

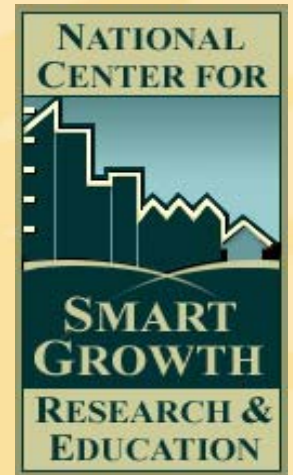


**IRA A. FULTON SCHOOL OF ENGINEERING**

Leading engineering discovery and innovative education for global impact on quality of life.

# Activity-Based Travel Demand Models

## Baltimore Metropolitan Council Realizing a Vision





# Understanding Travel Behavior

- Derived nature of travel demand (Jones, 1979)
  - Travel generally undertaken to fulfill activity needs and desires
  - Activities distributed in time and space necessitating travel
- Desire travel demand models that reflect this fundamental notion



# Roots of Activity Based Paradigm

- Microsimulation of individual activity-travel patterns
- Bring together two schools of thought
  - Hägerstrand's Constraints School (1969)
  - Chapin's Activity-pull (Needs and Desires) School (1971 and 1974)



# The Perfect Storm

- Why is vision being realized now?
  - Disaggregate modeling of travel behavior
  - Advances in statistical and econometric estimation methods
  - Quantum leaps in computational power
  - Policy questions with complex behavioral implications
  - Availability of databases (land use, travel behavior, GPS, networks)





# An Evolutionary Stream of Research

- Chapin (1971 and 1974) studied human activity patterns in urban contexts
- Hägerstrand (1969) examined activity patterns in the time-space domain (continuum) and identified series of constraints
- Activity-based analysis traces its roots to these schools of thought



# Hägerstrand's Constraints

- Three primary types of constraints identified
  - *Authoritative*: Time-space constraints
  - *Capability*: Biological needs and resources (sleep, income)
  - *Coupling*: Inter-agent interactions (children)



# Activity-Based Paradigm in Transportation

- Jones (1979) explicitly identified relationships among activities, travel, time, and space
  - Travel demand is a derived demand
- Followed with a conference in 1981 on *Travel Demand Analysis: Activity-Based and Other New Approaches*



# Activity-Based Paradigm in Transportation

- Impetus grew in late 1980s and into 1990s
  - Key legislative acts such as ISTEA (1991), CAAA (1990), and TEA-21 (1998)
  - Major lawsuit filed by Sierra Club against San Francisco Bay Area MTC
  - Federal Travel Model Improvement Program (TMIP)





# Activity-Based Paradigm in Transportation

- Early research efforts under TMIP
  - Development of TRANSIMS at Los Alamos National Laboratory
  - Activity-based model development research (AMOS)
- Four key papers published in *Transportation* (1996) offered frameworks for activity models

# Activity-Based Paradigm in Transportation

## ➤ Four papers in *Transportation*

- Late Kitamura/Pas
- Ben-Akiva/Bowman
- Stopher/Hartgen
- Slavin

## ➤ Other key publications

- Kitamura (1988); Axhausen and Gärling (1992); Jones et al (1990); Bhat and Koppelman (1999)

