SB	SA	OTAZ	DTAZ	S1TAZ	S2TAZ	TLOR	TLDS
1	1	1	2	1	0	1	943	987	0	964	1	3
1	1	2	1	2	1	0	943	731	856	0	3	3
1	2	1	4	1	0	0	943	952	0	0	1	2
1	3	1	2	4	1	1	943	565	698	982	1	2

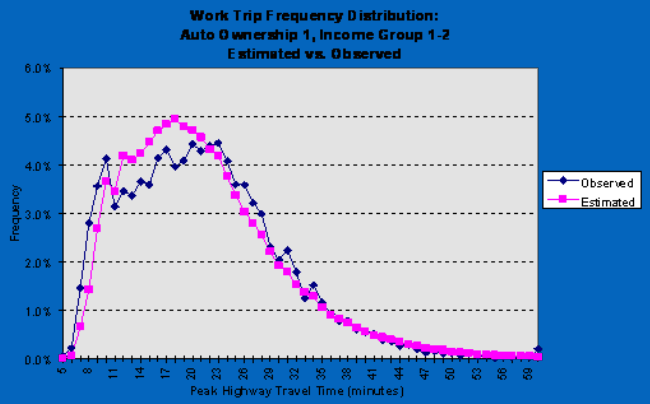


Maps, Graphics



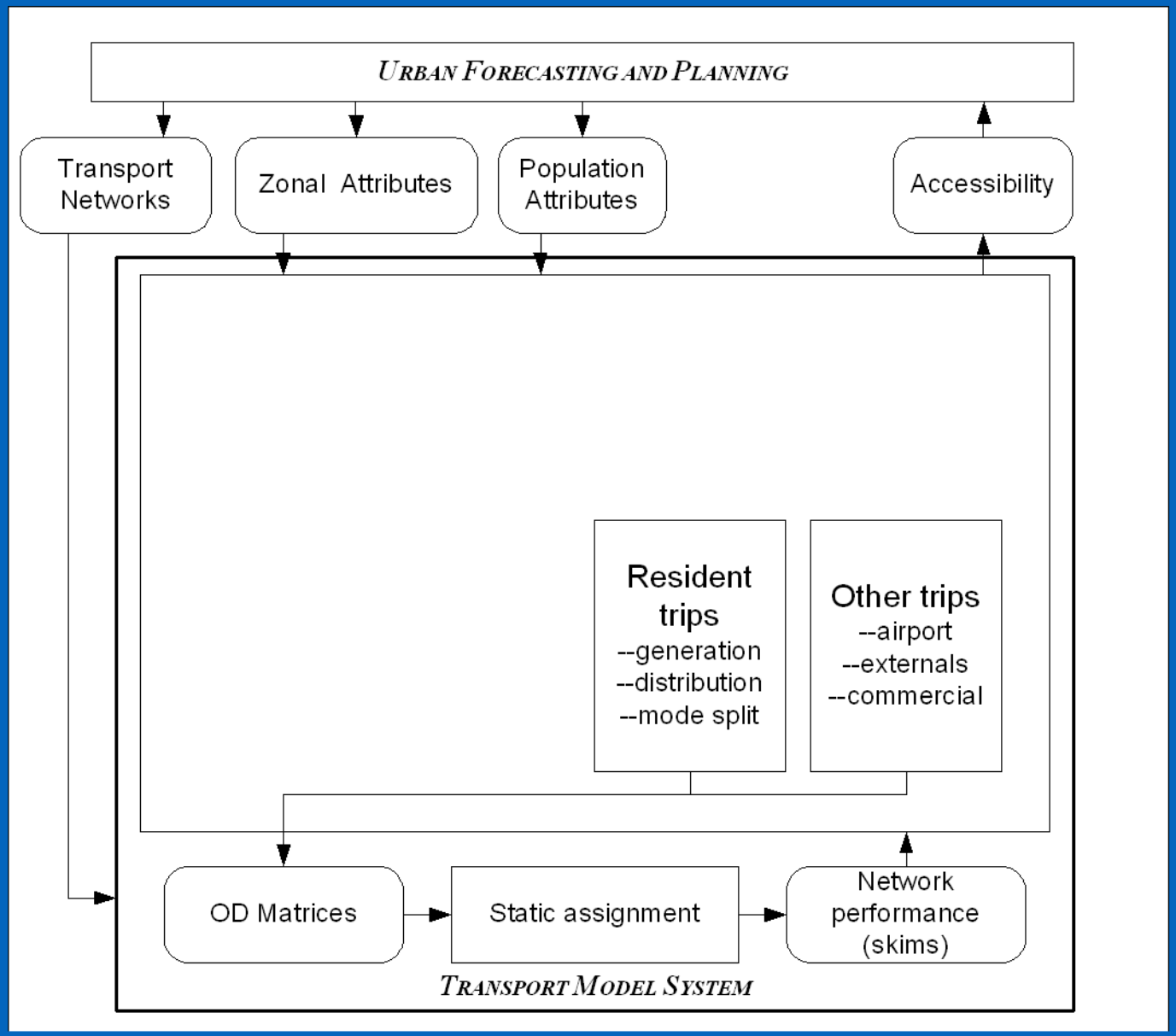
Trip Tables

Assignment

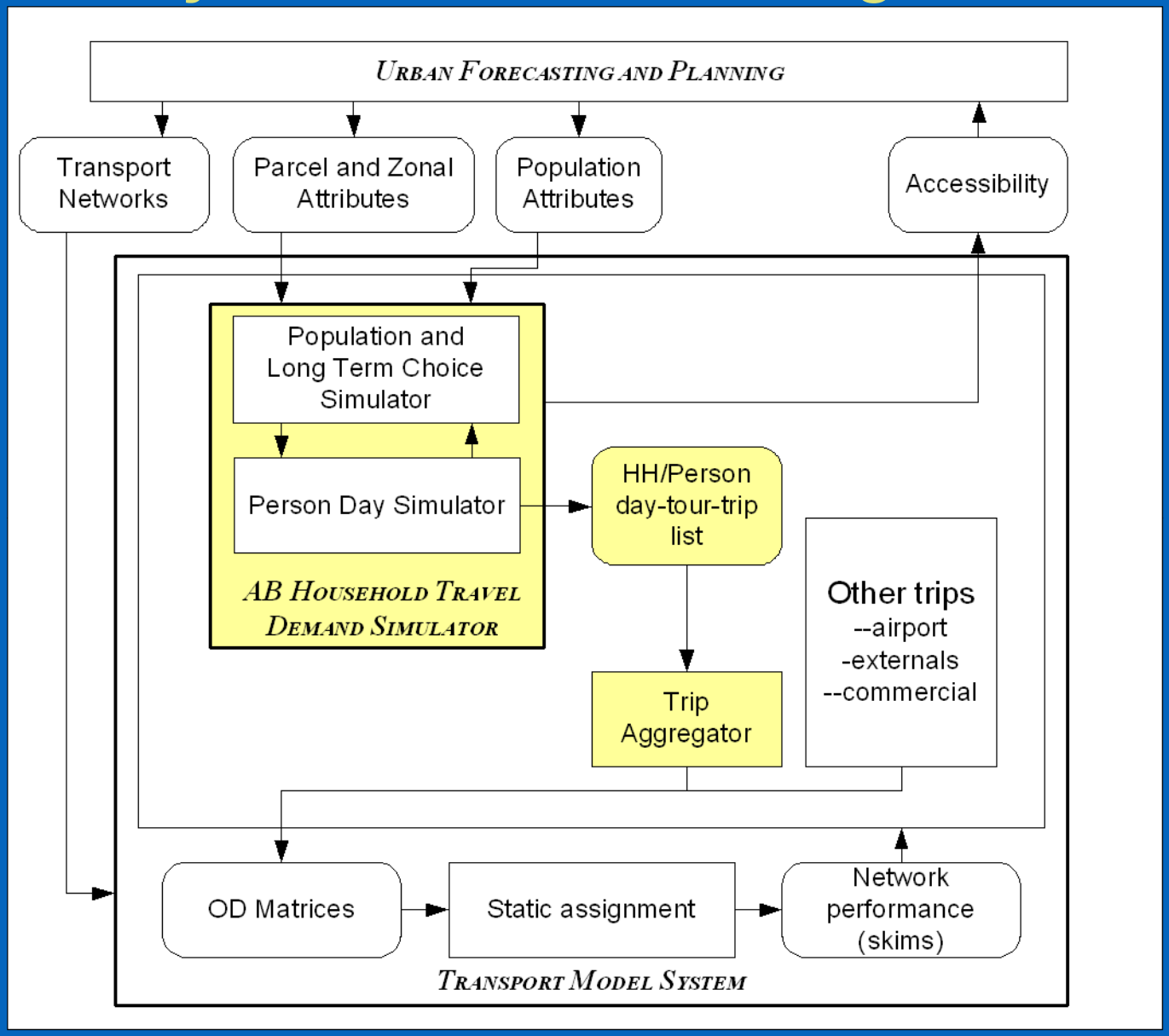


Other Summaries

Trip-Based Model System



