Transitioning to Activity-Based Models:
Learning from the Southern California Experience

presented to

Florida Model Task Force Meeting

presented by

Chandra R. Bhat, Professor, The University of Texas at Austin

Ram Pendyala, Professor, Arizona State University, Tempe

March 6, 2012

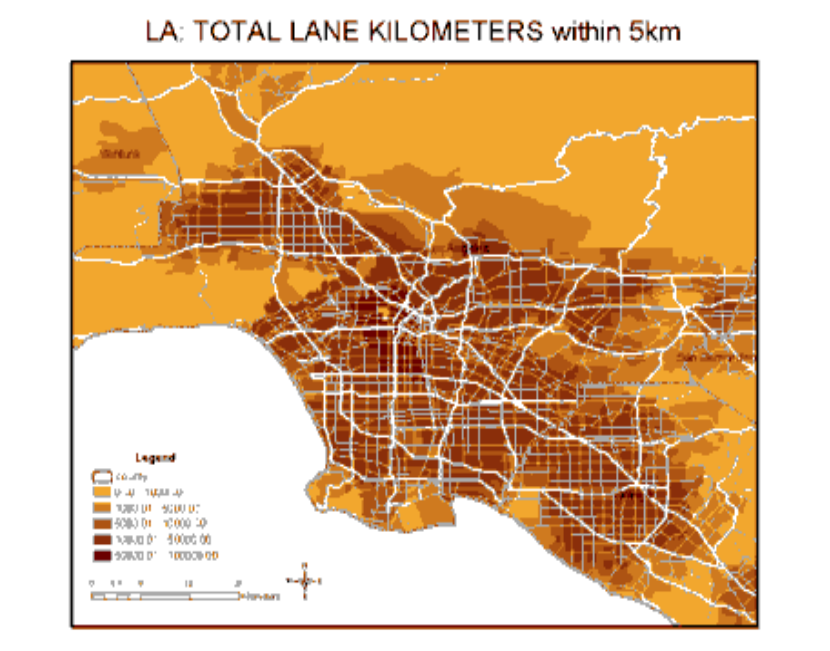
Experience with *SimAGENT*

*Sim*ulator of *A*ctivities, *G*reenhouse gases, *E*nergy, *N*etworks, and *T*ravel

- Setting and Policy Context
- Sensitivity Testing and Validation Exercises
- Salient Elements
- Data Needs for Developing ABMs
- Considerations and Pathways

SCAG Context

- Six counties – 188 cities – 14 subregions
- 38,000 square miles with 19 million residents
- Nation's largest region in terms of both population and size - socially, culturally and economically diverse
- 15th largest economy in the world



SimAGENT Vision for SCAG ABM

- Comply with the California Transportation Commission (CTC) 2008 guidelines for RTPs; responsive to California SB375
- Create an activity-based model that can address wide range of policies, including:
  - Economic analysis: location-based welfare, development impacts, maintain vibrancy
  - Equity analysis: change in welfare by household income class and minority populations
  - Sensitivity analysis: different parameters characterizing inputs and policy measures
  - Pricing analysis: evaluate different transportation pricing options, including corridor pricing (toll roads and managed lanes), cordon pricing, area pricing, congestion pricing, and parking pricing
  - Intermodal and Multimodal policy analysis: assess effectiveness of alternatives to traditional roadway system expansion options

Why Transition to Activity-Based Models

- Explicitly represent inter-dependencies, relationships, and constraints that exist among agents and entities
  - Relationships across trips in a tour/chain
  - Interactions among household members (task allocation and joint activity/trip engagement)
  - Time-space interactions and constraints
  - Institutional and modal constraints
- High-fidelity modeling
  - Disaggregate microsimulation of activity-travel patterns
  - Who is affected by policy/action, when are they affected, and how are they affected?
  - Representation of time and space as a continuum
  - Model behavior at the level of the individual choice-maker

Policies and Issues of Interest to SCAG

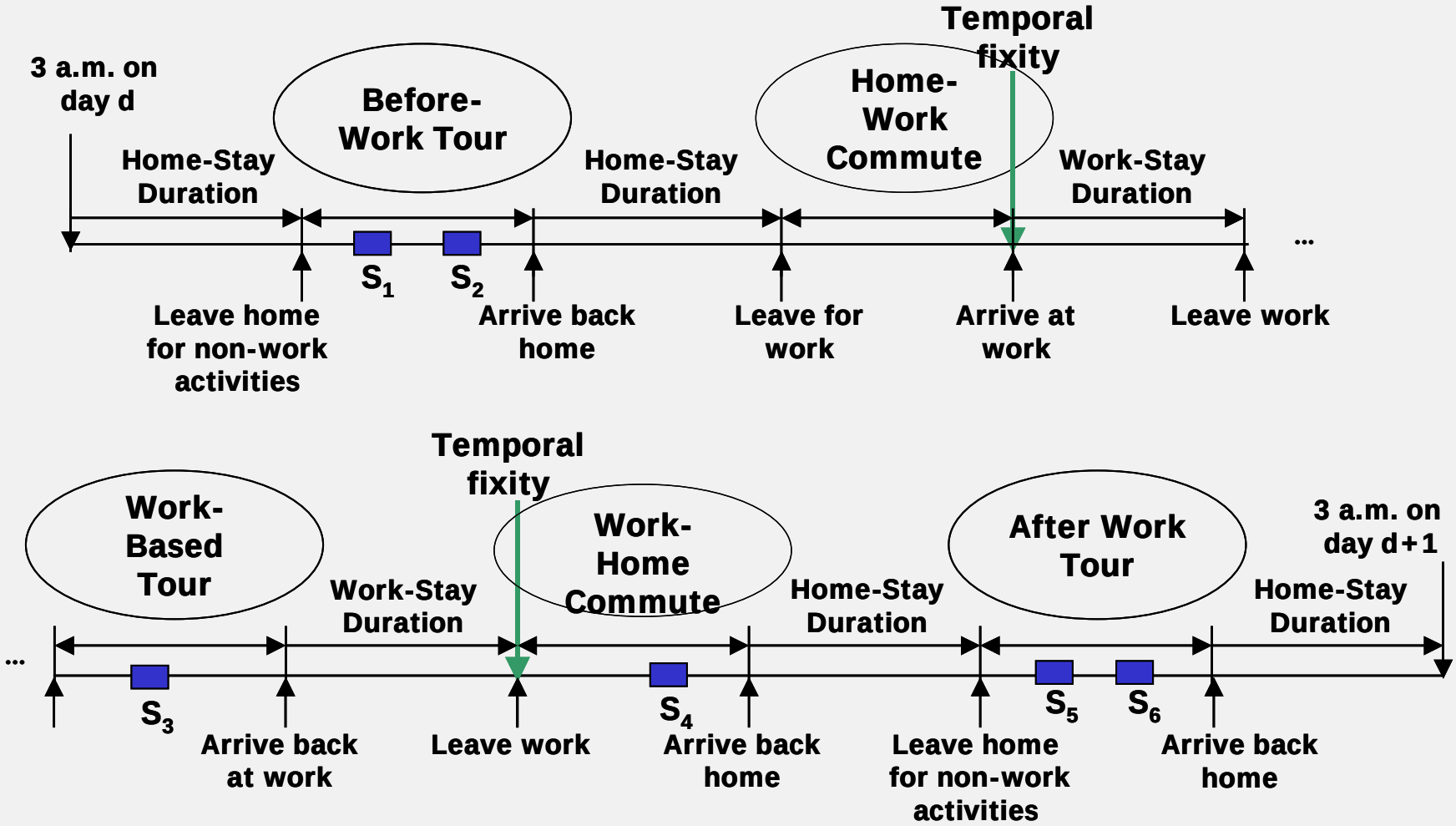
- Changes in land use patterns
- Congestion pricing
- HOV/HOT Lanes
- Parking policies, pricing, and duration/usage
- Transit fare and service changes; new modes
- Alternative work arrangements
- Changes in socio-economic characteristics
- Alternative fuel vehicle purchase/usage policies → emissions implications

Sensitivity Testing and Validation Exercises

CEMDAP: A Policy Responsive Tool

- Holistic model system with closely inter-related models
- Cascading effect with secondary and tertiary changes occurring throughout the activity schedule of the day
- Changes in the activity-travel pattern of one individual in a household affect activity-travel patterns of other household members
- Also recognizes the presence of constraints in activity-travel patterns that may result in little or no change
- Enhanced sensitivity to LU, built environment and development patterns, and multi-modal transportation policies – team has pioneered the development of time-sensitive, fine-scale, accessibility measures

CEMDAP: A Continuous-Time ABM



CEMDAP Sensitivity

- Work Start & End times
  - Auto IVTT & Cost
- Determining Households with Non-zero OH Non-Work Duration
  - Hansen Type Accessibility Measures: Retail and Service Employment Accessibility, Population Accessibility
  - Several Opportunity-based accessibility Measures
- Non-work Independent and Joint Activity Participation Decisions
  - Hansen Type Accessibility Measures: Retail and Service Employment Accessibility, Population Accessibility
  - Several Opportunity-based accessibility Measures
- Number of Non-Commute Tours
  - Several Opportunity-based accessibility Measures

CEMDAP Sensitivity (continued)

- Commute Mode Choice Decisions
  - IVTT, OVTT, Cost
  - Several Opportunity-based accessibility Measures
- Non-Commute Mode Choice Decisions
  - Hansen Type Accessibility Measures
  - Several Opportunity-based accessibility Measures
- Number of Stops in Tour
  - Several Opportunity-based accessibility Measures
  - IVTT for commute tours
- Stop Location Decisions
  - Hansen Type Accessibility Measures: Retail and Service Employment Accessibility, Population Accessibility
  - Several Opportunity-based accessibility Measures
  - Generalized cost

Policy Sensitivity Illustration

Increase in retail and service land-use

Generation Allocation Model System

Change in work location

Household's Decision to do Grocery Shopping

Change in decision to go to work and the work timing

Decision to participate in other independent activities

Allocation of Grocery shopping among adults

Change in Child's school travel mode

Change in allocation of parent to drop-off/ pick-up

Child's decision to participate in independent and joint discretionary activity

1) Commute mode

2) Number of commute stops

3) Presence and number of after-work, work-based, and before-work tours and stops

4) All aspects of each stop in each tour (including timing, location, and activity duration)

Scheduling Model System

Sensitivity Analysis for LA Region

Scenario	Description	Changes to Base Year
Base Scenario	2003 is the analysis year	---
15% Increase in Population and Employment Densities	Population and employment in the study area are increased by 15%	The population and employment density measures were increased by 25%
100% Increase in Cost—Drive Alone Mode	A 100% increase in cost for drive-alone for all time periods	LOS tables were altered by multiplying the drive alone auto cost by 2 in the a.m., p.m., and off-peak files
$2 Increase in CBD Cost—Auto Mode and Peak Periods	A $2 charge is imposed on the auto trips that enter/exit the CBD during a.m. and p.m. peak periods	LOS tables were altered by adding an additional $2 to the existing cost for auto trips that originate or end in the CBD in the a.m. and p.m. peak files
25% Increase in IVTT—Auto Mode and Peak Periods	A 25% increase in IVTT for the drive-alone and shared ride for the a.m. and p.m. peak time periods	LOS tables were altered by multiplying the auto IVTT by 1.25 in the a.m. and p.m. peak files

Policy Analysis

Employer-based demand management scheme

Base Case

8 AM — 5 PM

Work-based duration = 9 hours

Policy Case

8 AM — 2:30 PM

Work-based duration = 6.5 hours

Policy Analysis

Simulation results

Alternate activity-travel patterns

Base Case	Pattern	Policy Case
21	H → W → H	16
13	H → W → S → W → S → H	11
06	H → W → S → W → H	03
03	H → W → H → S → H	05
01	H → W → S → H	09
06	All Other Patterns	06

Drive Alone Cost Increase by 100% (LA Region)

Base Scenario

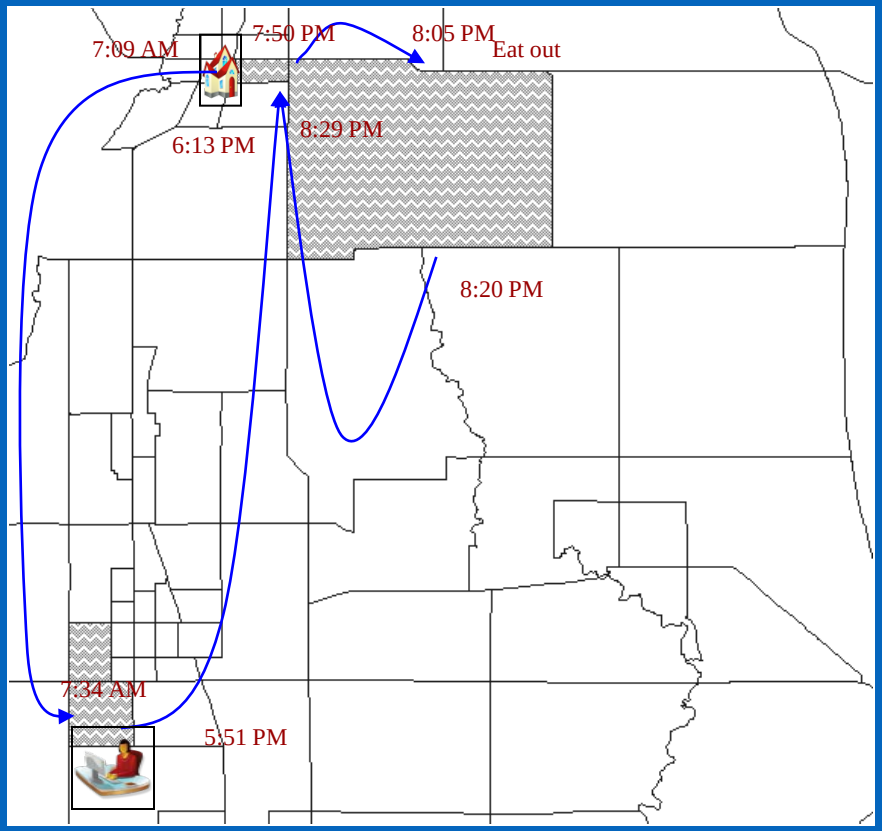
Overall Pattern	Commute and additional tour
Total mileage (miles)	47.17
HW Commute	
Number of non-work stops	0
Mode	Drive alone
Activity at non-work stops	-
WH Commute	
Number of non-work stops	0
Mode	Drive alone
Activity at non-work stops	-
Tour 1	
Number of stops	1
Mode	Drive alone
Activity at stops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