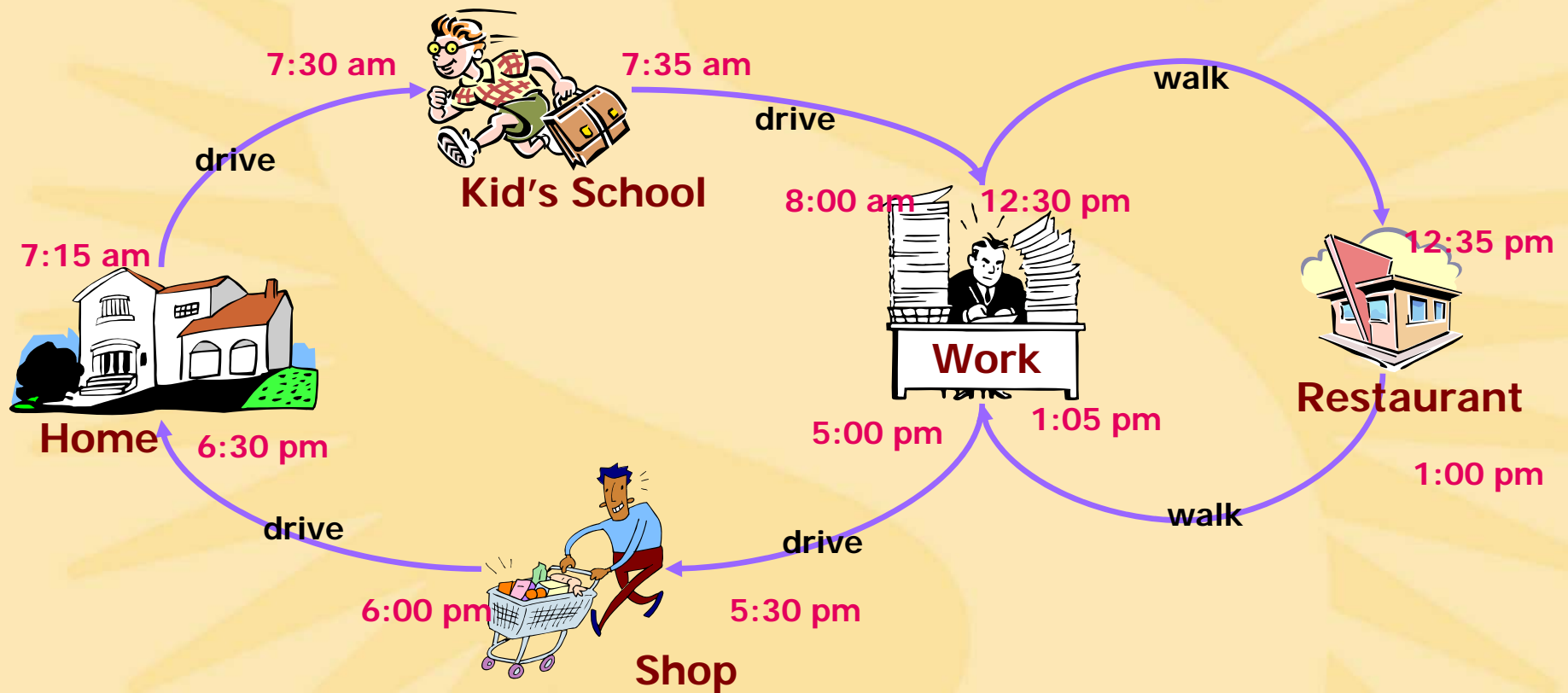


# Activity-Based Paradigm in Transportation

## ➤ Other key events

- 1996 Activity Based Modeling Conference (New Orleans) organized by TMIP – *everybody from Missouri?*
- 1995 and 2004 Netherlands Conferences in Progress in Activity-Based Analysis
- TRB Task Force on Moving Activity-Based Approaches to Practice (2003-2008) – *chaired by Prof. Kostas Goulias*

# A Daily Activity Itinerary

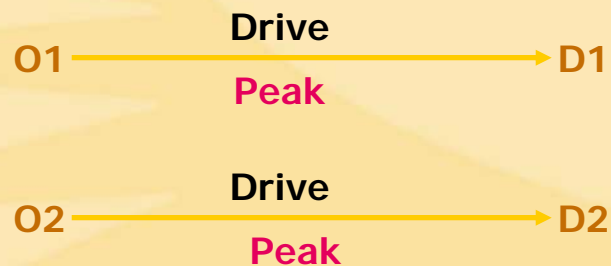




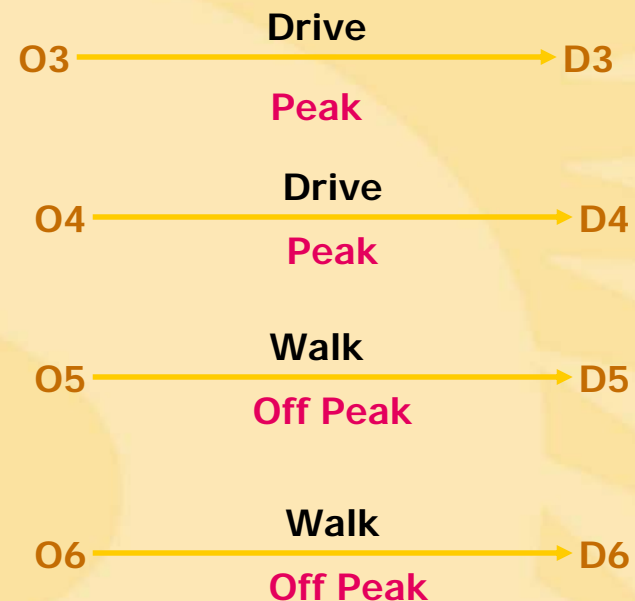
# Interactions and Constraints

- How does a four-step trip-based model view this itinerary?