AB Model System with Static Assignment



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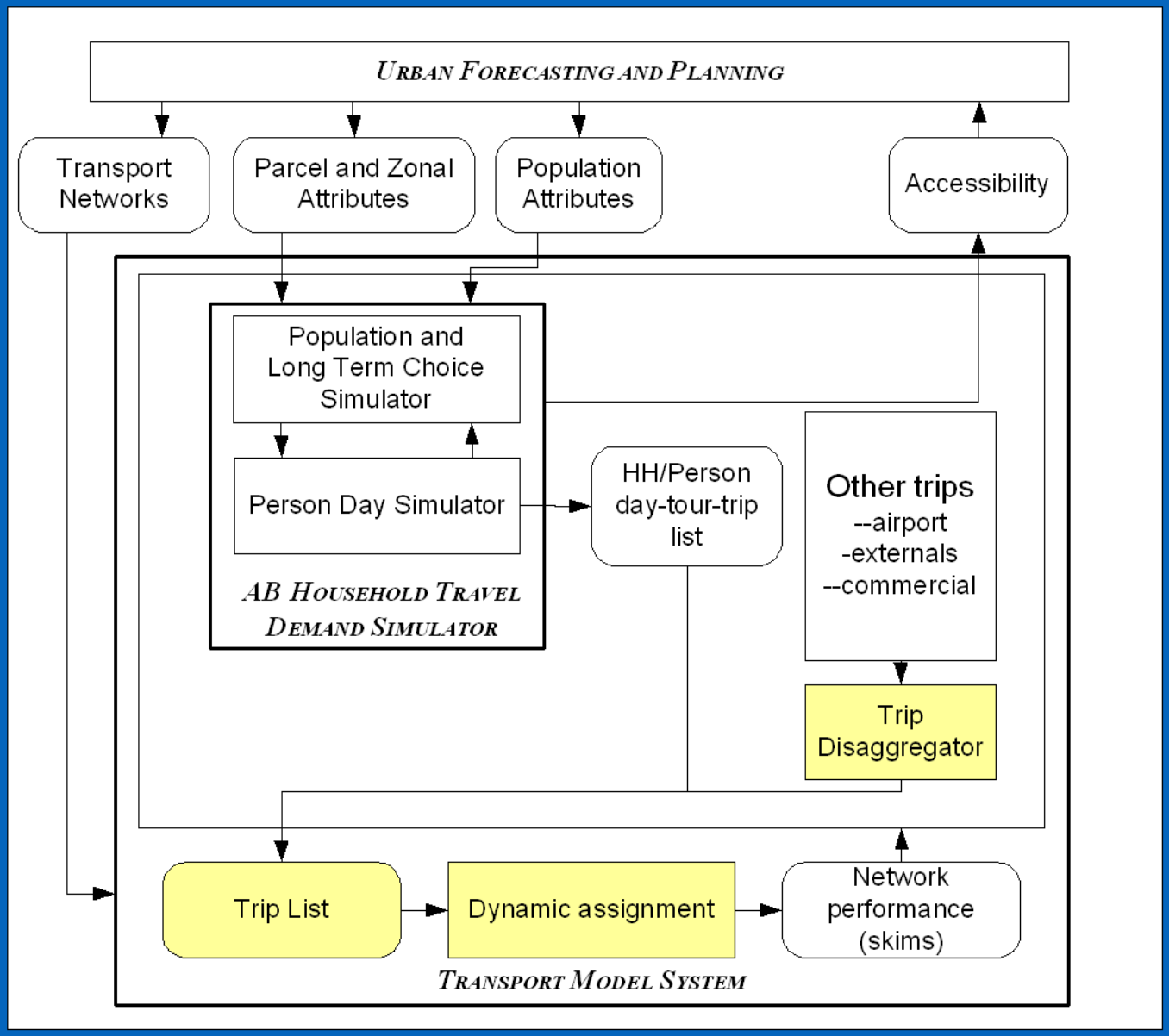
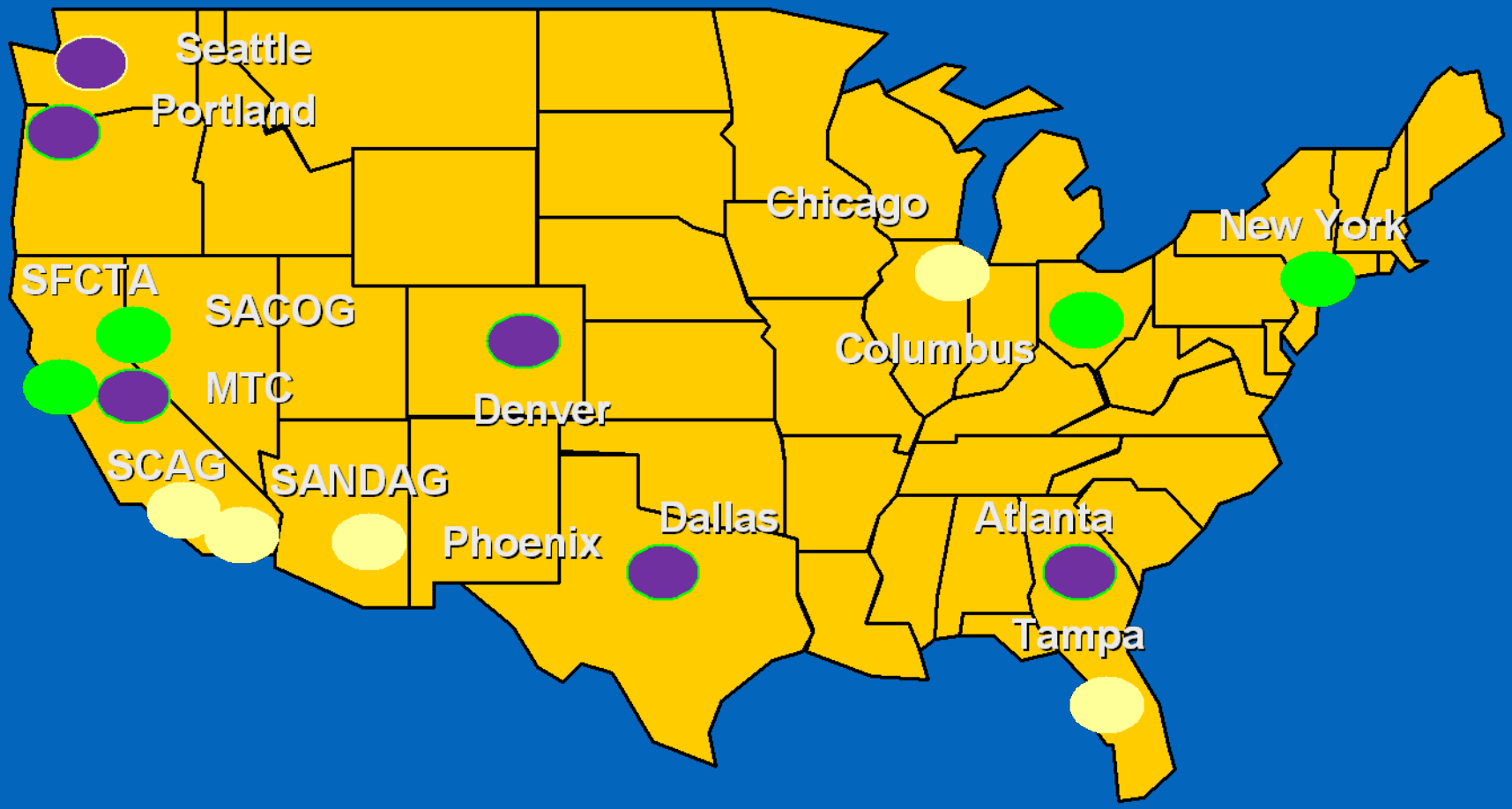