Policy Scenario

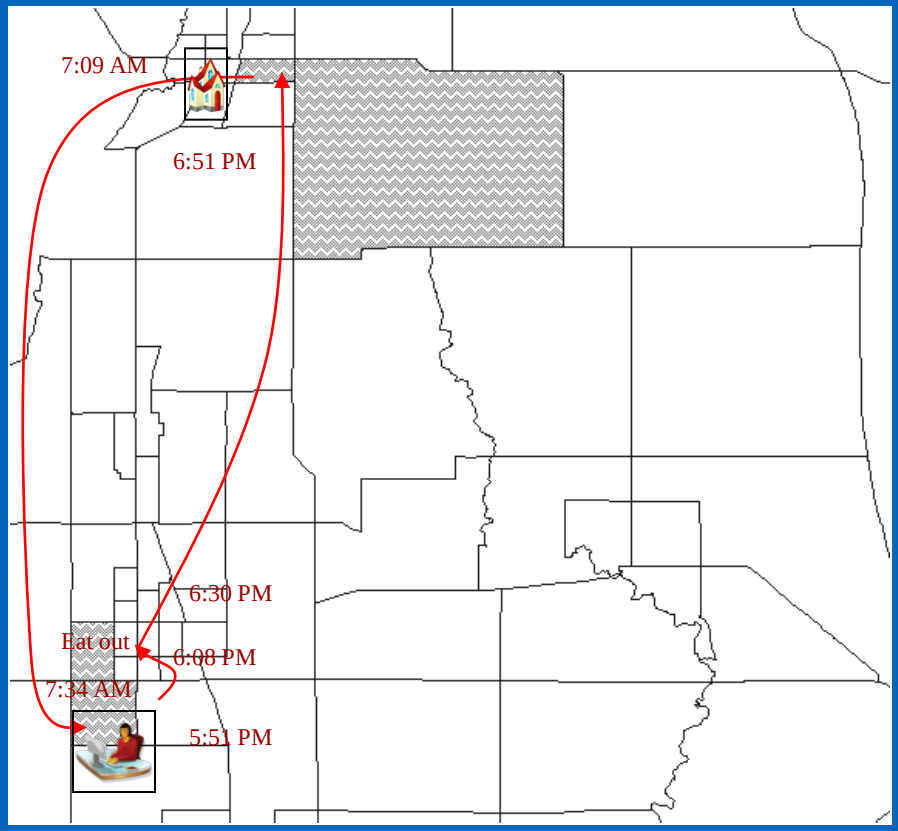
Overall Pattern	Commute tour
Total mileage (miles)	35.21
HW Commute	
Number of non-work stops	0
Mode	Drive alone
Activity at non-work stops	-
WH Commute	
Number of non-work stops	1
Mode	Drive alone
Activity at non-work stops	Eat out

Drive Alone Cost Increase by 100% (LA Region)

Base Scenario



Policy Scenario



Validation Analysis

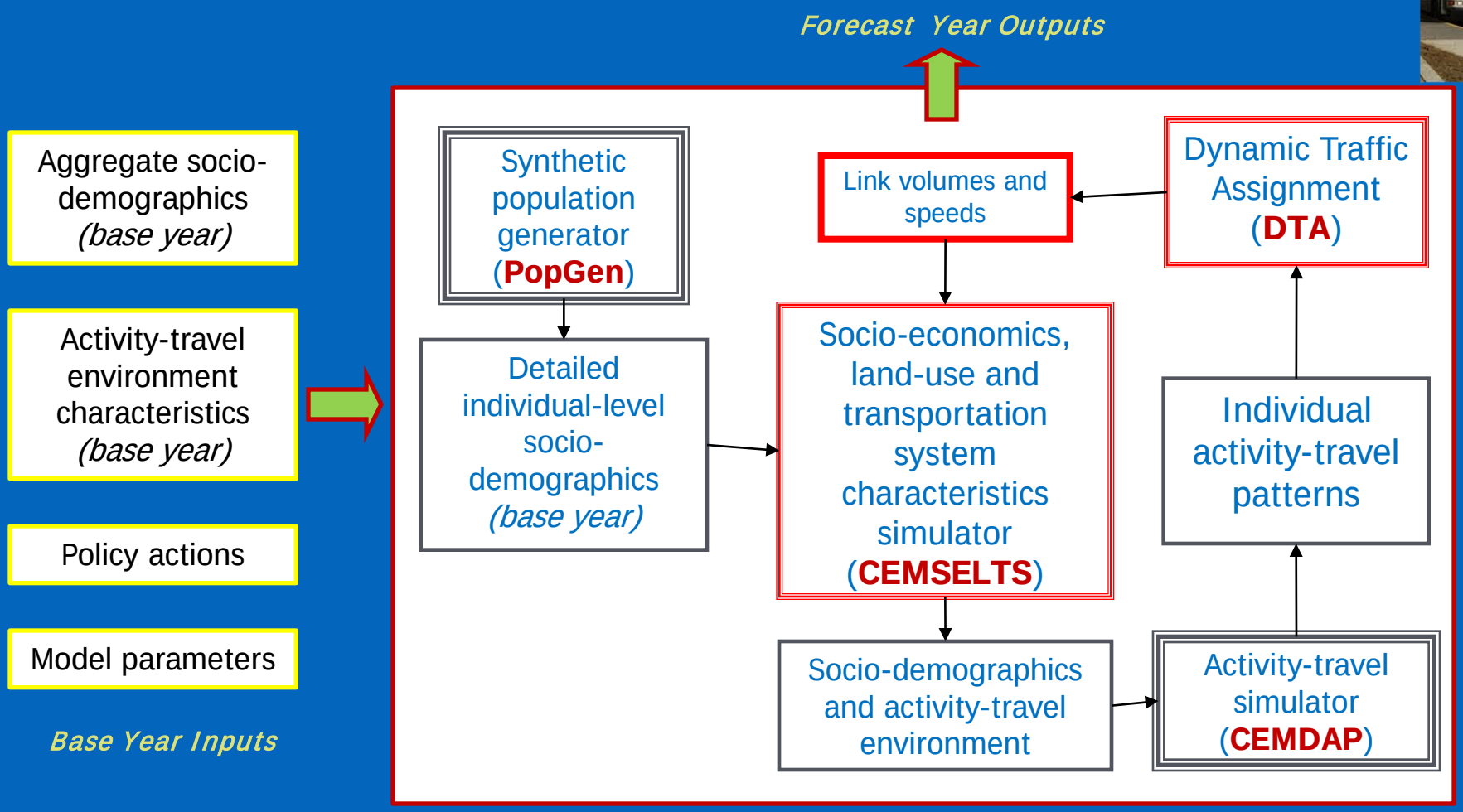
- No ad-hoc model calibration process using adjustment factors, modifications of constants, etc.
  - Examine model specification/structure and revise until survey data trends are accurately replicated
- Model validation based on several methods and measures
- True validation involves extensive assessment based on sensitivity and scenario analysis
  - Socio-economic scenarios
  - Social equity and environmental justice analysis
  - Transportation network capacity scenarios
  - Pricing scenarios
  - Vehicle technology/holdings scenarios
  - Homeland security and emergency management scenarios
  - Travel demand management strategy scenarios

Evaluate “Quality of Life”

- Activity-based model system capable of producing composite numeric “quality of life” measure
- Time-use utility measure derived from daily activity-travel pattern
  - Based on time spent traveling to/from and at activities of different type
  - Very useful to understand changes in “quality of life” as a result of a system change or policy intervention
  - Critical to social equity and environmental justice analysis

Salient Elements

SimAGENT Based on CEMUS



Salient Features of CEMDAP

Temporal Resolution

- Continuous time scale (1 min for DFW/SCAG application)
- Level-of-service data can be provided at any temporal resolution (5 time-of-day periods for DFW/SCAG application)
- Explicitly considers time-space interactions/constraints
- Enables consideration of time-varying and dynamic pricing policies

Spatial Resolution

- Allows for any spatial resolution, and multi-scale spatial resolution

Activity Resolution

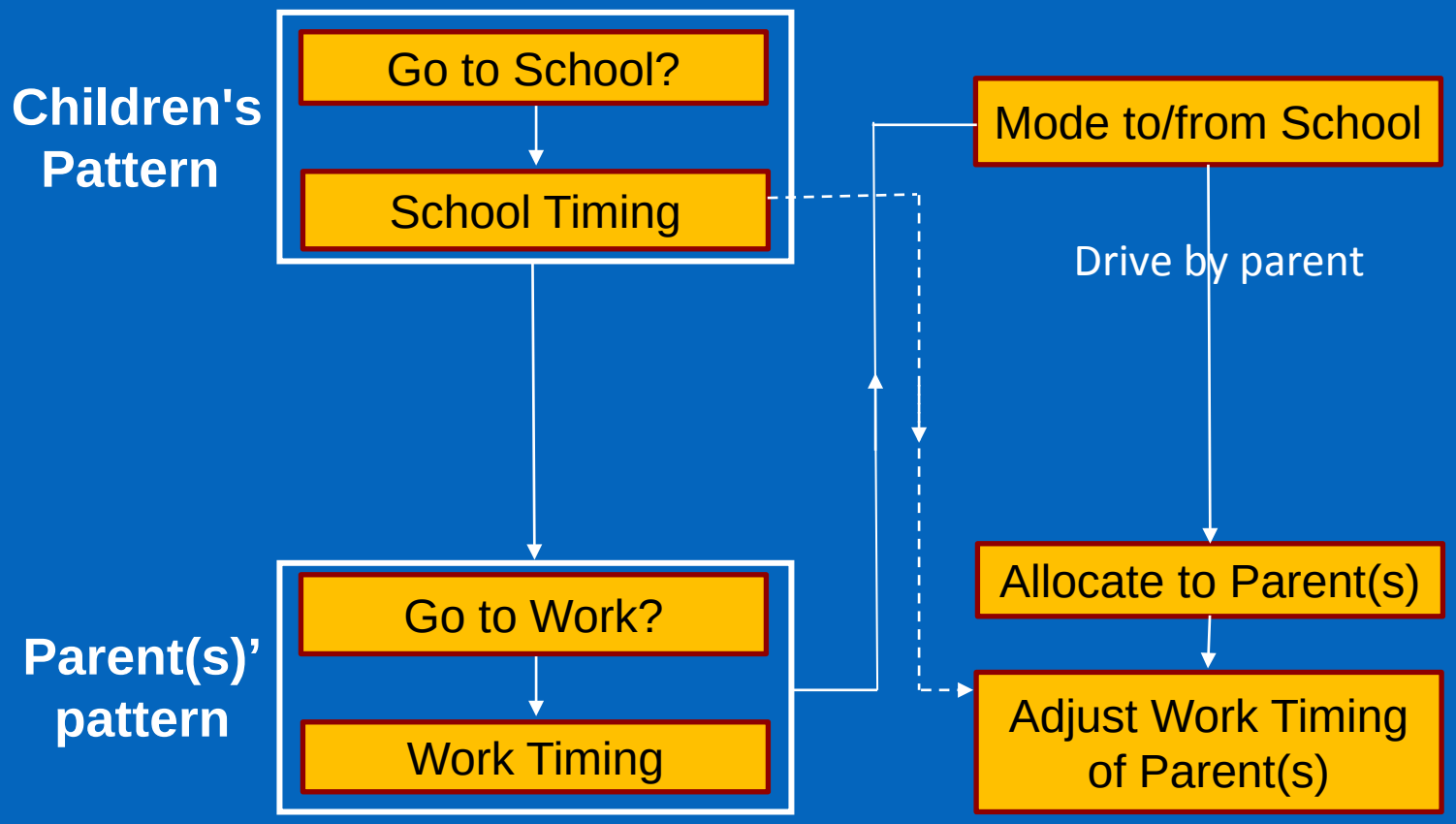
- Allows for any purpose resolution, and multiple resolution across market segments

Graphical User Interface

- Standard Windows-based user interface
- Allows user to modify model parameters
- Provides a friendly diagrammatic interface to help the user understand the logic of the system and the underlying models

Demonstration of CEMDAP Software

Adult-Child Interaction
An Interleaved Approach



Recent Advances in SCAG ABM

Joint Activity Participation

- Growing interest in accommodating joint activity participation across household members
- In conventional discrete choice frameworks, the need to generate mutually exclusive alternatives results in an explosion in choice sets
- Multiple Discrete-Continuous Extreme Value (MDCEV) allows us to tackle the problem by considering activity participation as a household decision
- MDCEV offers substantial computational and behavioral advantages
  - Employ one model to generate activity participation for all household members as opposed to one model per activity type and per person while simultaneously accommodating for joint activity participation
  - Accommodate substitution/complementarity in activity participation and household member dimensions

Example: 2 persons and 2 activity purposes – Single Discrete Case

P1	P2	P1 P2
None	None	None
A1	None	None
A2	None	None
A1 A2	None	None

P1	P2	P1 P2
None	None	A1
A1	None	A1
A2	None	A1
A1 A2	None	A1

P1	P2	P1 P2
None	None	A2
A1	None	A2
A2	None	A2
A1 A2	None	A2

P1	P2	P1 P2
None	None	A1 A2
A1	None	A1 A2
A2	None	A1 A2
A1 A2	None	A1 A2

Each box represents an alternative

P1	P2	P1 P2
None	A1	None
A1	A1	None
A2	A1	None
A1 A2	A1	None

P1	P2	P1 P2
None	A1	A1
A1	A1	A1
A2	A1	A1
A1 A2	A1	A1

P1	P2	P1 P2
None	A1	A2
A1	A1	A2
A2	A1	A2
A1 A2	A1	A2

P1	P2	P1 P2
None	A1	A1 A2
A1	A1	A1 A2
A2	A1	A1 A2
A1 A2	A1	A1 A2

P1	P2	P1 P2
None	A2	None
A1	A2	None
A2	A2	None
A1 A2	A2	None

P1	P2	P1 P2
None	A2	A1
A1	A2	A1
A2	A2	A1
A1 A2	A2	A1

P1	P2	P1 P2
None	A2	A2
A1	A2	A2
A2	A2	A2
A1 A2	A2	A2

P1	P2	P1 P2
None	A2	A1 A2
A1	A2	A1 A2
A2	A2	A1 A2
A1 A2	A2	A1 A2

P1	P2	P1 P2
None	A1 A2	None
A1	A1 A2	None
A2	A1 A2	None
A1 A2	A1 A2	None

P1	P2	P1 P2
None	A1 A2	A1
A1	A1 A2	A1
A2	A1 A2	A1
A1 A2	A1 A2	A1

P1	P2	P1 P2
None	A1 A2	A2
A1	A1 A2	A2
A2	A1 A2	A2
A1 A2	A1 A2	A2

P1	P2	P1 P2
None	A1 A2	A1 A2
A1	A1 A2	A1 A2
A2	A1 A2	A1 A2
A1 A2	A1 A2	A1 A2

Example: 2 persons and 2 activity purposes – Multiple Discrete Case

A1 P1	A1 P2	A1 P1P2
A2 P1	A2 P2	A2 P1P2

None

Each box represents an alternative

Total 7 alternatives versus 64 in traditional case

Total choice set size comparison for 3 activity purposes

Household Size	Single Discrete Model (MNL)	MDCEV
1	8	3
2	512	9
3	2097152	21
4	3.52×10^{13}	45
5	9.9×10^{27}	93
Total	9.9×10^{27}	171

Once the number of activities increases, the difference will be even more stark!