## *Two Home-based trips*

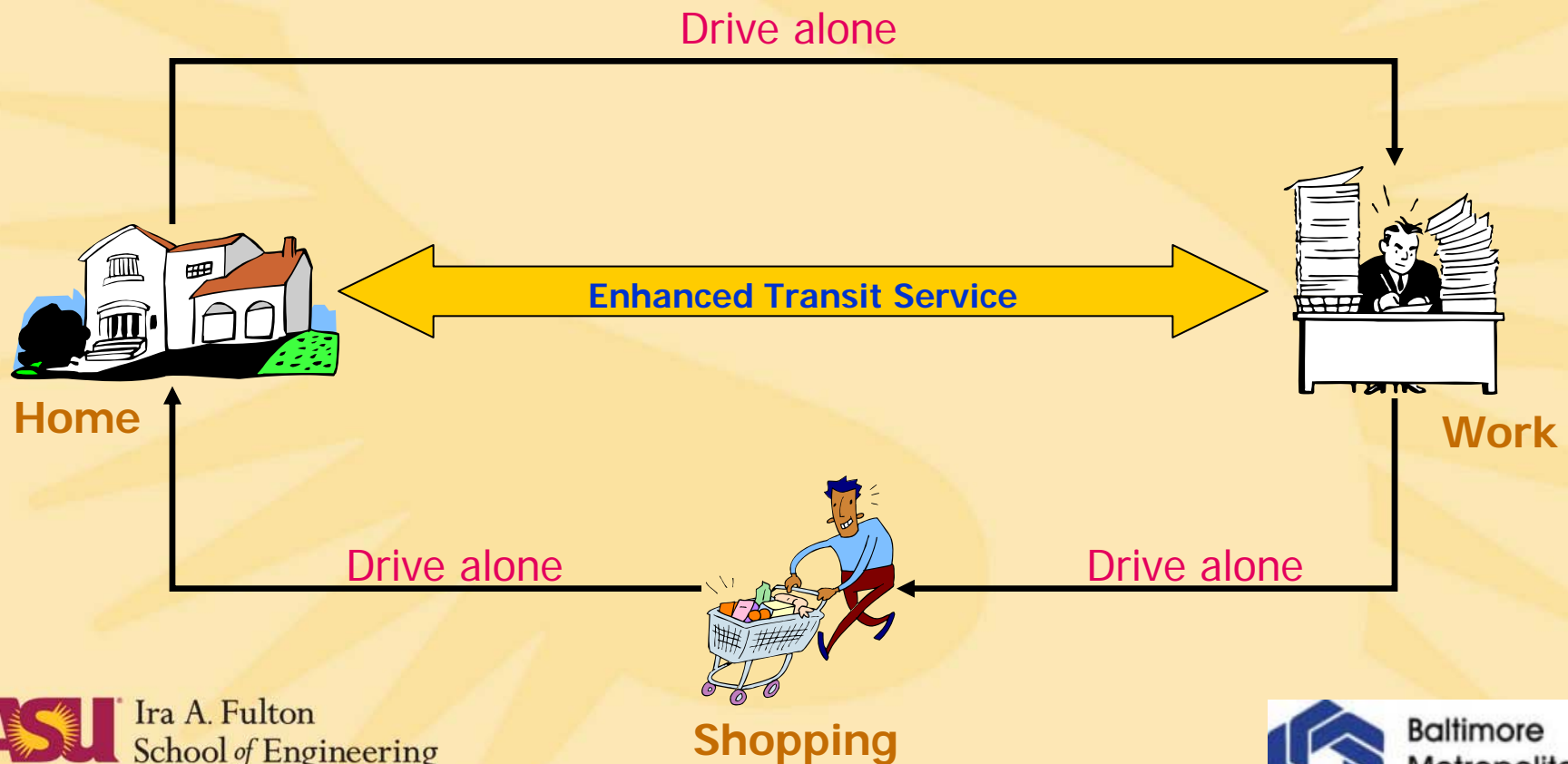


## *Four Non home-based trips*



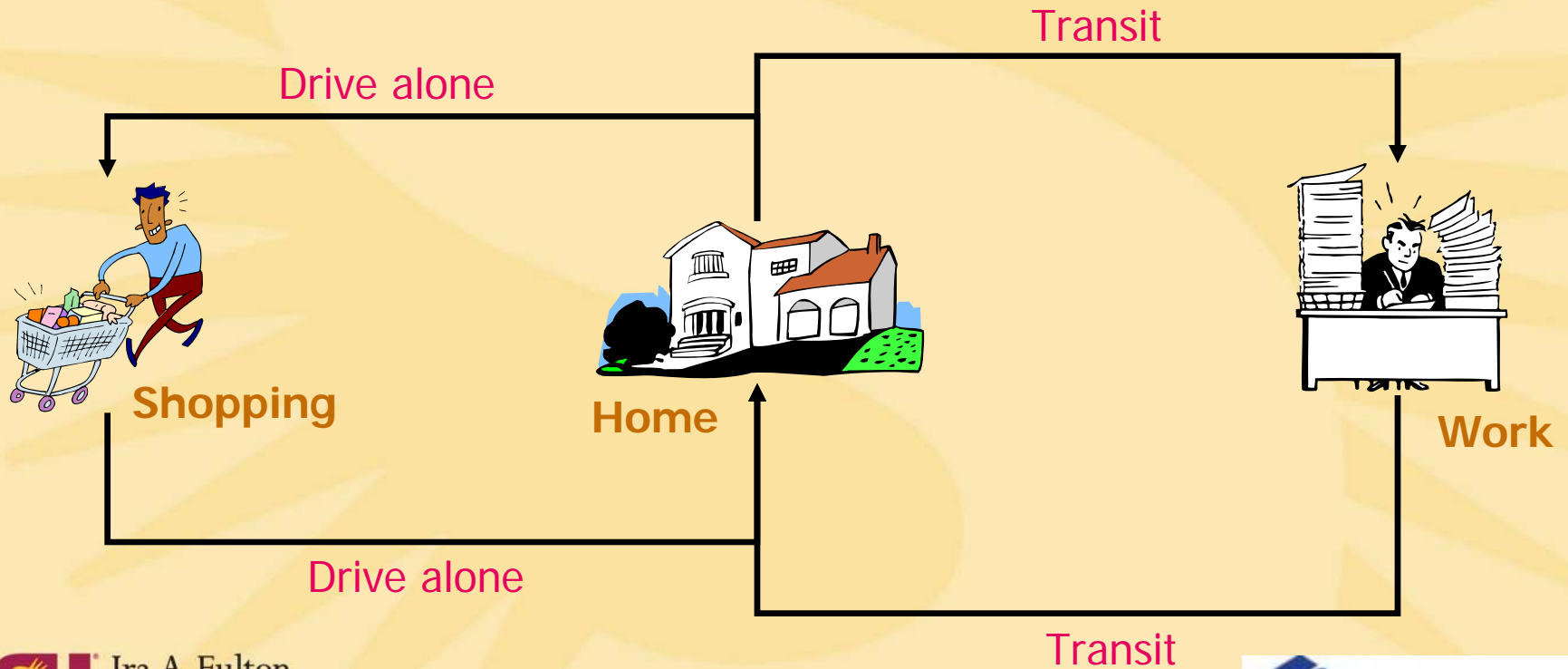
# Influence of Trip Chaining

- Consider a transit enhancement



# Influence of Trip Chaining

- How can a switch to transit be accommodated?





# Activity-Travel Inter-relationships

- Note series of inter-related behavioral responses
  - Shift in mode choice to work
  - Shift in destination choice for shopping
  - Shift in timing of shopping activity
  - Impact on trip generation (4 trips instead of 3 trips)





# Limits of Four-Step Trip-Based Models

- Consider a change in system conditions
  - Increase in capacity
  - Increase in congestion (travel time)
  - Change in fuel price



# Limits of Four-Step Trip-Based Models

- What do people do?
  - According to USA Today/Gallop Poll in June 2008, >80% consolidate errands → Direct impact on trip generation
  - However, activity participation remained largely unaltered
- Trip generation models in practice
  - Largely insensitive to system conditions



# Limits of Four-Step Trip-Based Models

- Insensitivity of trip generation to system conditions
  - Inability to model suppressed demand or induced demand
- Could incorporate accessibility measures in trip generation models, but...
  - Still very limited in ability to reflect interactions and constraints



# Social Equity and Quality of Life Issues

- Quality of life tightly connected to human activity patterns and how people spend “time”
- Activity-based paradigm offers ability to construct utility measures that directly address these issues



# Planning Issues

- Traditional/novel multimodal capacity additions/subtractions
- Transit/Pedestrian Oriented Development
- Bicycle facility enhancements
- HOV/HOT lanes, Congestion Pricing, Variable Pricing, Parking Pricing
- Telecommuting (Telecommunications), Flexible Work Schedules
- ITS deployments
- Equity, Social Exclusion, Environmental Justice
- Energy (Fuel Prices) and Environment (Air Quality)
- Homeland security and disaster management



# Basis for Model Design

- Policy issues and questions of interest
- Realistic behavioral paradigm/representation
- Computationally feasible and tractable
  - Estimation
  - Implementation
- Data availability (present and future)



# A Focus on Behavioral Considerations

- Multitude of choices define activity-travel behavior
  - Activity type/purpose
  - Activity timing (time-of-day)
  - Travel mode and destination
  - Activity duration
  - Activity linkage (trip chaining)
  - Accompanying persons
  - Network-level choices



# Behavioral Decision Processes

- Multitude of decision hierarchies possible
  - What is the sequence in which choices are made?
  - Virtually all model systems imply a certain decision hierarchy
- To what extent are choices made sequentially versus simultaneously/jointly?