There are many AB model systems (and active projects) in the US with static assignment



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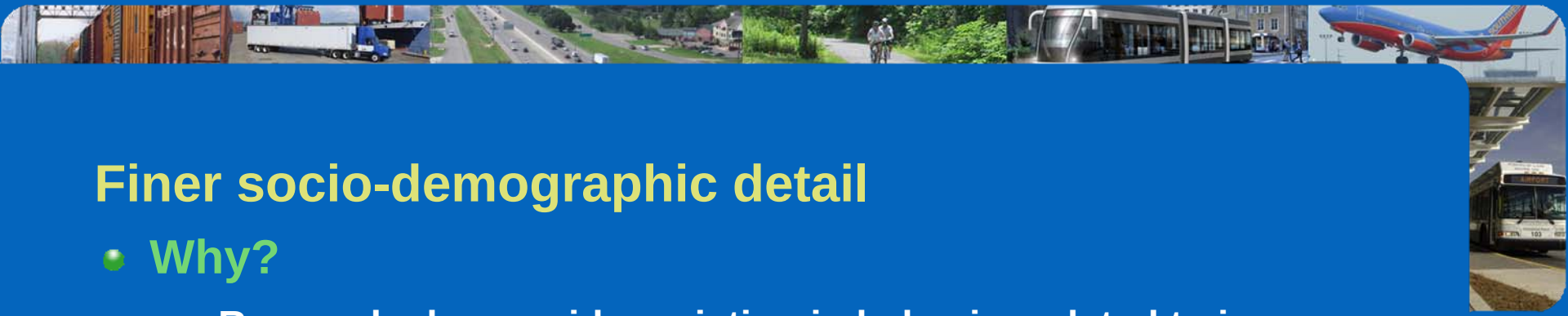
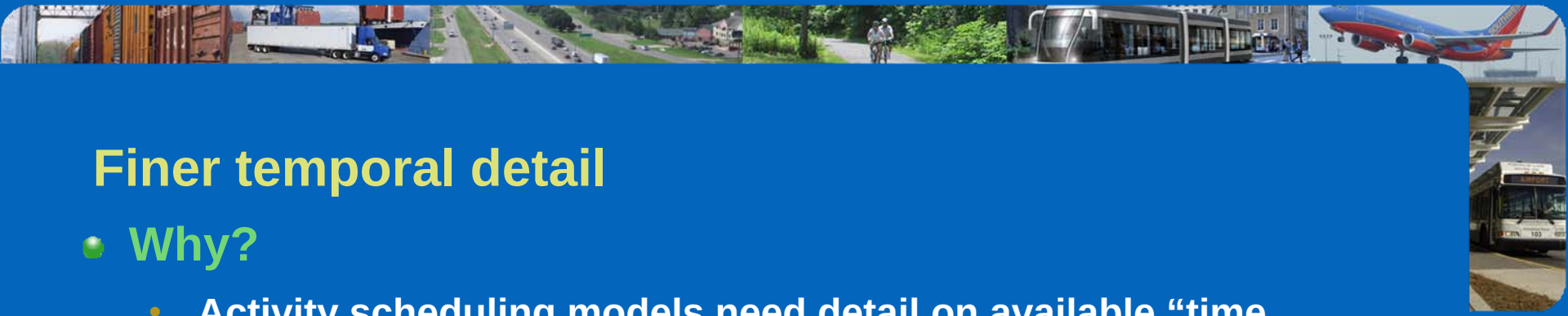
Accommodating greater detail

- How (in general)?
  - Population-based microsimulation procedures loop on individual households, persons, tours and trips
  - They do NOT loop on combinations of zones/zone pairs, population segments, trip purposes, time of day periods
  - So, run time depends mainly on the number of households, & is not very sensitive to the number of zones, time periods or population segments distinguished in the simulation.
  - But, there may be costs in terms of generating and using related network and land use data…



Finer socio-demographic detail

- **Why?**
  - Research shows wide variation in behavior related to income, household composition, employment status, age, and other household and person characteristics
  - Ignoring that variation leads to aggregation error and bias
- **When and where?**
  - All ABM implementations have used (various) procedures to generate synthetic, representative populations
- **How?**
  - Sample from PUMS / ACS records; control to Census data and available forecasts (HH size, HH income, HH workers).
  - New methods are evolving; integration with land use models



Finer temporal detail

- **Why?**
  - Activity scheduling models need detail on available “time windows” for each activity
  - Highway congestion can vary within short periods; departure time choice is more sensitive for small shifts
- **When and where?**
  - Continuous activity duration models (Bhat, Dallas, early 2000’s)
  - Discrete scheduling models with shorter periods (Vovsha, Bradley, Columbus, mid-2000’s)
  - A feature of all ABM since
- **How?**
  - Estimate and apply activity scheduling / duration models
  - Traffic assignment / skims for more times of day (?)