Household Vehicle Fleet models

- **Improves ability to forecast regional fleet mix and use**
- **Fundamentally important for travel demand modeling and transportation policy analysis**

HOUSEHOLD'S NUMBER OF VEHICLES + ***VEHICLE TYPE CHOICE*** + MILEAGE

Determinants of

Global Climate Change

Fuel Consumption

Green House Gas Emissions

Household Vehicle Fleet Models

- Currently travel models are interfaced with EPA's MOVES, or EMFAC, for emissions analysis
  - Assumptions regarding vehicle fleet mix may not reflect local conditions
  - No basis to forecast future vehicle fleet composition in response to changes in fuel prices, socio-economic shifts and policy actions

MDCEV Model Approach

- **MDCEV – Multiple Discrete Continuous Extreme Value**
  - **Simple closed form structure for the probability expressions**
  - **Allows the choice of multiple alternatives**
- **A disaggregate vehicle typology which is virtually impossible in traditional choice models**
- **MDCEV model can incorporate the notion that :**
  - **households own and use different vehicles for different functional purposes**
  - **different individuals can have different preferences**

In short, MDCEV model framework offers an elegant, theoretically consistent, and econometrically integrated approach to model vehicle ownership, vehicle type, and vehicle usage decisions, and all of them simultaneously .

MDCEV

Vehicle Type and Annual Mileage

Primary Driver

MNL

Vehicle Make Model

MNL

(Travel Simulator in SimAGENT)

Vehicle Type Model for Joint Tours in the HH

SimAGENT

For every auto tour

Output

Body Type

Vintage

Vehicle Make

Computational Techniques in CEMDAP

- Multi-threading/Parallel Processing
- Data Caching
  - PostgreSQL database with suitable indexing, caching of frequently used data items and hash tables for look up
- Sampling Analysis
- Constant (Pseudo) random numbers across different policy scenarios
  - Minimize the random simulation bias in policy analyses
  - Allows a disaggregate level assessment of policies

Evolving Data Collection and Availability to Support Activity-Based Modeling

Data for Estimation of ABMs

- Core Behavior and Household Characteristics
  - Other aspects – policy relevant (cars and costs, long term choices and lifestyle preferences, attitudes)
- Other agents (firms, institutions, and developers)
- Landscape/Environment/Context
  - Activity locations
  - Homes/Jobs/Schools
  - Availability over time

Data to Support ABMs

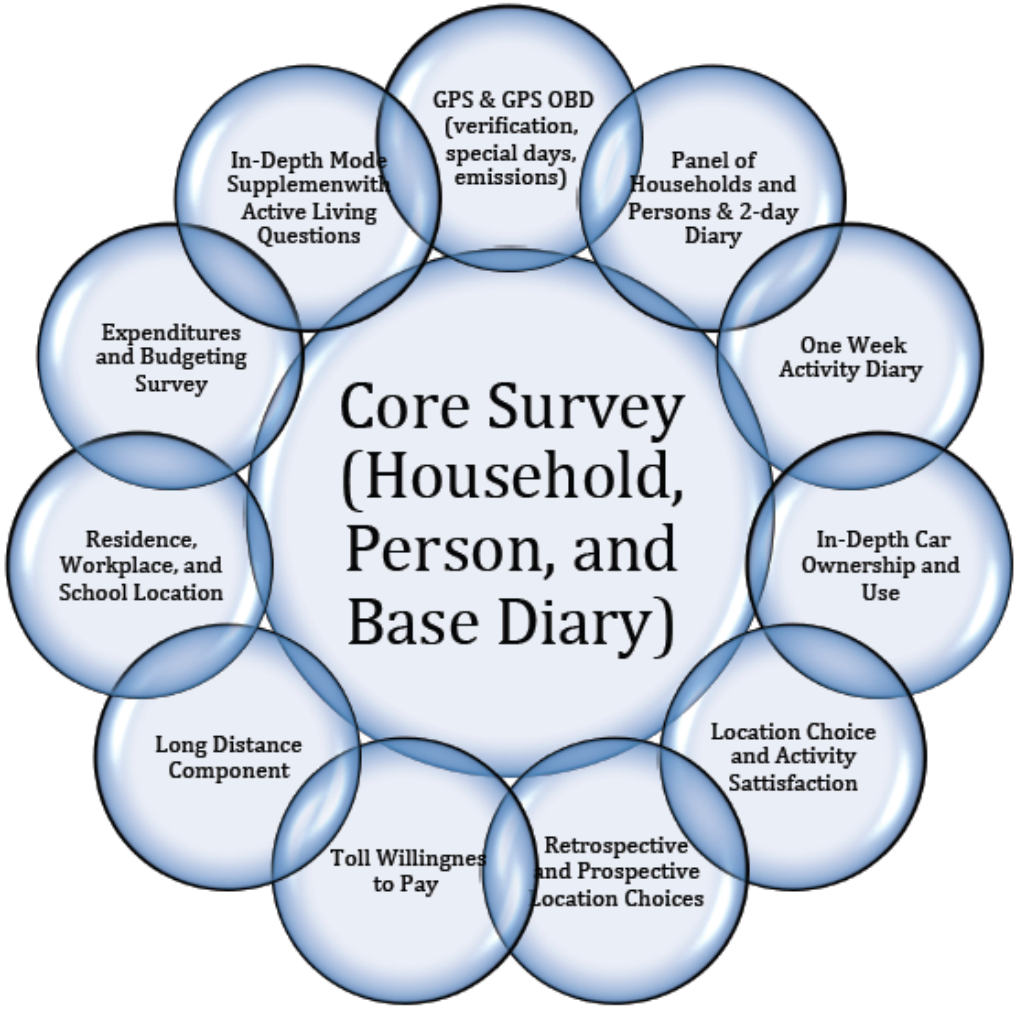


Figure 4 The Data Collection Overall Scheme

Multiple-Day 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

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).

Residence, Workplace, and School Location Choice

- Critical survey component for behaviorally integrated land use activity-travel demand models
- In-depth survey to identify the determinants for each of the residential, workplace, and school choices
- 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)

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

Data for Application of ABMs

- Information on all individuals and households of the study area for the base year
- Synthetic population generation supplemented with a series of other demographic models provide this data
- For a future year forecasting exercise, the inputs should consist of the future year synthetic population, land use, and level-of-service data
- Need ability to generate detailed input data (i.e., the synthetic population, level-of-service and land-use data) for future years

Data 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

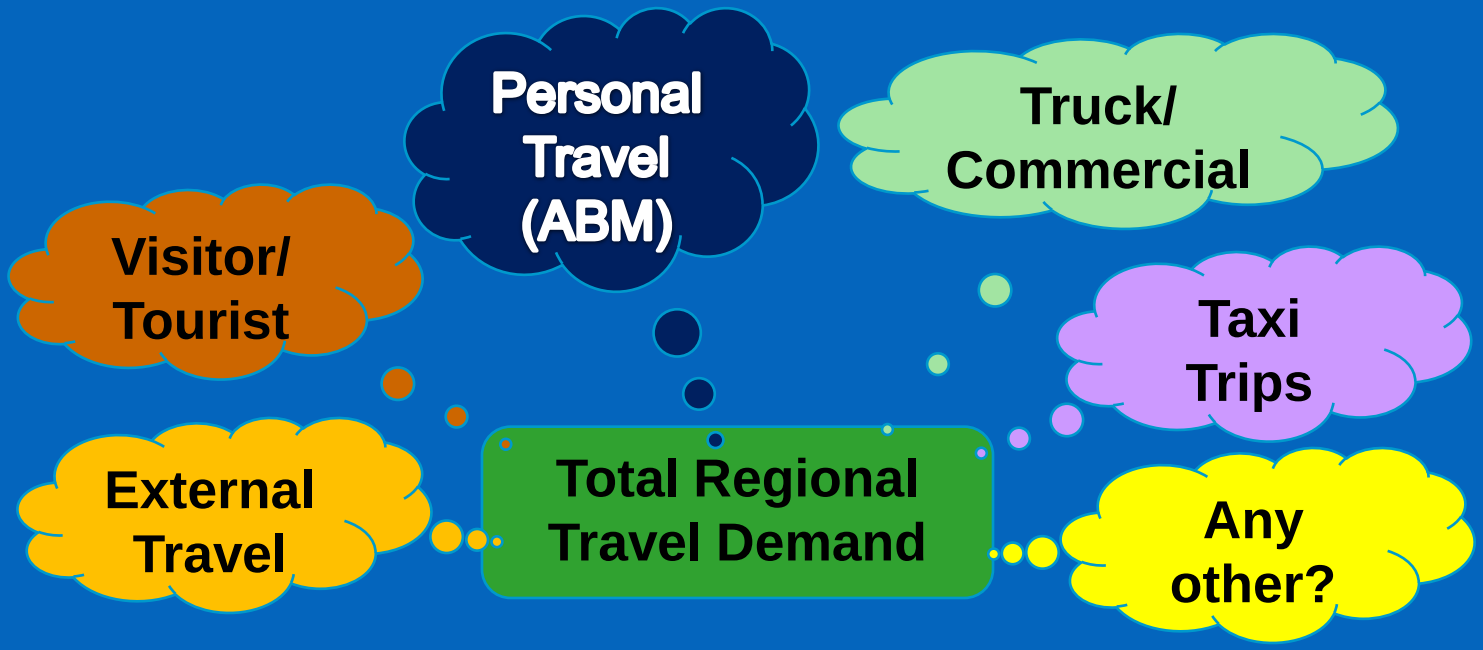
Data for Calibration and Validation of Activity-Travel Model Outputs

- Comparison with observed traffic patterns
- Desirable to have detailed traffic volume and speed data
  - land-use and level-of-service data
  - observed traffic volumes by vehicle class
  - spatio-temporal distribution of traffic
  - household activity and/travel survey data
  - Census data
- Also use sensitivity analysis as basis for assessing model validity

Considerations and Pathways

What is Missing in Activity-Based Travel Models?

- Activity-based travel models account for intra-regional personal travel



- Need to combine personal travel estimated by ABM with other travel estimated by four-step or other model to get complete picture of travel demand in region

Approaches to Account for “Other” Travel

- Alternative approaches to combine sources of travel demand from different models
- In a traditional static traffic assignment context
  - Aggregate activity-travel records from ABM into OD matrices by time of day
  - Combine OD matrices across sources of travel as appropriate
  - Run traditional static traffic assignment procedures to obtain network flows
- In a dynamic traffic assignment (DTA) context, two options possible
  - Produce OD matrices by time of day from activity-travel records, combine with other OD matrices, and input to DTA model
  - Disaggregate other OD matrices into trip lists using time-of-day distributions from surveys/counts
  - Provide disaggregate trip lists/records to DTA model

Common Themes/Directions in ABM

- Microsimulation-based model system with activity-travel demand estimated for each agent
- Enhancing behavioral realism
  - Time-space interactions and constraints
  - Intra-household interactions – in particular, child-adult interactions
  - Treatment of time as a continuous (or near-continuous) entity
  - Activity generation (and other choice dimensions) responsive to multimodal micro-scale accessibility measures – induced and suppressed demand
  - Accounting for behavioral heterogeneity in population (choice set determination, alternative decision structures, unobserved factors)
  - Accommodation of simultaneity in choice processes – some choices made jointly as a bundle
  - Enhanced representation of car ownership and usage by type, vintage, and fuel technology
  - Demographic and vehicle fleet evolution models

Heterogeneity in Planning Contexts

- Florida considerably diverse in terms of geography, sizes of metro areas, level of multimodal presence, and policy issues of importance
- How can one size fit all?
  - Some areas may not need a continuous time model
  - Some areas may not be interested in a vehicle type choice and usage model
  - Other areas may not be interested in explicitly modeling household member interactions
- Current FSUTMS context accommodates variations across areas
  - Provides a common foundational knowledge-base and infrastructure
  - Individual areas can refine model system by implementing custom specifications, adding special modules, or simplifying components

Florida Standards for Activity Based Modeling

- May consider different model structures by planning context, metro area size, or level of multimodal presence
- Identify two or three model structures that would meet the needs of all planning contexts in state
- However, strive for consistency in foundational elements
  - Microsimulation approach (synthetic population generation, output individual activity-travel records for each person)
  - Treatment of time (resolution/fidelity)
  - Treatment of space (resolution/fidelity)
  - Computation of accessibility measures
  - Defining terms – chains, tours, stops, journeys, and trips
  - Accounting for simulation variation across multiple model runs
  - Menu based on choice dimensions of interest – required, desirable, optional – for example:
    - Destination Choice – required
    - Household interactions – desirable
    - Vehicle type choice and usage – optional
- Input databases and output databases/reports

Setting Up Infrastructure for Transition to Activity Based Modeling (2-5 years?)

- Data collection and assembly
- Establish database structures and software environments
- Methods to integrate ABM output with other travel components for assignment
- Demonstration projects in selected areas – compile experience and lessons learned
- Develop strategies for small areas (transferability studies; integration within larger regional model systems)
- Training and documentation

Five Pillars of ABM Design

- Sensitive to policy issues and planning applications of interest
- Based on sound behavioral theory/paradigm
- Computationally feasible and tractable
  - Model estimation
  - Model implementation
- Optimal use of available data (present and future)
- ABM should be both an Activity-Based Model and an Agent-Based Model

Thank You!

FLORIDA MODEL TASK FORCE

Congestion Pricing

- Toll strategies/pricing
  - Impose a toll and predict elasticity of demand (-0.1 to -0.4)
- Conventional models
  - Predict shifts in departure & arrival time
  - Observed elasticity lower than predicted
  - Why?
    - Joint activities
    - Latent demand
    - Value of time very different among segments
    - Entire activity-travel schedule modified by pricing
- Activity-based models could address these issues
  - Predict who reacts to policy at the individual level
  - Predict activity scheduling and task allocation changes within households

HOV/HOT Lanes

- Conventional models
  - HOV as a mode (time and cost)
  - Overestimate the number of users
  - The problem is lack of accounting for intra-household interactions, constraints, and carpool formation
- Activity-based models
  - Include household member interactions
  - Include model/routine for car assignment to person

Parking

- Conventional models
  - Parking duration not modeled
  - Parking lot = destination of trip
  - Summary demand by period of day
- Activity based models
  - Explicit estimation of parking duration
  - Operate at fine temporal resolutions
  - Can keep track of cars in households

Note: More inventory data needed!

Transit Fare

- Conventional models
  - Zone to zone base fares
  - Examine changes in ridership and correlate with fare changes
- Activity based models
  - Transit paths can be developed
  - The impact of waiting times and costs examined in terms of overall change in scheduling
  - Too much work? Should we calibrate this to potential for change?