# Decision Hierarchies

- Large variety of decision hierarchies possible
  - Heterogeneity in the population
  - Careful market segmentation based on decision processes
- Growing evidence of simultaneity in choice decisions
  - People choose an activity-travel (lifestyle) package
- If choice process is sequential, more constrained choice precedes less constrained choice
  - In household with vehicle ownership constraints, would mode choice precede destination choice?



# The Role of Time

- The notion of time and time use is central to the activity-based modeling paradigm
  - Time is not just a “cost” to be minimized
  - Rather, it is a finite resource whose “use” people strive to “optimize”
  - Time is an all-encompassing entity in activity-based models



# The Role of Time

- Time appears in activity-travel agendas in numerous ways
  - Daily time allocation to activities and travel
  - The duration of single activity and travel episodes
  - The timing (time-of-day) of activities/trips
  - Multi-day (weekly) activity scheduling



# The Role of Time

- Consideration of relationships between in-home and out-of-home activity time use
- Evidence of increased availability of leisure time
- Evidence of increase in travel time expenditures
  - Productivity efficiencies brought about by specialized services and technology deployment



# The Role of Time

- Do people treat time as a continuous entity or a discrete entity?
  - Discrete time-of-day choice models (break the day into discrete periods)
  - Continuous duration models where activity timing is modeled along the continuous time axis
- Scheduling may be discrete while time allocation may be continuous

# Agent Interactions

- Task allocation and joint activity-travel engagement
  - With whom and for whom?
- Activity dependency (children)
- Household vehicle allocation
- Residential and workplace location choices
- Real-time activity scheduling
  - Influence of mobile technologies
  - Generate activities on-the-fly in model?

# Time-Space Interactions

- Gain realism by incorporating time-space prism constraints
- Constraints on modal transition, public transit availability, and destination choices
- Generate work/school schedules and tours first (define anchor points)
  - Discretionary activities simulated along the time axis recognizing constraints imposed by work and school