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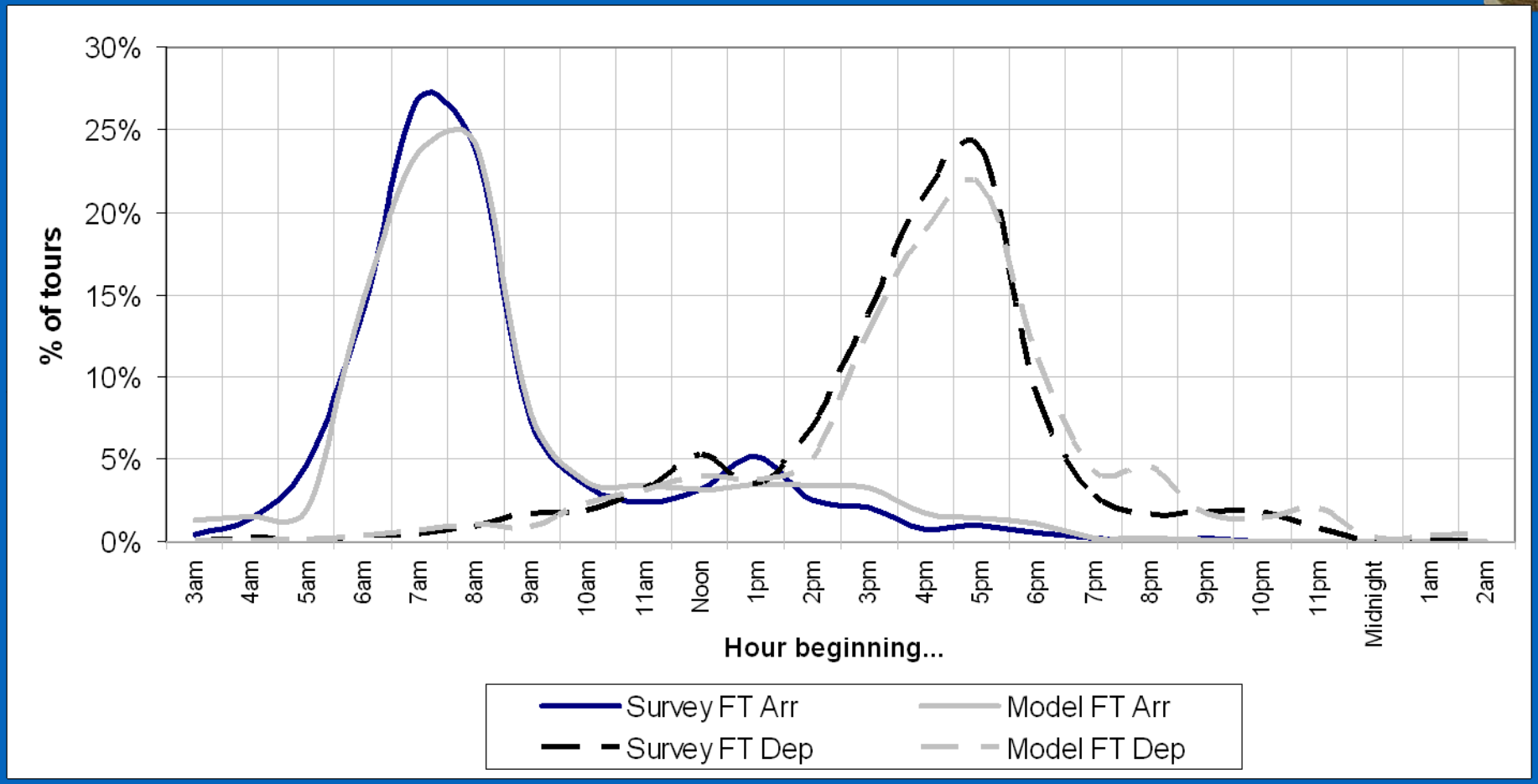
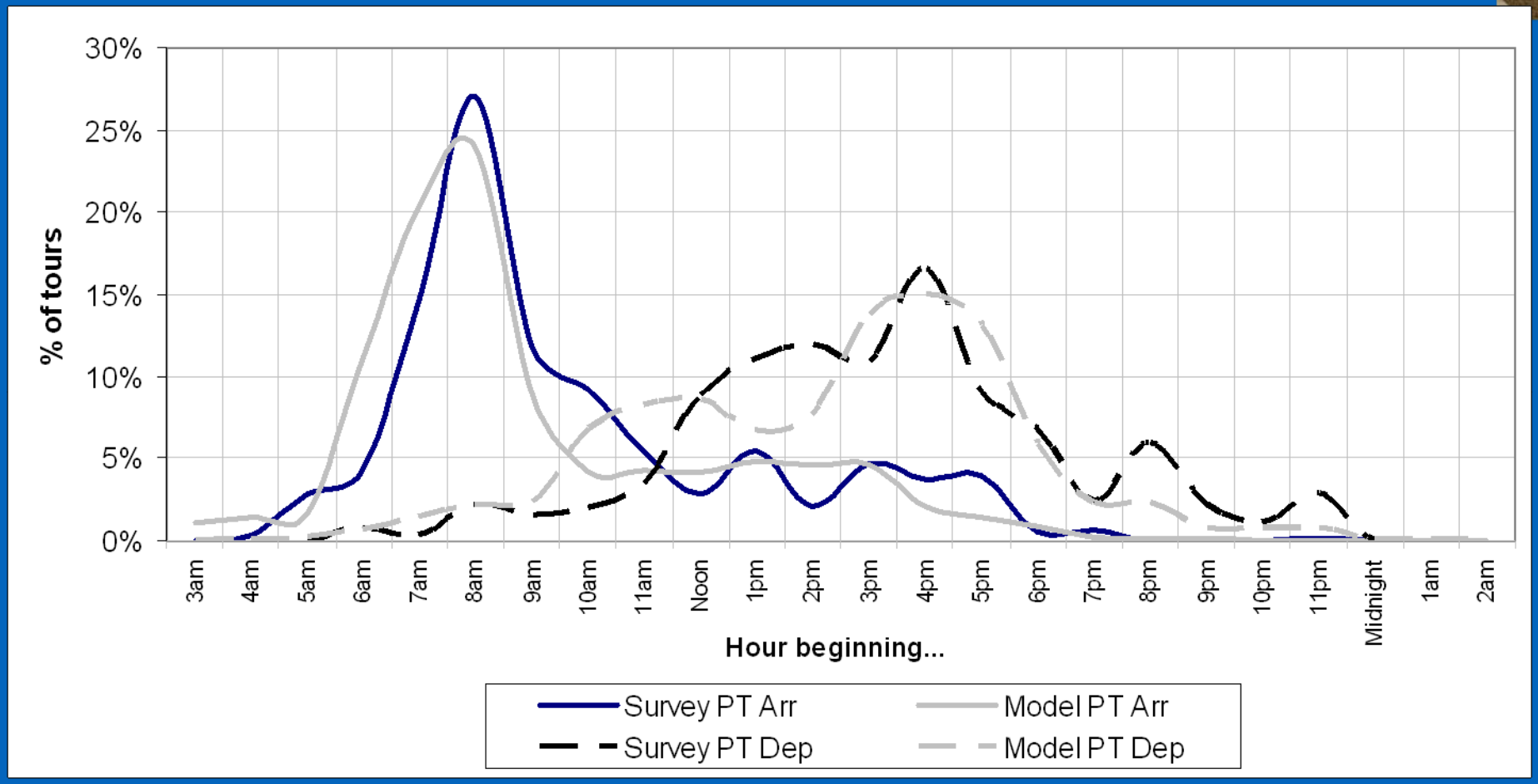
SACSIM TOD validation versus survey- Work Tours by full-time workers