Shorter Days and Weeks

- Conventional models
  - Not sensitive to work duration
  - Impose change in trip generation and see what happens
- Activity-based models
  - Activities, travel, and duration of activities are tied together
  - Changes in work duration and days of the week are explicitly modeled (increases in after work periods, available extra day to do other things and so forth)

Demographic Shifts

- Conventional models
  - Very few segments
  - Operate at OD level
- Activity based models
  - Operate at the individual and household levels
  - Include full-time vs. part time workers
  - Include children by age groups
  - Include many additional segmentations because of synthetic population generation
  - Key to this region's ethnic diversity!

Car Ownership and Type

- Conventional models
  - Absent
  - Number of cars per household
- Activity-based models
  - Explicit car ownership and assignment to persons (identify primary driver)
  - Vehicle type choice can be incorporated (including body and fuel type)

Emissions Inventory

- Conventional models
  - Vehicle activity is handled by post-processing
  - Does not account for within household vehicle assignment and does not produce a vehicle trace → loss of vehicle use profiles
- Activity-based models
  - Details about who uses each vehicle and when/where
  - Some produce traces of vehicles during the day
  - New emissions models able to take advantage of such information
  - Beginning to explore linkages with dynamic traffic assignment

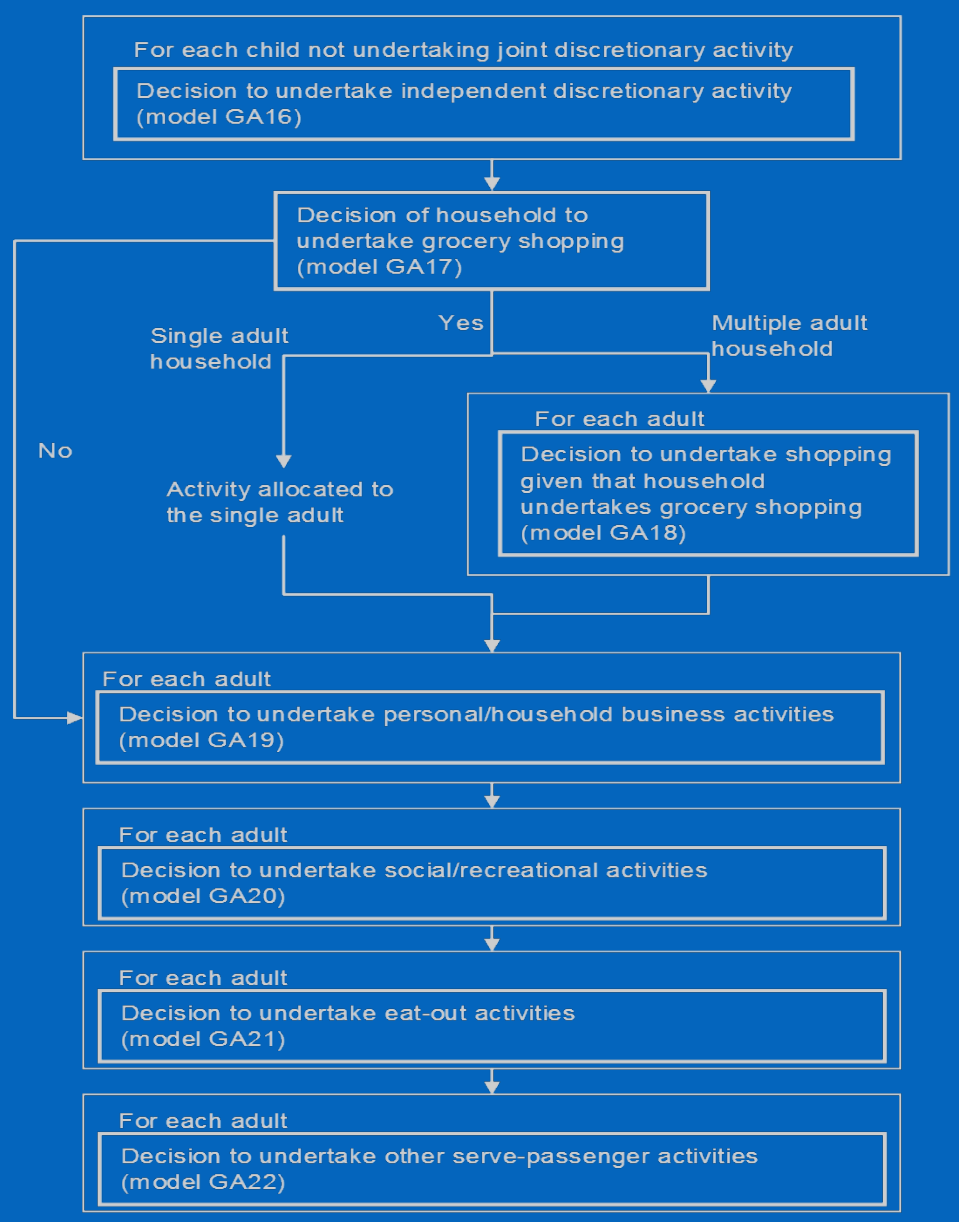
Land Use & Development

- Conventional models
  - Build scenarios and data input to 4-step model
  - Zone to zone travel time and costs (accessibility indicators) used in land use
  - Can be done in a feedback fashion for lagged effects over time
- Activity based models
  - Offer opportunity for true integration
  - Land use driven by location desires (and developer desires)
  - Travel models use more detailed land use data
  - Moving to parcel level, but many issues are not solved yet

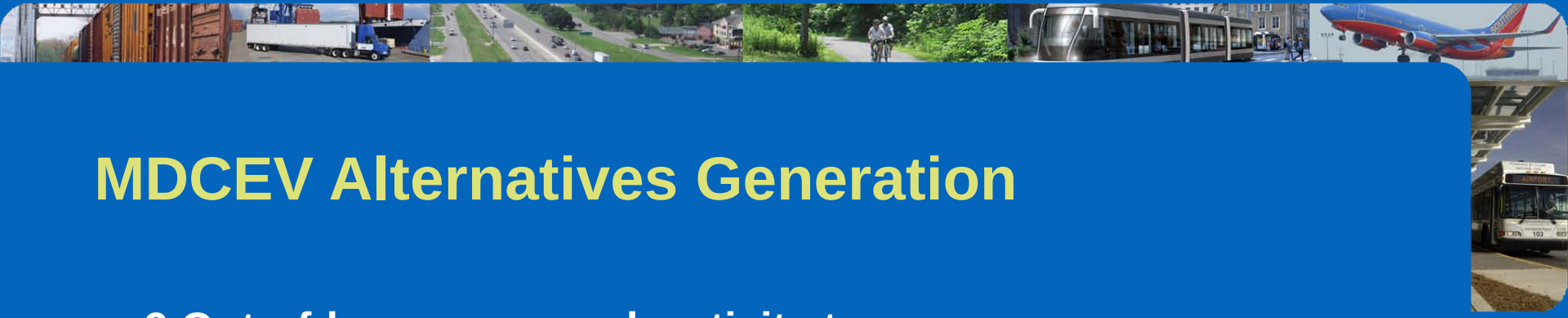
CEMDAP – Objectives

- To allow for rapid implementation of system variants
- To accommodate possible future system expansions
- To deliver a transparent - as opposed to a “black-box” - modeling tool
- To perform simulation in realistic run-time

How MDCEV alters CEMDAP



For every household model activity participation using MDCEV Model



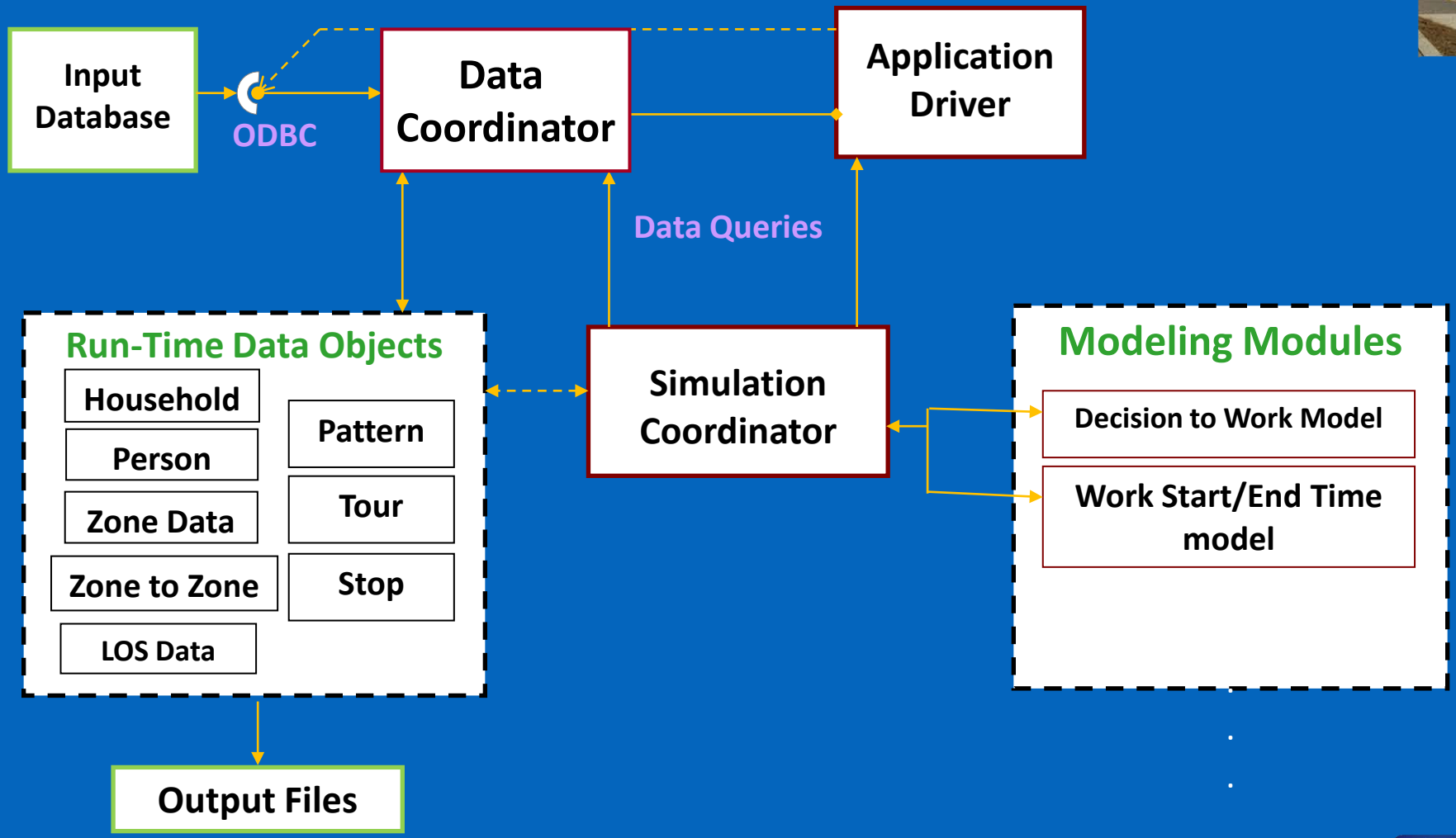
MDCEV Alternatives Generation

- 9 Out-of-home non-work activity types
  - Shopping
  - Maintenance
  - Social
  - Entertainment
  - Visit
  - Active Recreation
  - Eat out
  - Other
  - Work-related
- Joint activity allowed in the first eight activities

Vehicle Fleet + Primary Driver Model

- Joint estimation of the household vehicle fleet characteristics and identification of the primary driver for each of the vehicles
- Emphasis on primary driver assignment is important
  - household decisions of what body type and vintage of vehicles to own, and who the primary drivers would be for each vehicle, are not made independently
  - the assignment of a primary driver for each vehicle owned by a household can be used in SimAGENT to assign a vehicle to each trip made by the household
  - the primary driver allocation → central behavioral consideration to produce more accurate travel and emissions forecasts in activity based models

CEMDAP – Software Architecture



CEMDAP's Modeling Framework

- Two major steps:
  - Generation Allocation
  - Scheduling

CEMDAP: Simulation Outputs

- CEMDAP produces complete activity-travel patterns for a day for every individual in the population of interest
- There are seven output files:
  - Adults: decisions to undertake activities of different types for adults
  - Children: decisions to undertake activities of different types for children
  - Workers: pattern-level attributes of the workers' (including adult students)
  - Students: pattern-level attributes of the child students
  - Non-workers: pattern-level attributes of non-workers
  - Tours: tour-level attributes
  - Stops: stop-level attributes

Vehicle Holdings and Use

Vehicle Type/ Vintage

Coupe Old	33 makes/models
Coupe	23 makes/models
Sedan Mini/Subcompact Old	10 makes/models
Sedan Mini/Subcompact New	7 makes/models
Sedan Compact Old	25 makes/models
Sedan Compact New	19 makes/models
Sedan Mid-size Old	24 makes/models
Sedan Mid-size New	21 makes/models
Sedan Large Old	16 makes/models
Sedan Large New	12 makes/models
Hatchback/Station Wagon Old	23 makes/models
Hatchback/Station Wagon New	12 makes/models
SUV Old	15 makes/models
SUV New	23 makes/models
Pickup Truck Old	12 makes/models
Pickup Truck New	13 makes/models
Minivan Old	13 makes/models
Minivan New	15 makes/models
Van Old	6 makes/models
Van New	5 makes/models
Non-motorized vehicles	

Vehicle Fleet + Mileage Model

- MDCEV model provides aggregate forecasts of annual mileage of each of the vehicles in the household which is used by SimAGENT

- Aggregate mileage forecasts used as a quick-response tool
  - Examine the impact of a variety of land-use and transportation policies on GHG emissions and energy consumption
  - No need to run the complete SimAGENT system for each policy

Support from Texas Advanced Computing Center

- Free access to Linux based super computer, Ranger
- 11th fastest supercomputer in the world!
- 62, 976 computer cores, 128 TB of aggregate memory, 1.73 PB of shared high speed storage
- Computer cluster configuration to run the activity based model
- Fast implementation of activity based travel demand model
- Can be used even after completion of project by SCAG
  - Currently using 50 nodes with 16 processors each, so a total of 800 processors.
  - 1 hour 40 minutes to run CEMDAP for 100% population

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).

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).