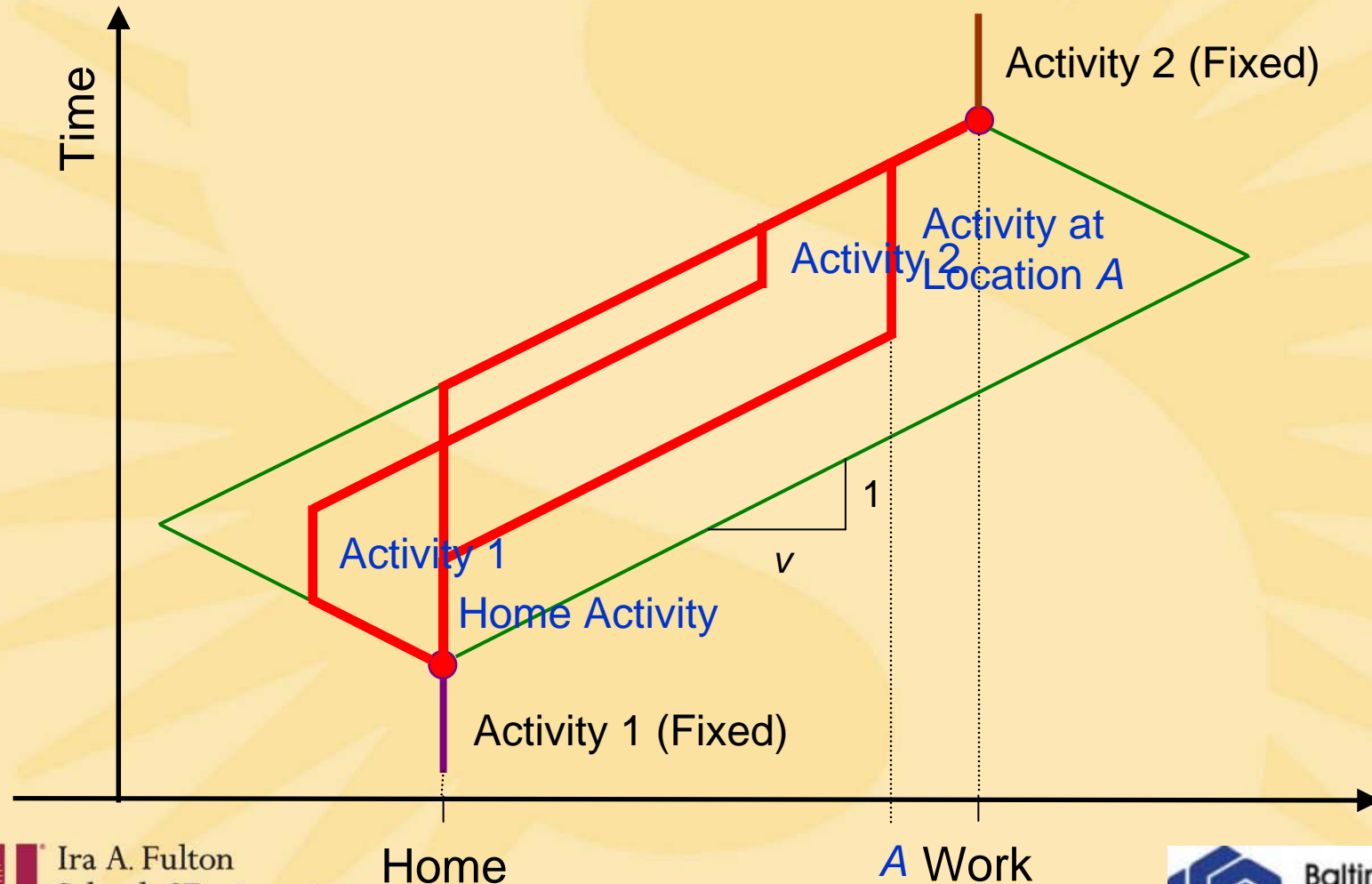


# Time-Space Interactions

- Prism Constrained Activity-Travel Simulator (PCATS) of Kitamura – now embedded in *OpenAMOS*
- Divides a day into open periods and blocked periods
- Defines a Hägerstrand's prism for each open period and simulates activities and travel within it



# Time-Space Interactions





# Time-Space Interactions

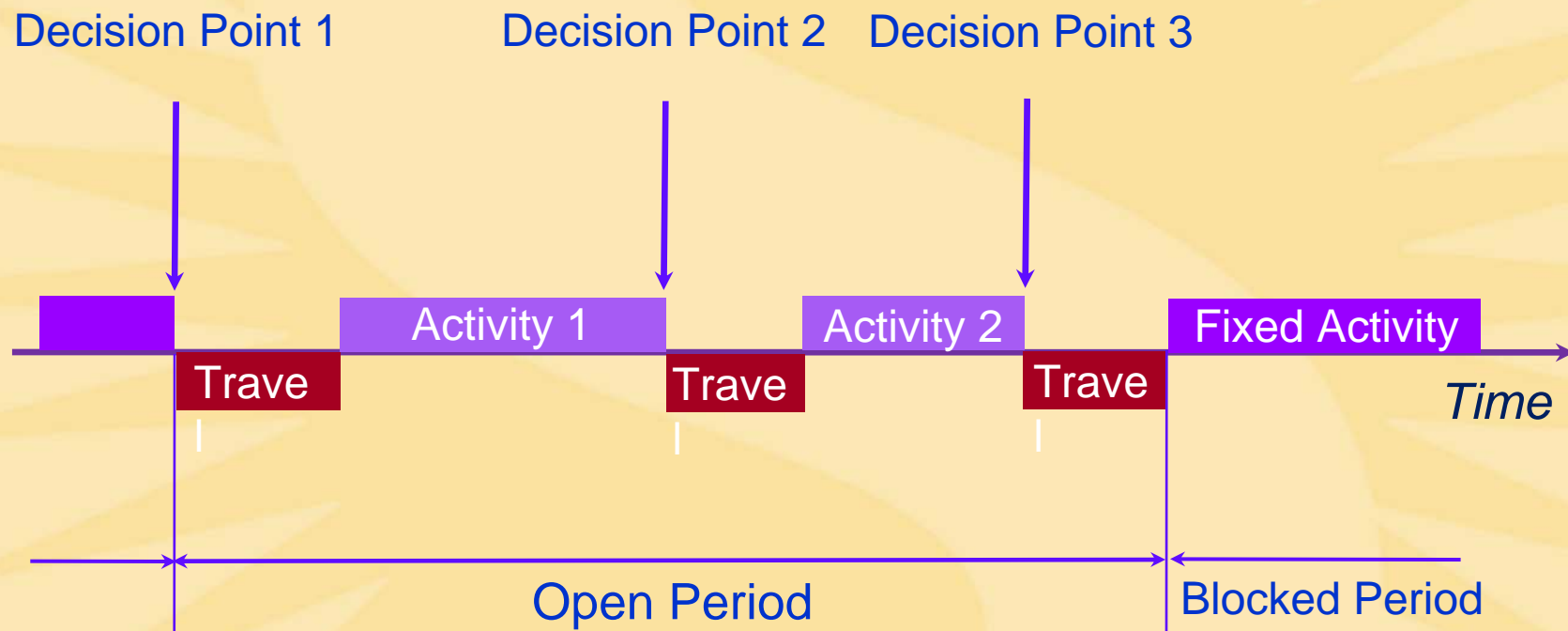
## ➤ Sequential structure

- The attributes of an activity and trip to it are simulated activity by activity, conditional on past activity engagement
- Operational hierarchy: activity type → mode-destination → activity duration