SACSIM TOD validation versus survey- Work Tours by part-time workers



Finer spatial detail

- **Why?**
  - Most TAZ systems are too sparse to adequately model
    - Effects of localized traffic congestion
    - Use of walk and bicycle modes and walk access to transit
    - Effects of changes in urban design and land use
- **When and where?**
  - Sacramento (SACSIM) implemented at parcel level (2005)
  - Denver, Seattle, Jacksonville will be at parcel/point level
  - San Diego uses very detailed subzones for transit access
- **How?**
  - Estimate and apply more detailed location choice models
  - Methods to forecast parcel-level land use data
  - Traffic assignment / skims for more network nodes(?)

FIGURE 4. SACMET (TAZ-to-TAZ) Measures of Travel Distance for Short Trips

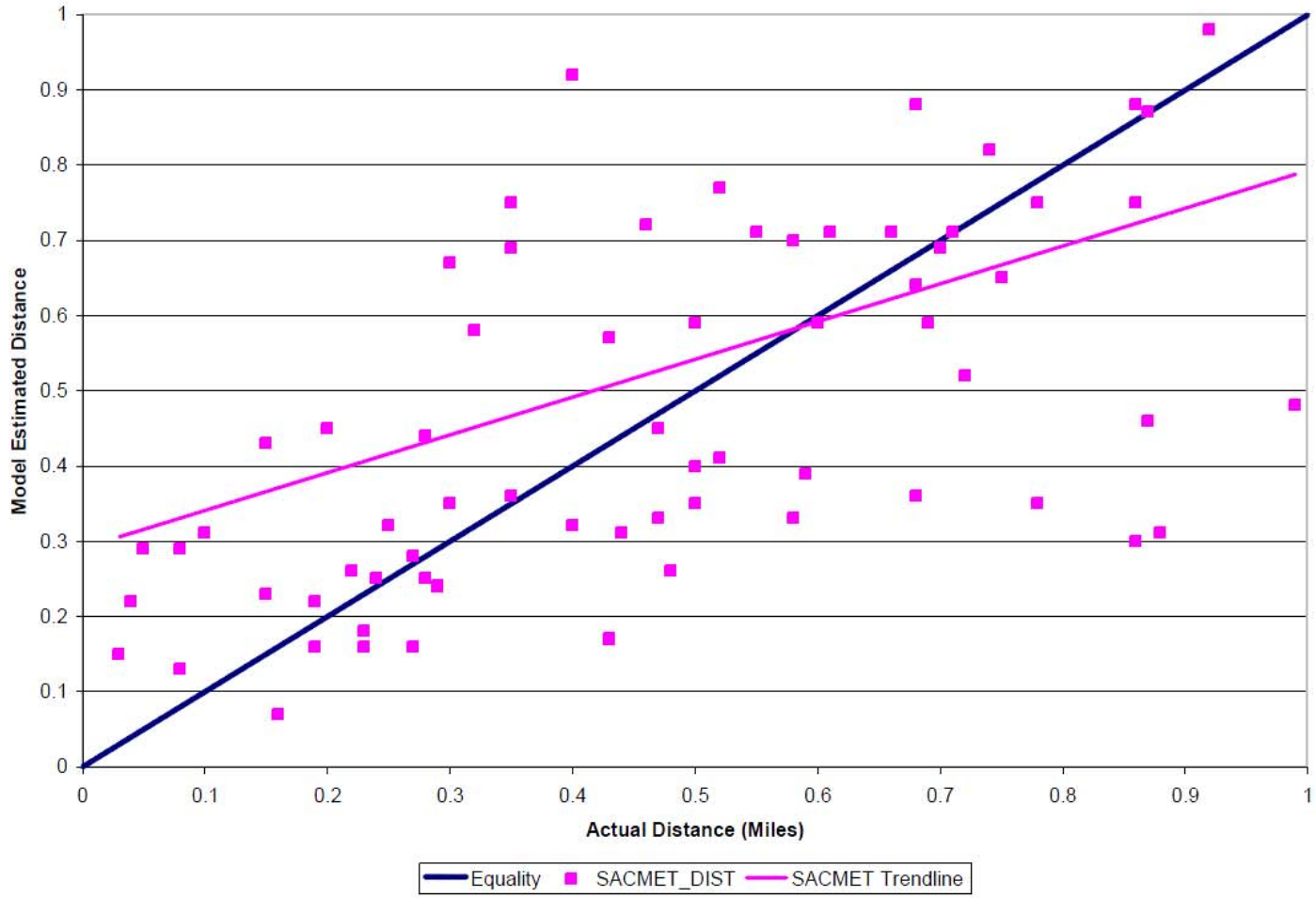
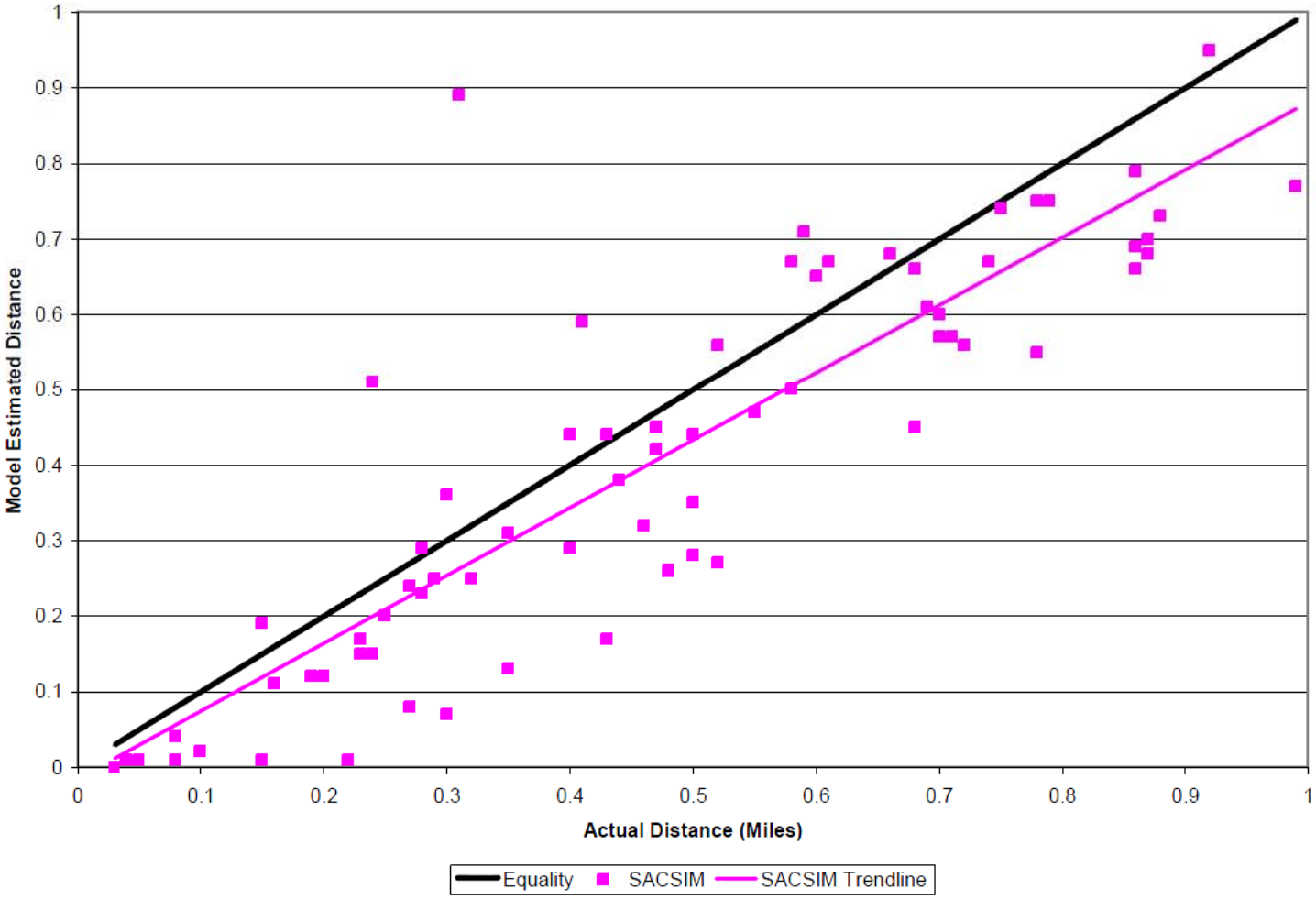
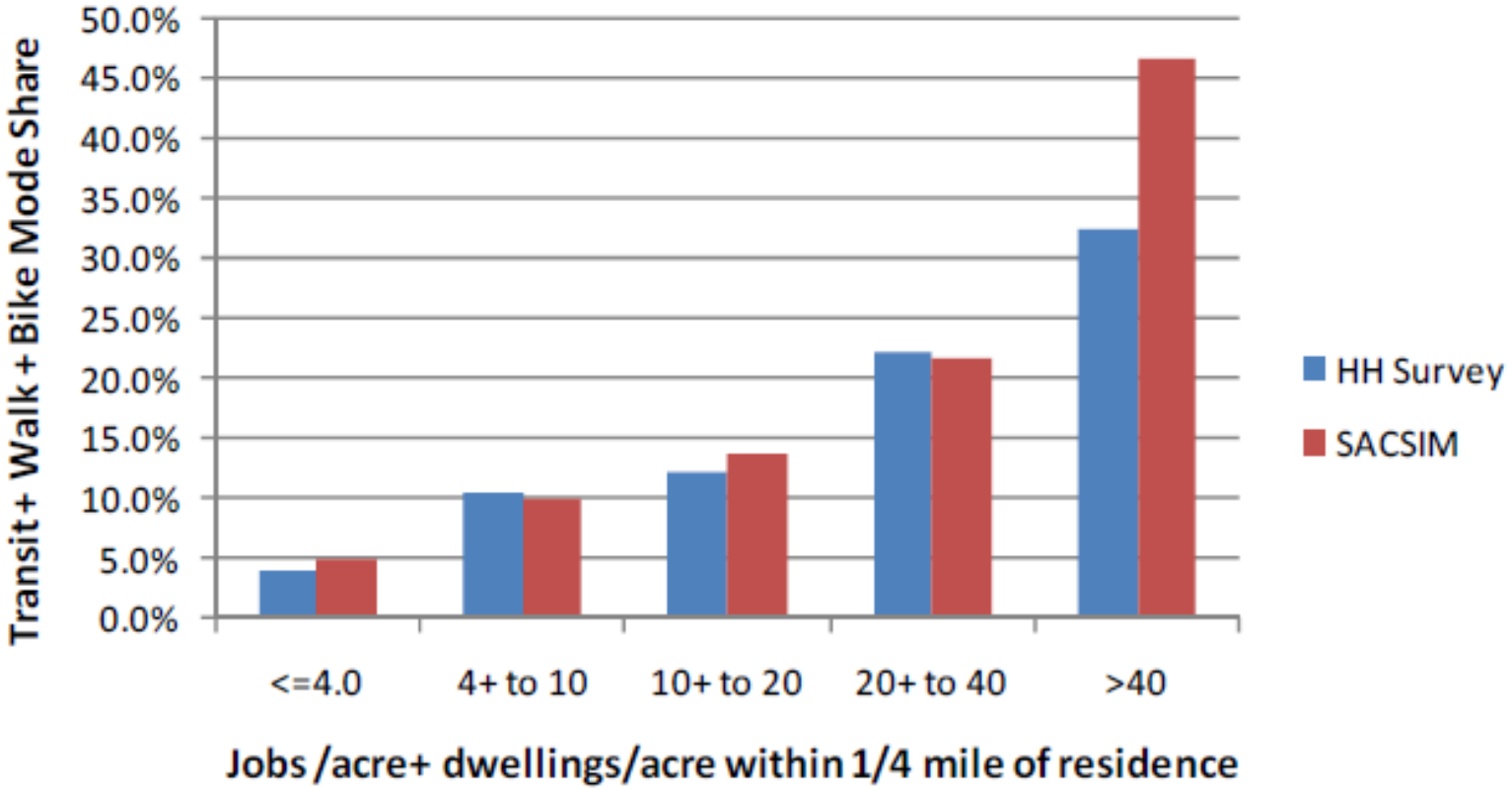
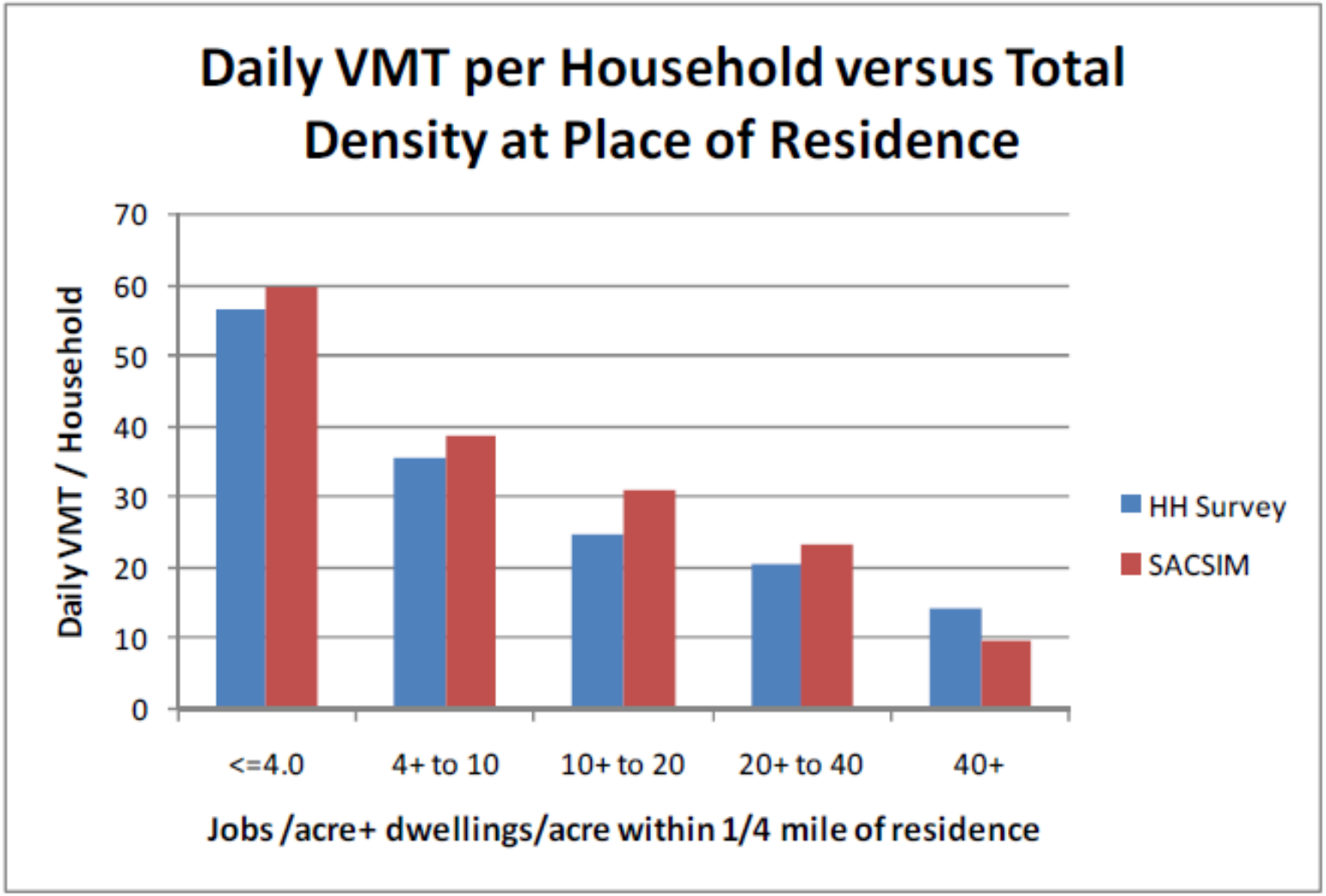