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

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

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

Energy Use and Expenditures

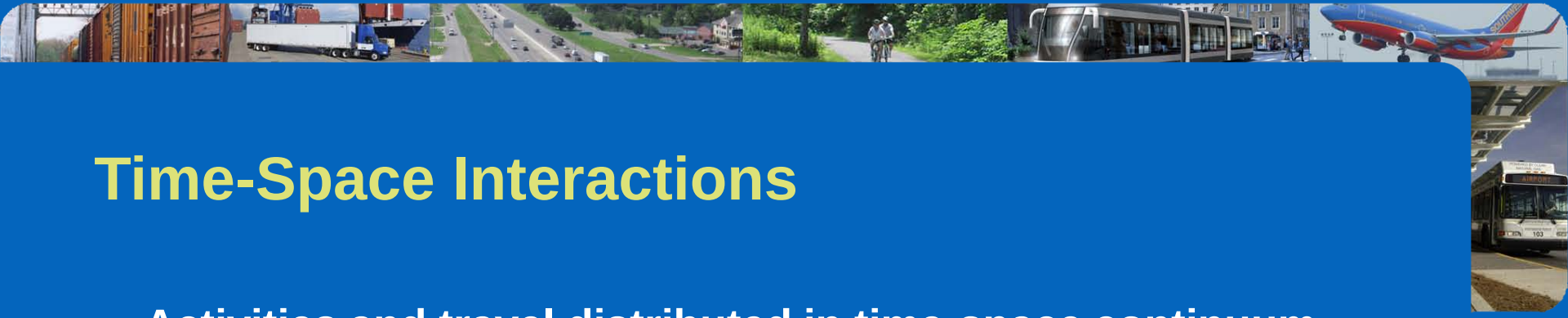
- Link housing to transportation demand
- Develop more complete household Greenhouse footprints
- Develop models of comprehensive accounting of energy demand
  - Annual, monthly, or even weekly expenditures for activity participation, travel, and vehicles and housing units maintenance ownership and energy consumption are not collected in typical travel survey
  - 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).

Behavioral Basis of ABM

- Decision hierarchies and choice processes
  - A variety of behavioral decision structures possible
  - Virtually all models assume a sequential decision structure similar to traditional four-step models for computational convenience
- Considerable evidence of simultaneity in behavioral choice mechanisms
  - Several choices made simultaneously as a lifestyle package

Behavioral Basis of ABM

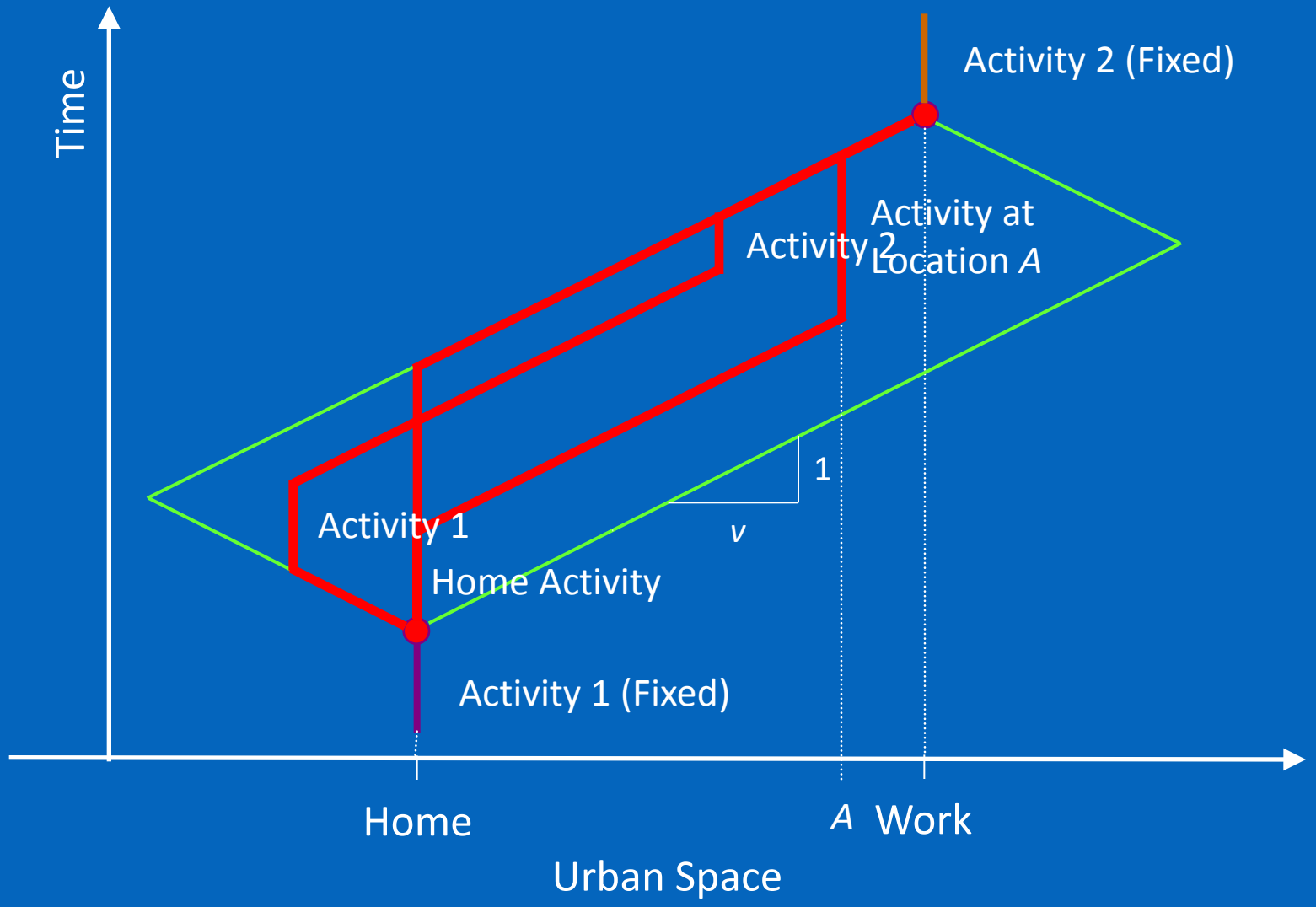
- Examples of simultaneous choice packages
  - Residential location, vehicle ownership, mode to pre-planned activities (e.g., work)
  - Activity type, activity duration, and activity timing (scheduling)
- In sequential choice processes, more constrained choice generally precedes less constrained choice
- Behavioral heterogeneity
  - Differences in choice processes across market segments
  - Identify market segments both exogenously and endogenously (latent market segments)

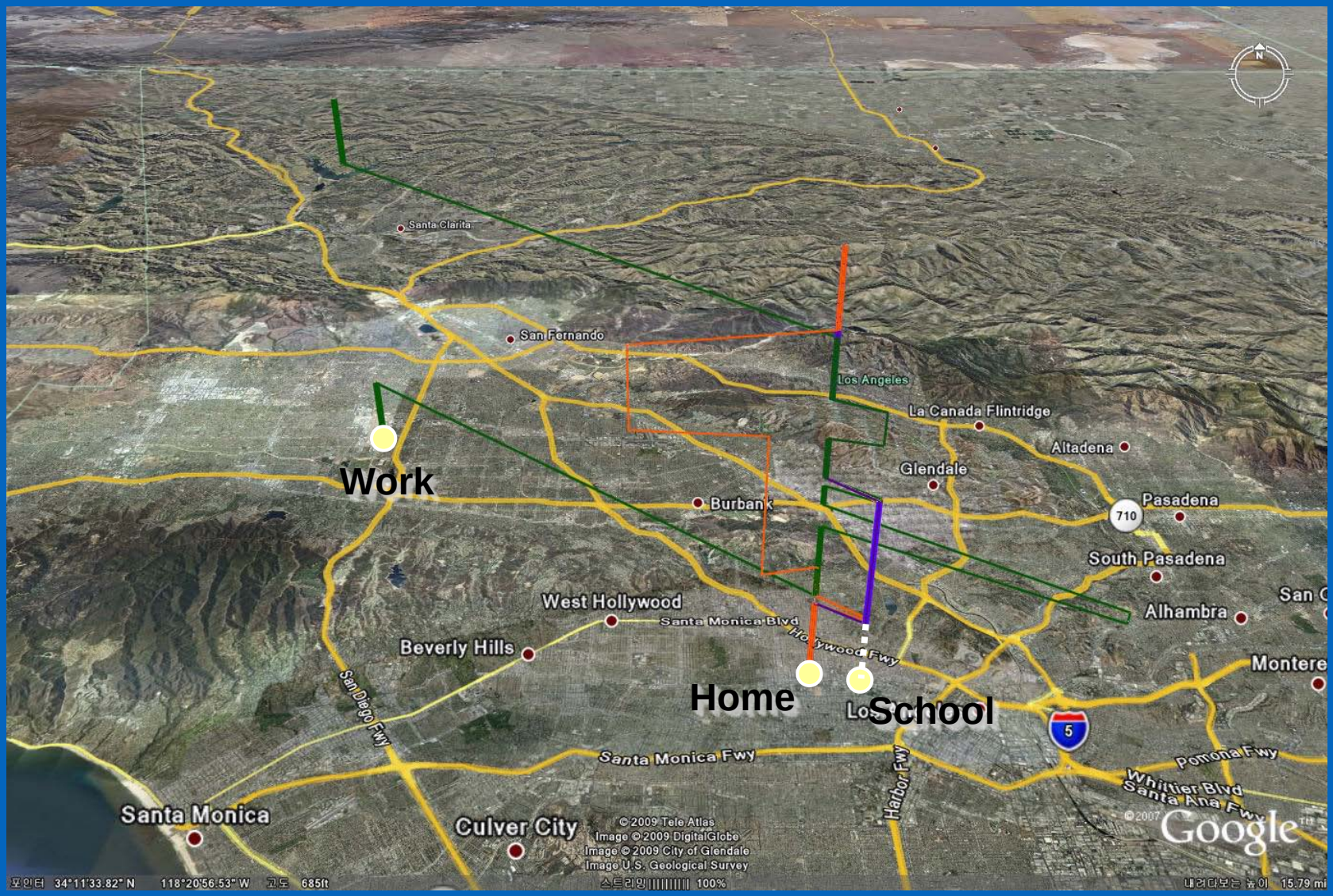


Time-Space Interactions

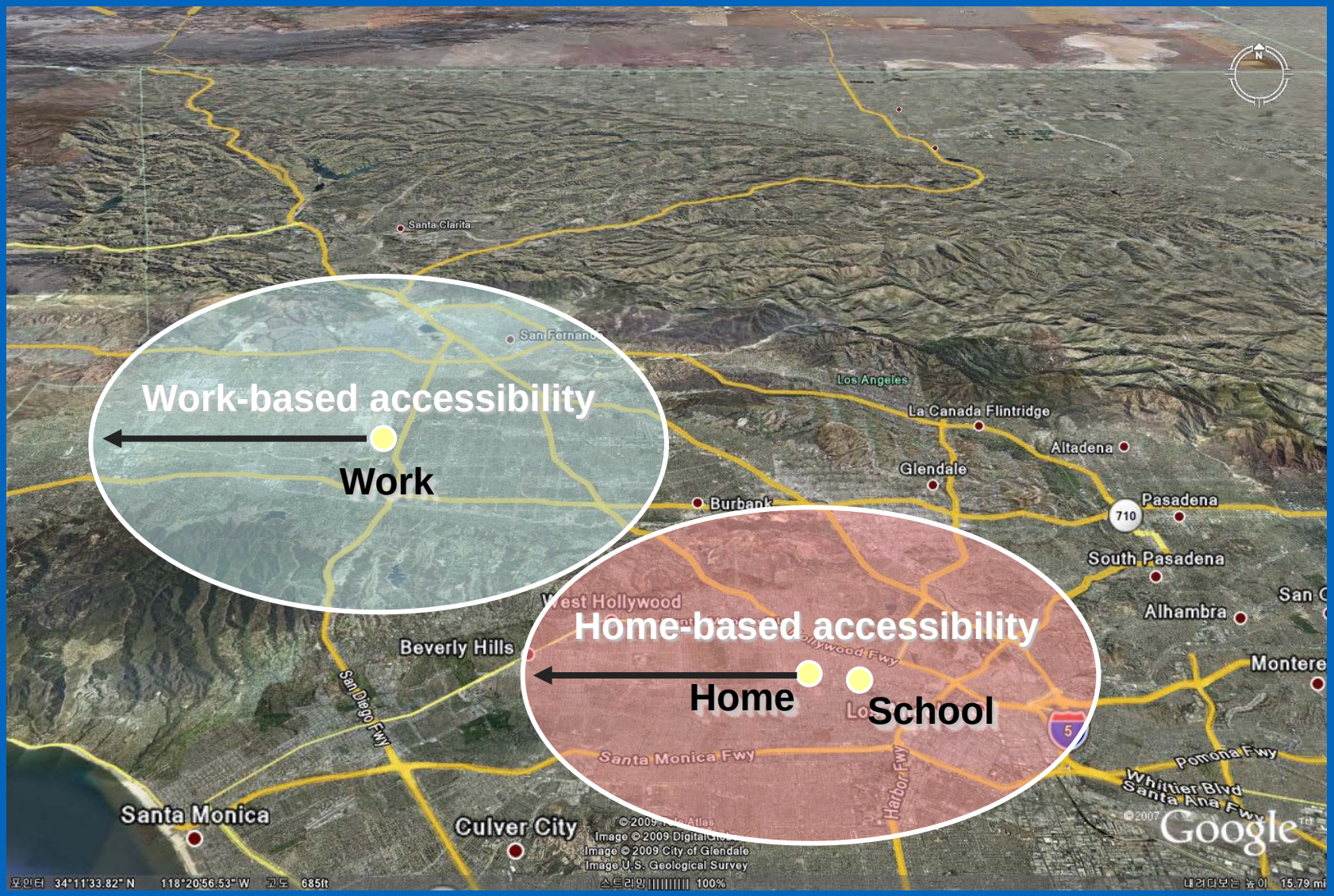
- Activities and travel distributed in time-space continuum
  - Recognize time-space constraints in mode choice (transitions), destination choice, and activity-type choice
- Role of time-space accessibility
  - Critical to modeling activity generation processes
  - Ability to explicitly represent induced or suppressed demand
  - Incorporation of Hägerstrand's prism concept

Time-Space Interactions

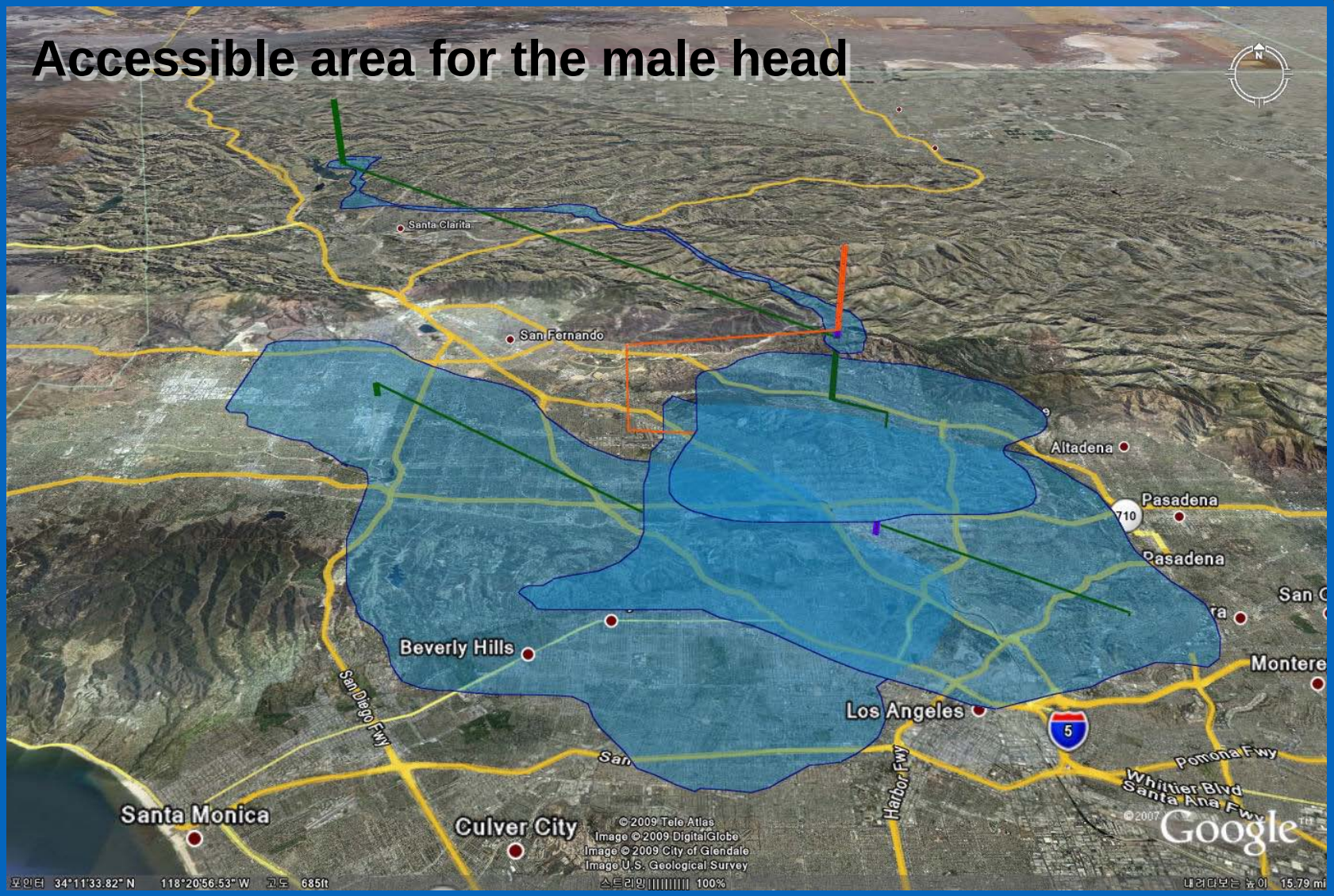




Male head — Female head — Child

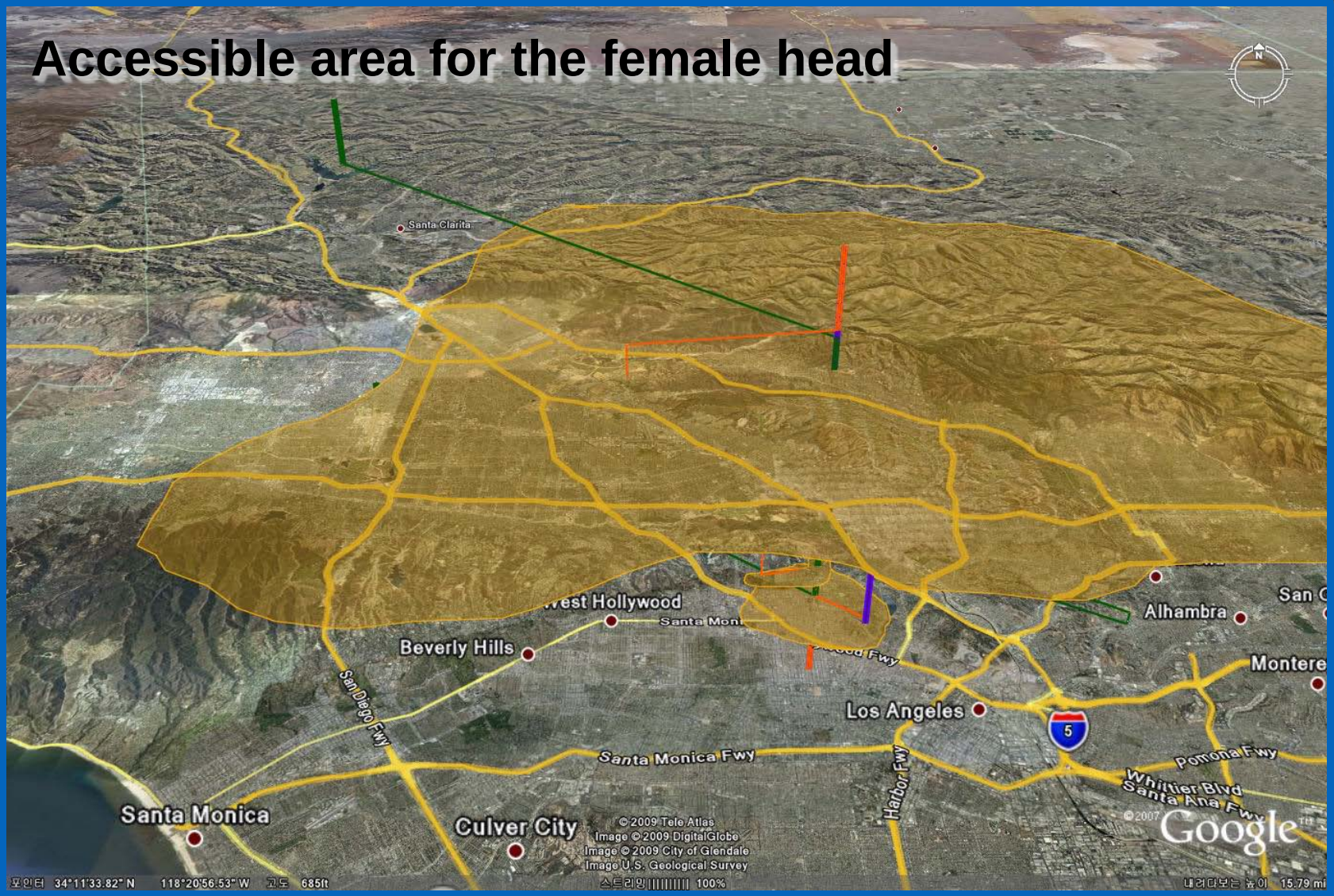

Work-based accessibility
Work
Home-based accessibility
Home
School
Santa Clarita
San Fernando
Los Angeles
La Canada Flintridge
Altadena
Glendale
Burbank
Pasadena
710
South Pasadena
Alhambra
West Hollywood
Beverly Hills
San Diego Fwy
Santa Monica Fwy
Harbor Fwy
Pomona Fwy
Whittier Blvd
Santa Ana Fwy
Santa Monica
Culver City
Image © 2009 DigitalGlobe
Image © 2009 City of Glendale
Image U.S. Geological Survey
Google

Accessible area for the male head



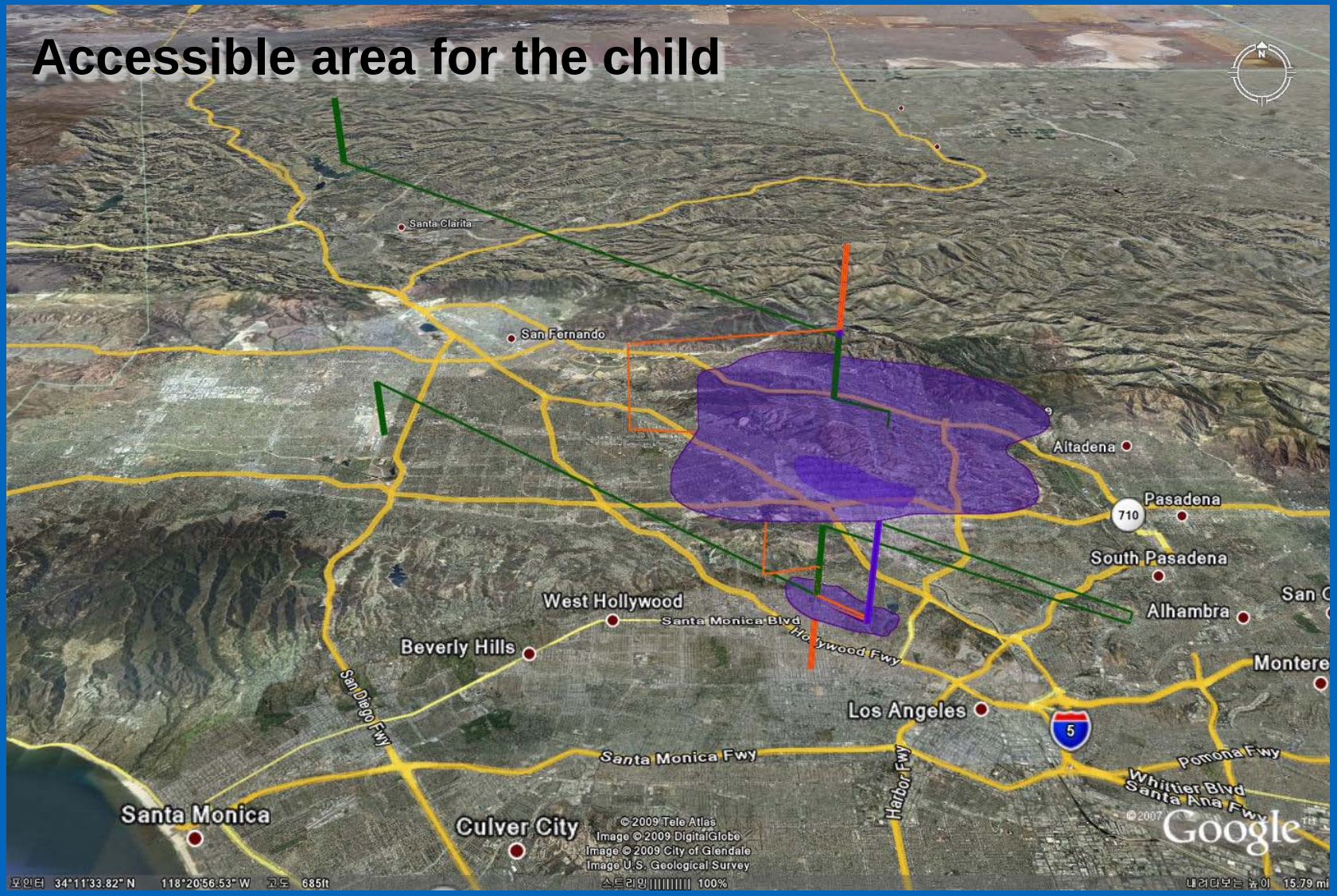
Male head Female head Child

Accessible area for the female head



Male head Female head Child

Accessible area for the child



Male head Female head Child

Activity Attributes

- Disaggregate activity purpose definition
  - Challenge traditional notion of mandatory and discretionary activities/trips
  - Movie, ball game, and child's tennis lesson or soccer game often have spatial and/or temporal fixity
  - Characterize activities and trips by level of spatial and temporal fixity/constraints (besides purpose
    - Can be accomplished using concepts of time-space geography
    - Automated method to add attributes describing degrees of freedom according to set of spatial/temporal fixity criteria to activity records in data set

Central Role of Time Use

- Notion of time is central to activity-based modeling
  - Explicit modeling of activity durations (daily activity time allocation and individual episode duration)
  - Treat time as “continuous” and not as “discrete choice” blocks
- Activity engagement is the focus of attention
  - Travel patterns are inferred as an outcome of activity participation and time use decisions
  - Continuous treatment of time dimension allows explicit consideration of time constraints on human activities
- Reconcile activity durations with network travel durations (feedback processes)

CEMSELTS Validation Work Flows (LA Region)

County-County Flows (2000 Census Data)

		% within County of Work						
		Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total
County of Residence	Imperial	97.2	0.0	0.0	0.1	0.0	0.0	0.6
	Los Angeles	1.0	89.9	12.0	1.9	7.2	10.8	56.9
	Orange	0.4	4.7	81.9	2.4	1.7	0.2	19.3
	Riverside	1.0	0.9	3.8	85.0	10.6	0.1	8.4
	San Bernardino	0.4	2.8	2.2	10.6	80.4	0.2	9.7
	Ventura	0.0	1.7	0.1	0.0	0.1	88.7	5.0
	Total	0.6	59.3	19.9	7.3	8.5	4.4	100.0

County-County Flows (CEMSELTS Work location module)

		% within County of Work						
		Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total
County of Residence	Imperial	99.3	0.0	0.0	0.1	0.0	0.0	0.2
	Los Angeles	0.0	97.8	14.1	9.2	20.4	29.0	58.5
	Orange	0.0	1.4	85.8	9.8	2.7	0.0	16.9
	Riverside	0.7	0.0	0.0	69.4	4.8		9.4
	San Bernardino	0.0	0.4	0.1	11.5	72.2	0.0	10.1
	Ventura	0.0	0.4	0.0	0.0	0.0	71.0	4.8
	Total	0.2	51.8	17.0	12.8	11.7	6.5	100.0

County-County Flows Error Matrix

		% within County of Work						
		Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total
County of Residence	Imperial	2.1	0.0	0.0	0.1	0.0	0.0	0.4
	Los Angeles	1.0	7.9	2.1	7.3	13.1	18.3	1.6
	Orange	0.4	3.2	3.9	7.5	1.0	0.2	2.4
	Riverside	0.3	0.9	3.8	15.6	5.9	0.1	1.0
	San Bernardino	0.4	2.4	2.1	0.9	8.2	0.2	0.4
	Ventura	0.0	1.4	0.1	0.0	0.1	17.8	0.2
	Total	0.4	7.5	2.8	5.4	3.2	2.1	

Base Year Generation Validation: Household Level

Housing Type for Renters	Predicted	Census
Single Family Detached	26.8	20.6
Single Family Attached	8.4	3.9
Multi-Family/Apartment/Condo	64.8	73.0
Mobile Home/Trailer	0.0	2.5

Vehicle Ownership	Predicted	Census
Zero Vehicles	6.8	6.1
One Vehicle	40.3	35.6
Two Vehicles	37.1	42.5
Three Vehicles	12.5	12.1
Four or more Vehicles	3.4	3.8

CEMSELTS Validation Person Level (LA Region)

	CEMSELTS	ACS 2003
Educational Attainment (18 yrs & above)		
High school or less	70.4	69.6
Associate	5.3	6.1
Bachelors	19.0	16.1
Graduate	5.4	8.1
Total error	1.8	-
Labor Participation		
Unemployed	49.9	42.9
Employed	50.1	57.1
Total error	7.0	-
Employment Industry		
Construction and Manufacturing	18.7	20.7
Wholesale Trade and Transportation	14.1	9.7
Professional, Personal, and Financial	33.7	48.2
Public and Military	5.8	3.8
Retail and Repair	24.3	11.2
Other Industry	3.4	6.4
Total error	6.5	-