FIGURE 3. SACSIM (Point-to-Point) Measures of Travel Distance for Short Trips

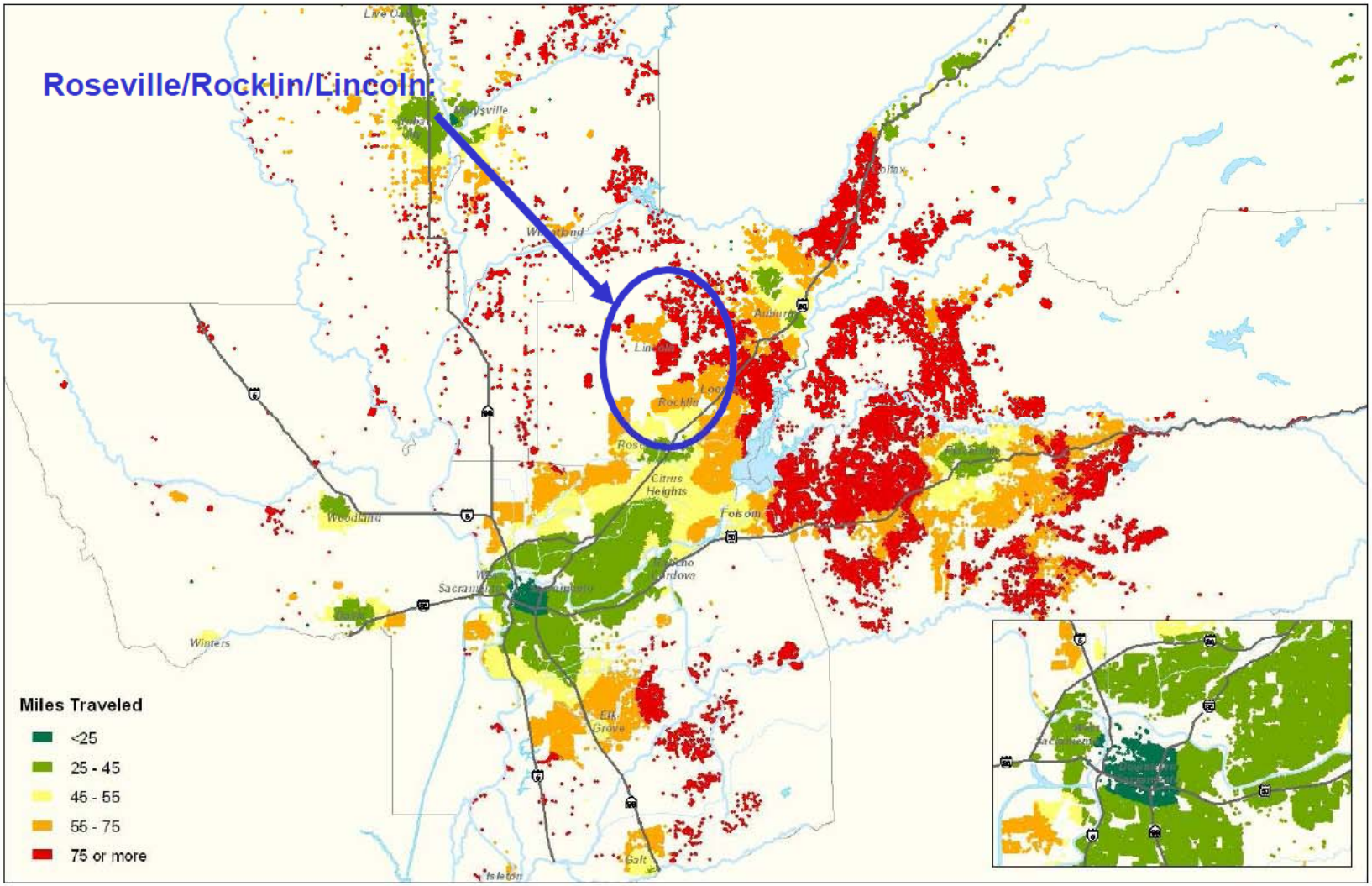


Non-Auto Mode Share versus Total Density at Place of Residence




Daily VMT per Household versus Total Density at Place of Residence
Daily VMT / Household
70
60
50
40
30
20
10
0
<=4.0
4+ to 10
10+ to 20
20+ to 40
40+
Jobs /acre+ dwellings/acre within 1/4 mile of residence
HH Survey
SACSIM

Areas of Improvement: 2005 VMT / HH



Areas of Improvement: 2035 MTP VMT / HH

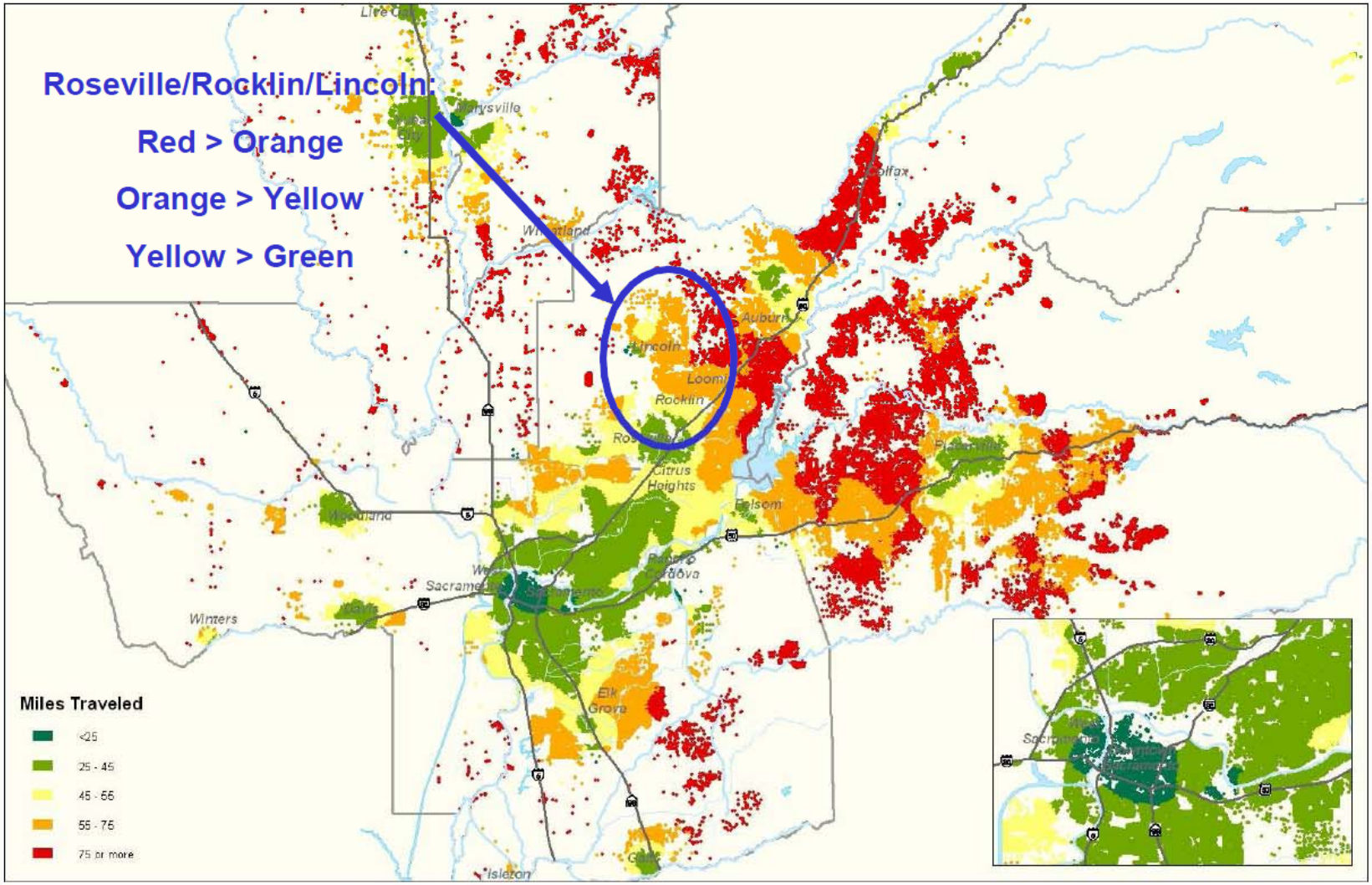


Table 4. Summary Results from Model Sensitivity Tests

Test variable	Transit fare	Auto fuel cost	Highway capacity	Household income
Response variable:	*Elasticity*	*Elasticity*	*Elasticity*	*Elasticity*
Total person trips	-0.001	-0.010	+0.012	+0.119
Vehicle trips	+0.004	-0.036	+0.021	+0.151
Vehicle miles traveled	+0.006	-0.126	+0.144	+0.090
Transit trips	-0.226	0.151	-0.035	-0.415
Walk and bike trips	+0.005	0.067	-0.055	-0.091

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Potential issues in the transition to ABM (1)…

The models are more complicated and hard to understand

- **Only to "veterans"; For students, ABM are more intuitive**

The models are so complicated that they may not reflect behavior realistically

- **Model components can be integrated via logsums**

The methods are still evolving (a moving target)

- **Recent applications evolving toward a common structure**

The model results contain some random variation

- **Can be minimized using multiple runs and random number synchronization across scenarios. Helps avoid false precision in interpreting results.**

Potential issues in the transition to ABM (2)…

Can the models be used in the New Starts process?

- Yes (San Francisco, New York, Sacramento)

Requires software in addition to standard network packages

- The main software approaches are open source, and becoming more user-oriented over time

The models take longer to run

- Sometimes true, but much can be done with improved software and hardware (multi-processing, more memory)

Need to integrate travel demand models with other models

- It is already done now. In the future, ABM more "in synch" with the shift towards dynamic land use and traffic simulation models, with finer spatial and temporal resolution (SHRP 2 C10 project)