CEMSELTS Validation Household Level (LA Region)

	CEMSELTS	ACS 2003
Number of workers		
Households with no worker	16.8	12.2
Households with 1 worker	38.2	34.2
Households with 2 workers	30.0	40.0
Households with 3 or more workers	15.0	13.6
Total error	5.0	-
Number of vehicles		
Households with no vehicles	8.6	8.3
Households with 1 vehicle	37.4	33.3
Households with 2 vehicles	32.3	37.5
Households with 3 vehicles	15.0	14.1
Households with 4 or more vehicles	6.6	6.8
Total error	2.1	-

	CEMSELTS	ACS 2003
Residential Tenure		
Rent	33.3	44.3
Own	66.7	55.7
Total error	11.0	-
Housing Type for Owners		
Single Family Detached	93.8	88.1
Single Family Attached	3.2	
Mobile Home/Trailer	3.0	5.2
Multi-Family/Apartment/Condo	0.0	6.7
Total error	5.9	-
Housing Type for Renters		
Single Family Detached	30.5	27.9
Single Family Attached	8.4	
Mobile Home/Trailer	0	1.4
Multi-Family/Apartment/Condo	61.1	70.7
Total error	7.3	-

CEMDAP Validation: Trip Generation (LA)

CEMDAP

County / Trip Purpose	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total
Home Based Work	84421	4251118	1840505	1117733	1087162	554893	8935832
Home Based Non-work	237162	15006163	5186908	3157026	3186762	1426082	28200103
Non-home based	103084	7165100	2544863	1629896	1499246	779227	13721416
Total	424884	30807841	9602245	5954942	5888380	2773915	55452207

SCAG MODEL

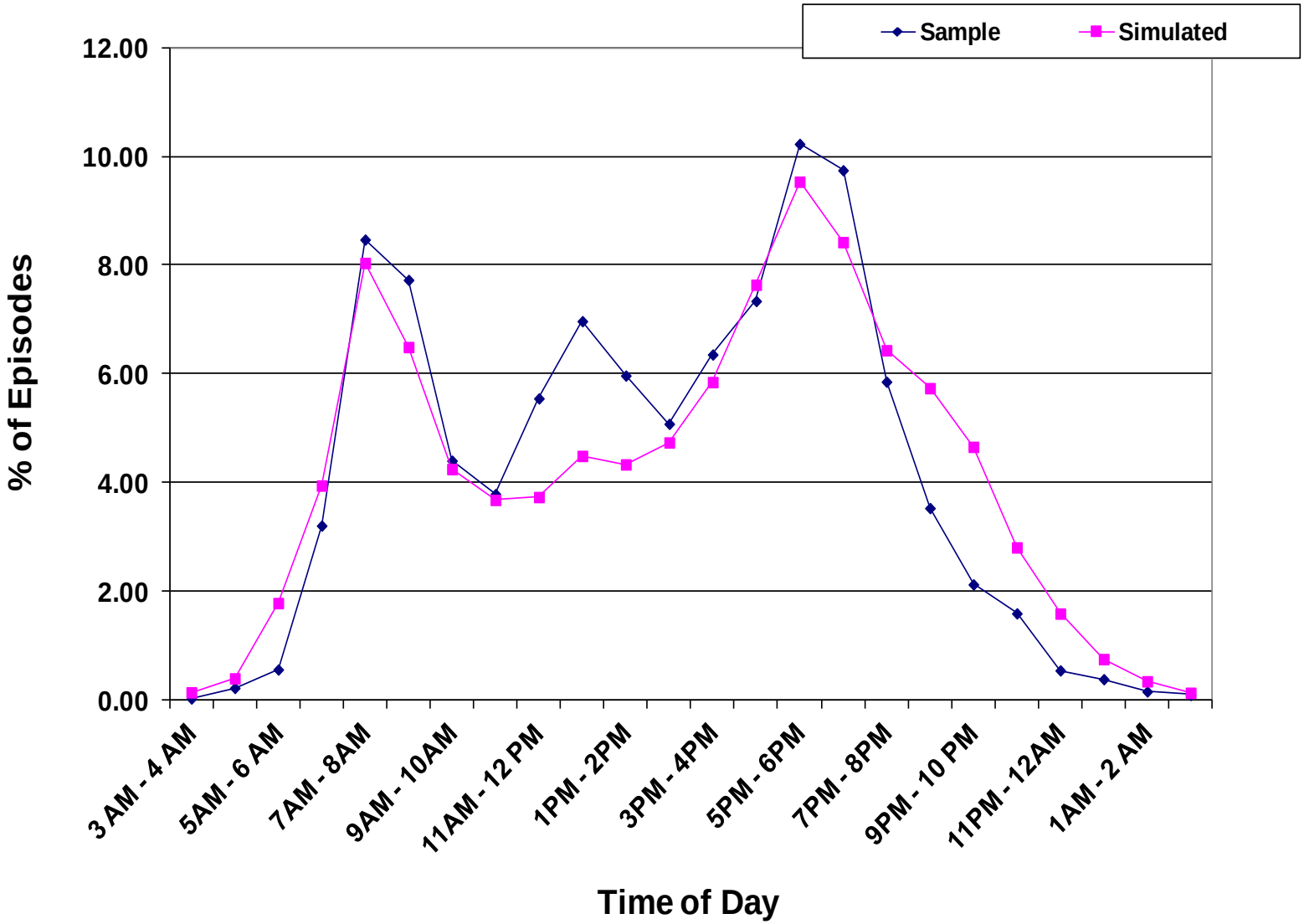
County / Trip Purpose	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total
Home Based Work	85537	6373271	2136243	1012238	1082147	559912	11249349
Home Based Non-work	254430	16854127	5012646	3022069	3225586	1365002	29733860
Non-home based	110998	9834957	3374279	1497380	1538297	750077	17105987
Total	450966	33062356	10523168	5531687	5846030	2674991	58089196

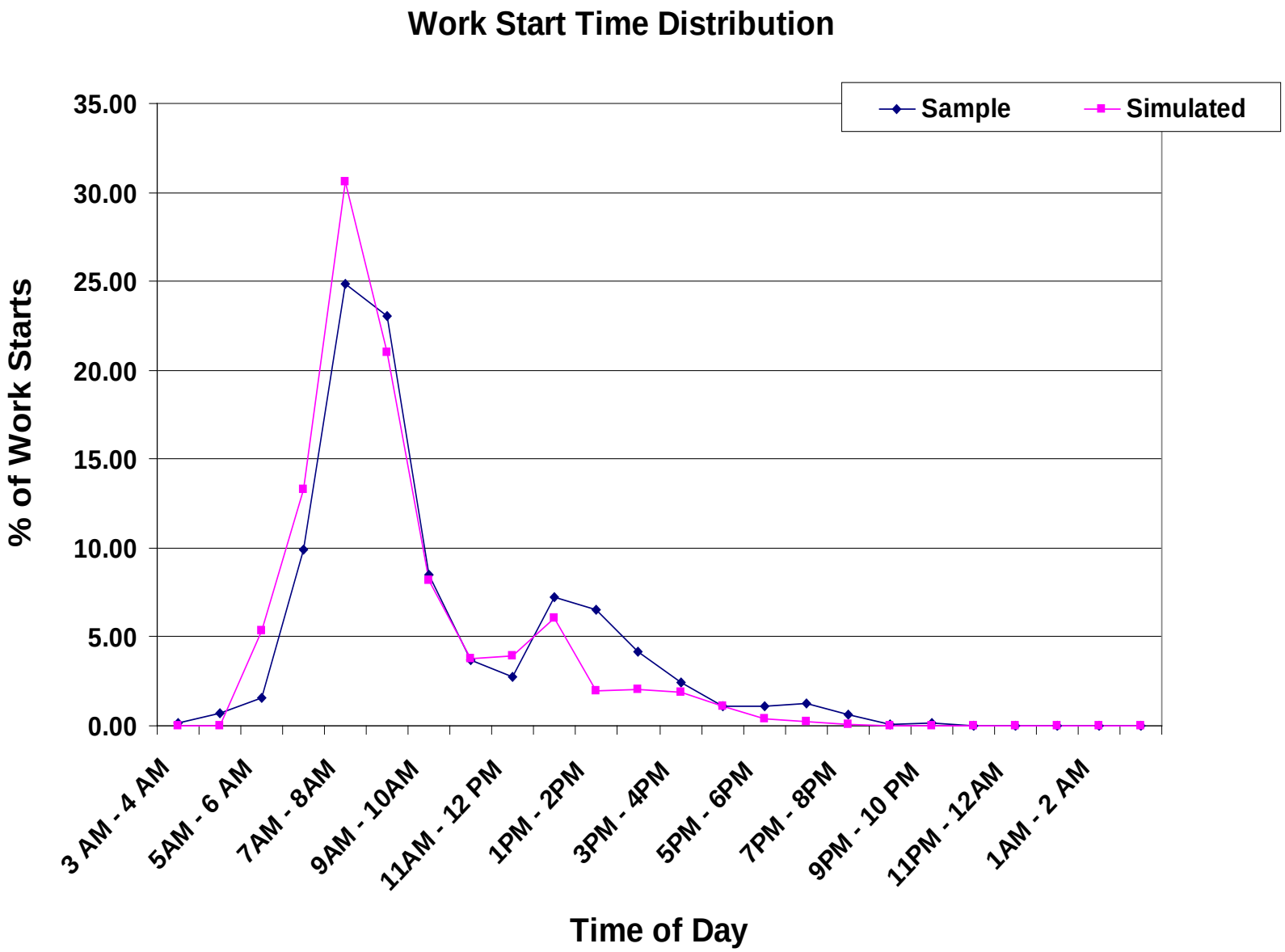
CEMDAP Validation: Mode Shares

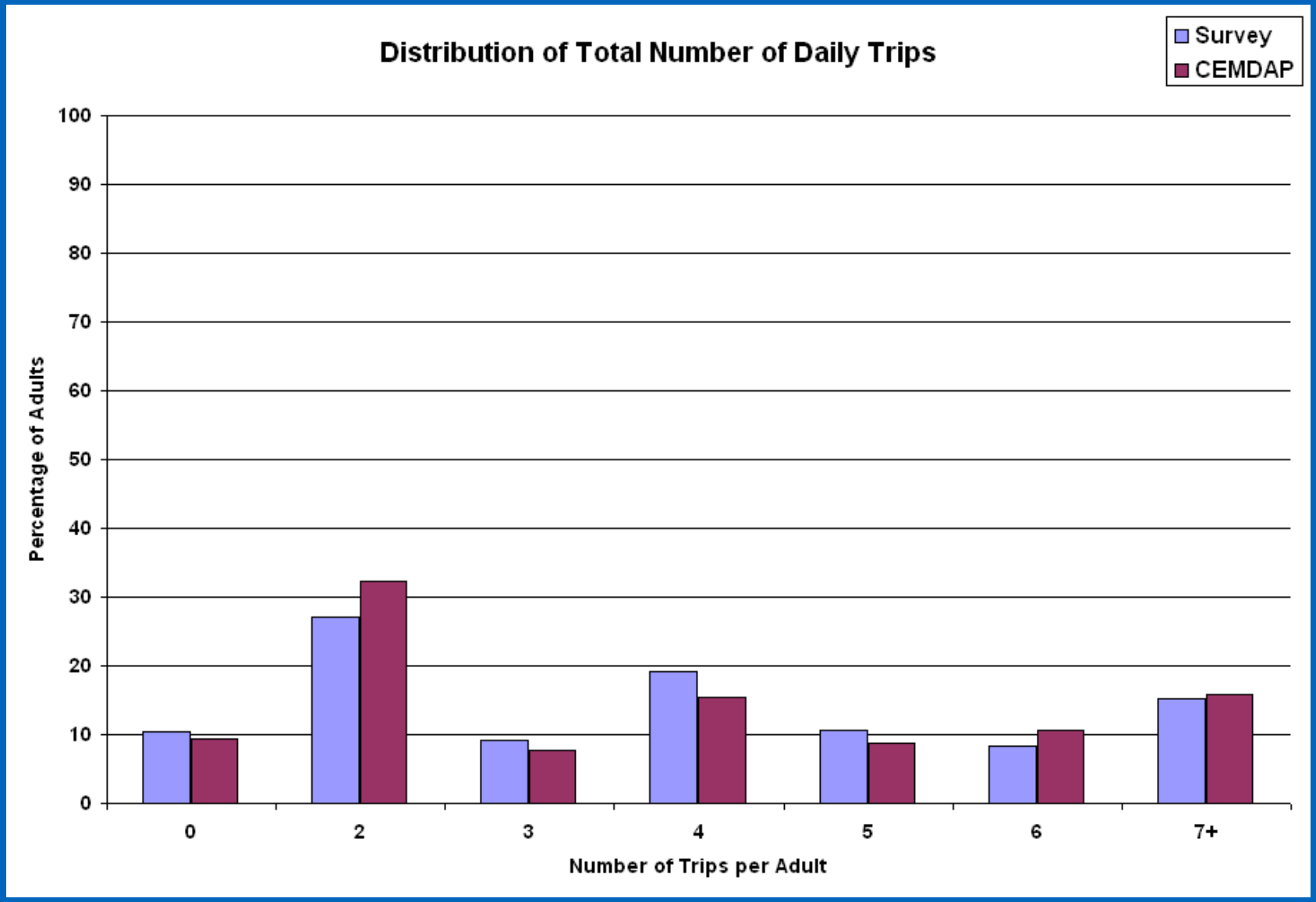
CEMDAP	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total
Drive Alone	39.0%	37.9%	39.5%	41.3%	40.1%	40.8%	39.1%
Shared Ride (as driver)	22.6%	22.4%	22.6%	22.1%	22.4%	22.0%	22.4%
Shared ride (as passenger)	28.5%	28.4%	27.9%	27.6%	28.2%	27.8%	28.2%
Transit	.0%	1.4%	1.1%	.3%	.4%	.7%	1.0%
School Bus	1.5%	1.1%	1.0%	1.3%	1.4%	1.1%	1.1%
Non-motorized	8.4%	8.7%	7.9%	7.3%	7.6%	7.7%	8.2%

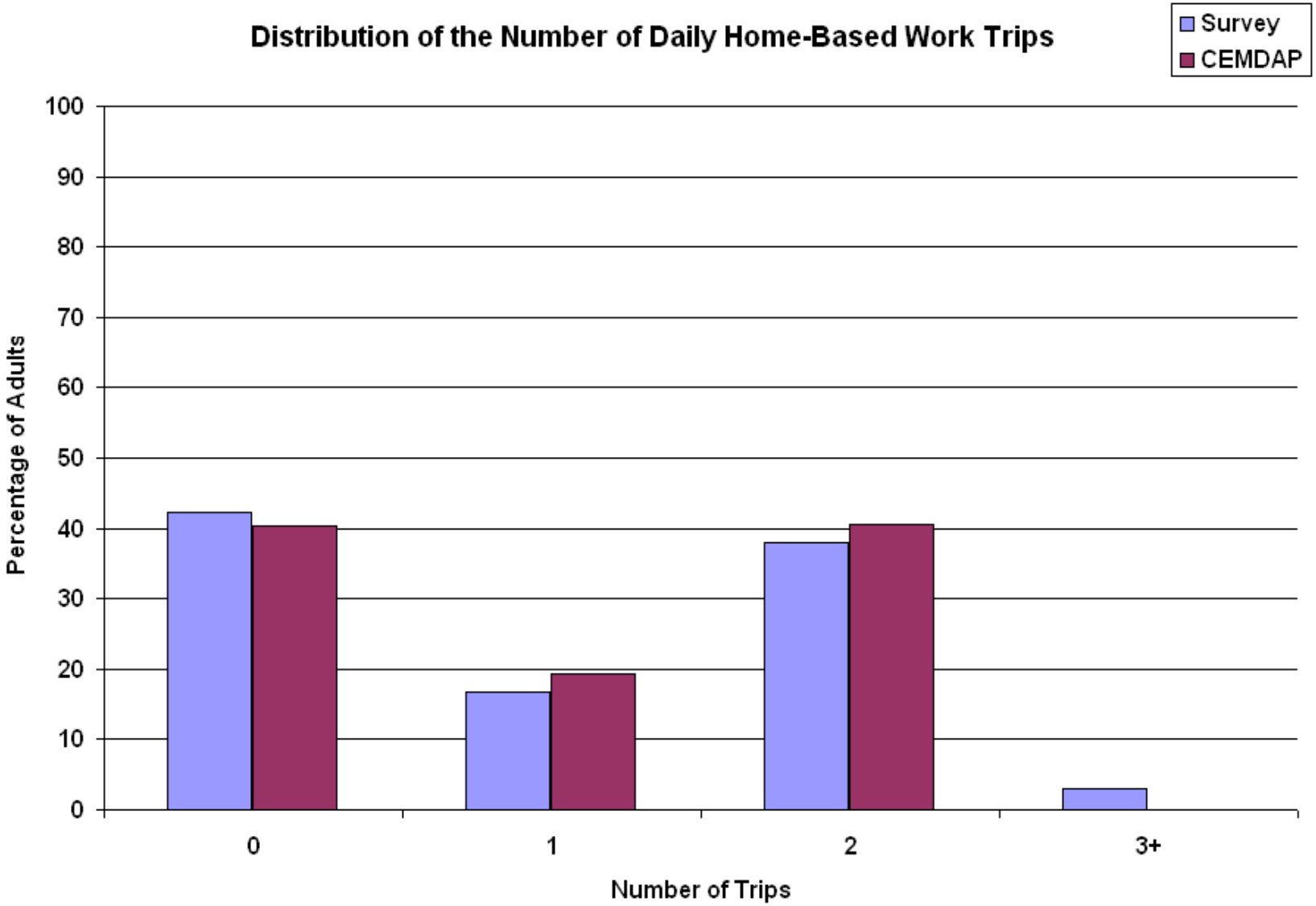
SCAG MODEL	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total
Drive Alone	39.76%	40.72%	45.78%	40.91%	39.91%	45.98%	41.81%
Shared Ride (as driver)	21.16%	20.02%	18.44%	20.73%	21.34%	18.41%	19.86%
Shared ride (as passenger)	24.04%	24.06%	22.56%	25.41%	25.97%	22.32%	24.00%
Transit	0.19%	2.27%	0.98%	0.38%	0.65%	0.47%	1.59%
School Bus	1.29%	0.97%	0.87%	1.13%	1.20%	0.97%	0.99%
Non-motorized	13.55%	11.96%	11.36%	11.43%	10.92%	11.87%	11.71%

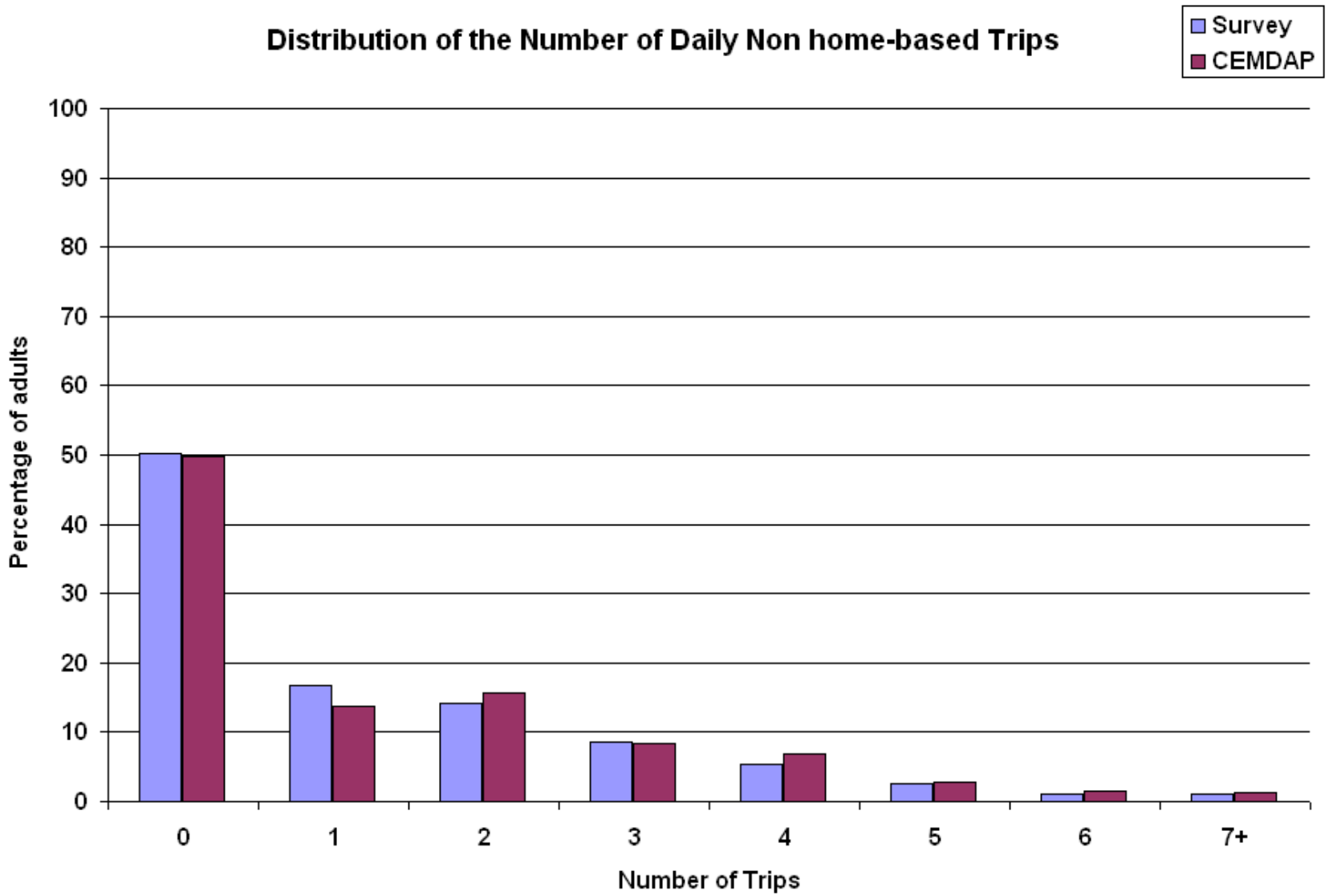
Episode Start Time Distribution

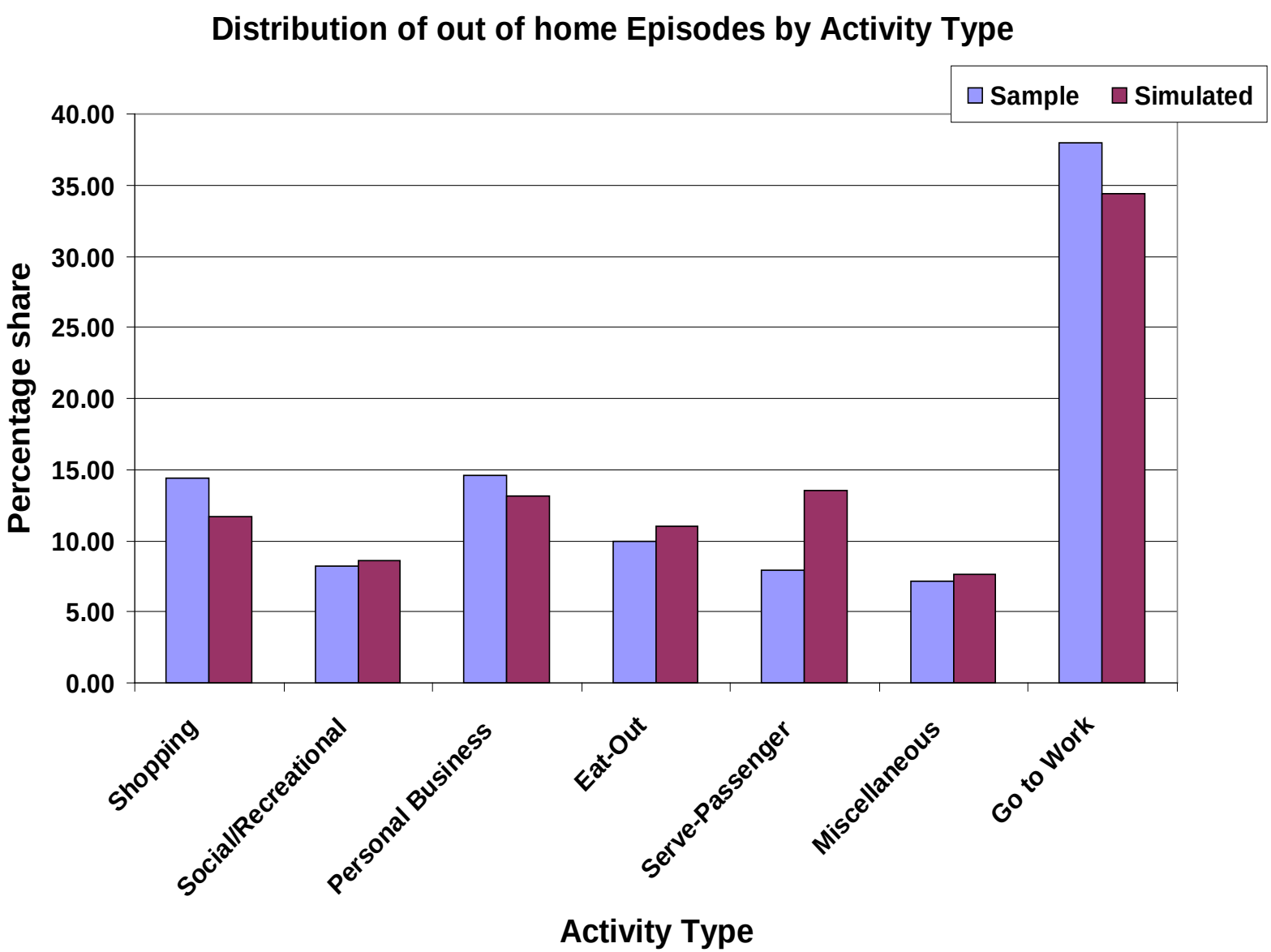



Work Start Time Distribution
Sample
Simulated
% of Work Starts
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
3 AM - 4 AM
5AM - 6 AM
7AM - 8AM
9AM - 10AM
11AM - 12 PM
1PM - 2PM
3PM - 4PM
5PM - 6PM
7PM - 8PM
9PM - 10 PM
11PM - 12AM
1AM - 2 AM
Time of Day


Distribution of Total Number of Daily Trips
Survey
CEMDAP
Percentage of Adults
100
90
80
70
60
50
40
30
20
10
0
0
2
3
4
5
6
7+
Number of Trips per Adult


Distribution of the Number of Daily Home-Based Work Trips
Survey
CEMDAP
Percentage of Adults
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3+
Number of Trips


Distribution of the Number of Daily Non home-based Trips
Survey
CEMDAP
Percentage of adults
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7+
Number of Trips


Distribution of out of home Episodes by Activity Type
Sample
Simulated
Percentage share
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Shopping
Social/Recreational
Personal Business
Eat-Out
Serve-Passenger
Miscellaneous
Go to Work
Activity Type

CEMDAP Validation: Trip Distribution

CEMDAP

	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total
Imperial	410071	1831	477	9920	2309	276	424884
Los Angeles	2176	29363649	639404	134919	379363	288330	30807841
Orange	486	634720	8793012	116677	54957	2393	9602245
Riverside	9608	138170	108418	5330618	364179	3949	5954942
San Bernardino	2375	376014	59325	361655	5084934	4077	5888380
Ventura	164	288605	1877	3661	3512	2476096	2773915
Total	424880	30802989	9602513	5957450	5889254	2775121	55452207

SCAG MODEL

	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total
Imperial	444061	217	122	6056	504	5	450965
Los Angeles	998	30875478	1317551	140232	426536	301559	33062354
Orange	810	1225351	9057299	119533	111676	8498	10523166
Riverside	13792	256533	242381	4552028	463754	3198	5531686
San Bernardino	2321	614208	199507	425591	4597644	6758	5846030
Ventura	52	374800	10856	2240	4898	2282145	2674991
Total	462034	33346587	1.1E+07	5245680	5605014	2602162	58089193

CEMSELTS Validation: Person Level (LA Region)

	CEMSELTS	ACS 2003
Educational Attainment (18 yrs & above)		
High school or less	70.4	69.6
Associate	5.3	6.1
Bachelors	19.0	16.1
Graduate	5.4	8.1
Total error	1.8	-
Labor Participation		
Unemployed	49.9	42.9
Employed	50.1	57.1
Total error	7.0	-
Employment Industry		
Construction and Manufacturing	18.7	20.7
Wholesale Trade and Transportation	14.1	9.7
Professional, Personal, and Financial	33.7	48.2
Public and Military	5.8	3.8
Retail and Repair	24.3	11.2
Other Industry	3.4	6.4
Total error	6.5	-

Linux Platform CEMDAP

- Successfully ported to Linux supercomputer
- Run Time
- Steps:
  - Copy the database to all the nodes. It takes about 25 minutes for copying the database to all nodes
  - The run time after finishing the database copying is about 85 minutes
  - Total run time on 50 nodes is 25+75 = 100 minutes
- Also, as the number of nodes increases, the amount of time we have to wait in the queue to get access to the super computer also increases significantly
- With 50 nodes, we should get the access to super computer within 2-3 hours and then should be able to run the entire population in another 1 hour 40 minutes