## ➤ Representation of prism constraints

- Activity type choice/generation ← remaining time in prism
- Mode-destination choice ← constrained choice set
- Duration choice ← remaining time in prism

# Decision Time Points for Discretionary Activities



# PCATS Model Components

- Prism vertex models
  - Stochastic frontier models to determine unobserved prism vertices
- Activity type choice models
  - Multinomial logit models that determine activity engagement in each open period

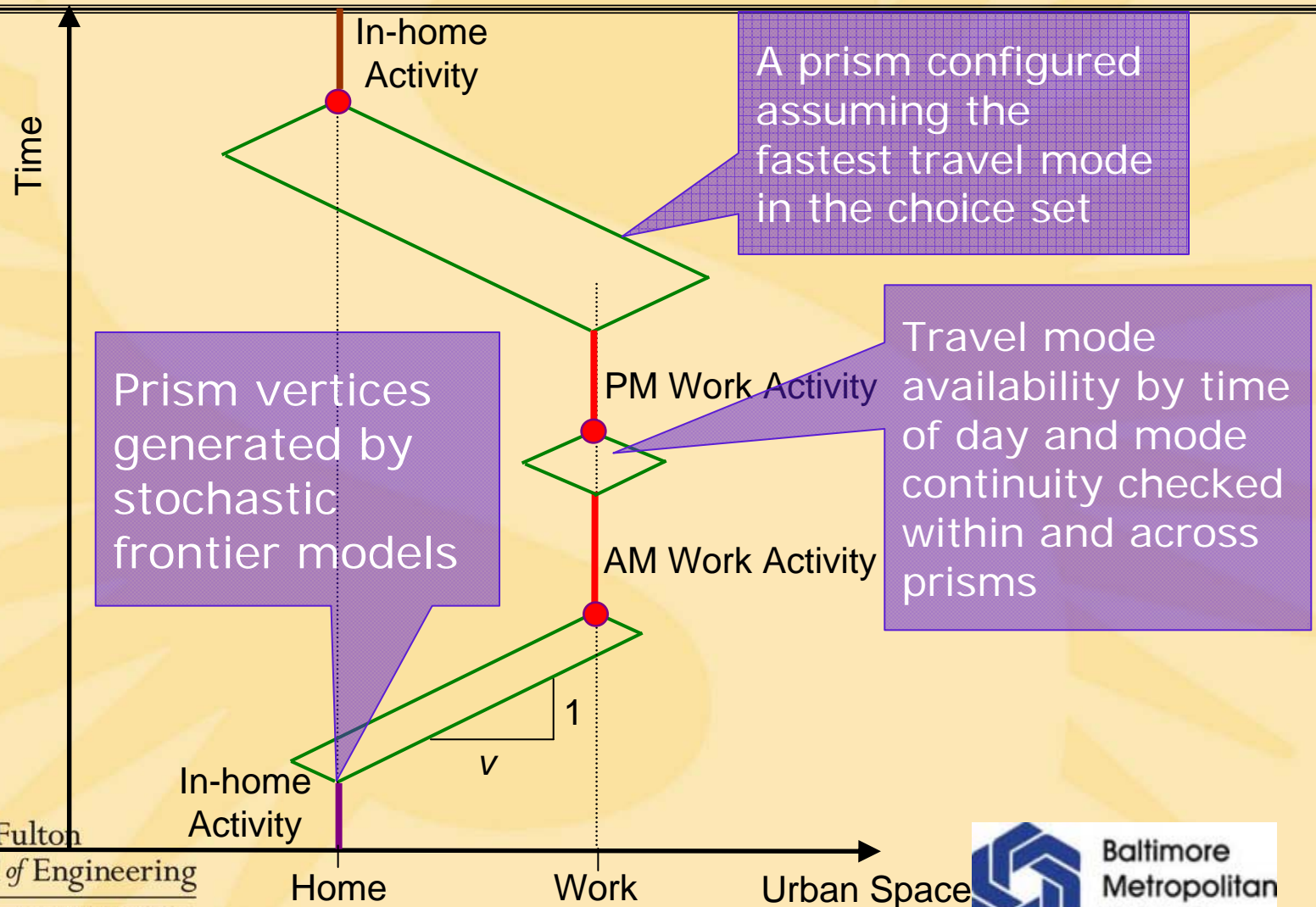




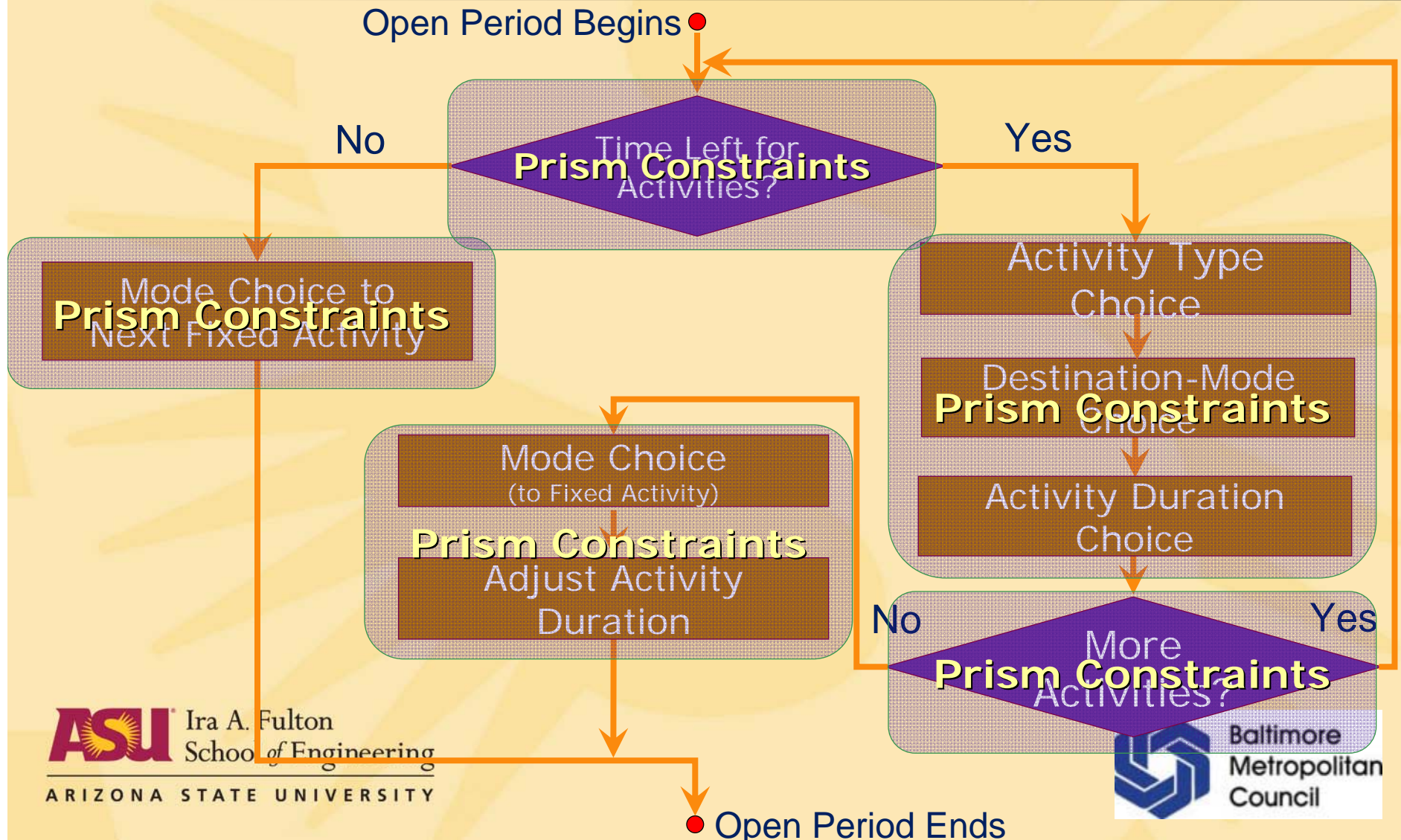
# PCATS Model Components

- Destination-Mode choice models
  - Nested logit models that assign a destination-mode pair to each activity within a prism
- Activity duration models
  - Split-population survival models that determine length of each activity while considering the prism size

# Representing Prism Constraints



# Activity Generation Process







# Integrate with Dynamic Traffic Simulator

- Maximize use of information from activity-based model system
  - Activities and trips generated along the continuous time axis
  - Load trips on the network as they are generated (at one-minute resolution)
  - Dynamic interface and concurrent execution, along the time axis, of the activity simulator and a network simulator
  - No post-processing of model outputs



# Integration with Traffic Simulator

## Decision Processor

Decision to engage  
in some activity

Determine  
destination and  
mode

Given arrival time,  
determine  
activity duration

Decision to engage  
in some activity

## Event Manager

Agent on  
*Process Waiting  
List*

Scanning Interval (1")

Activity duration

Agent on  
*Actor List*

## Traffic Simulator

Travel

Agent on  
*Traveler List*

*Time Axis*

Baltimore  
Metropolitan  
Council



# Enhancing Behavioral Realism

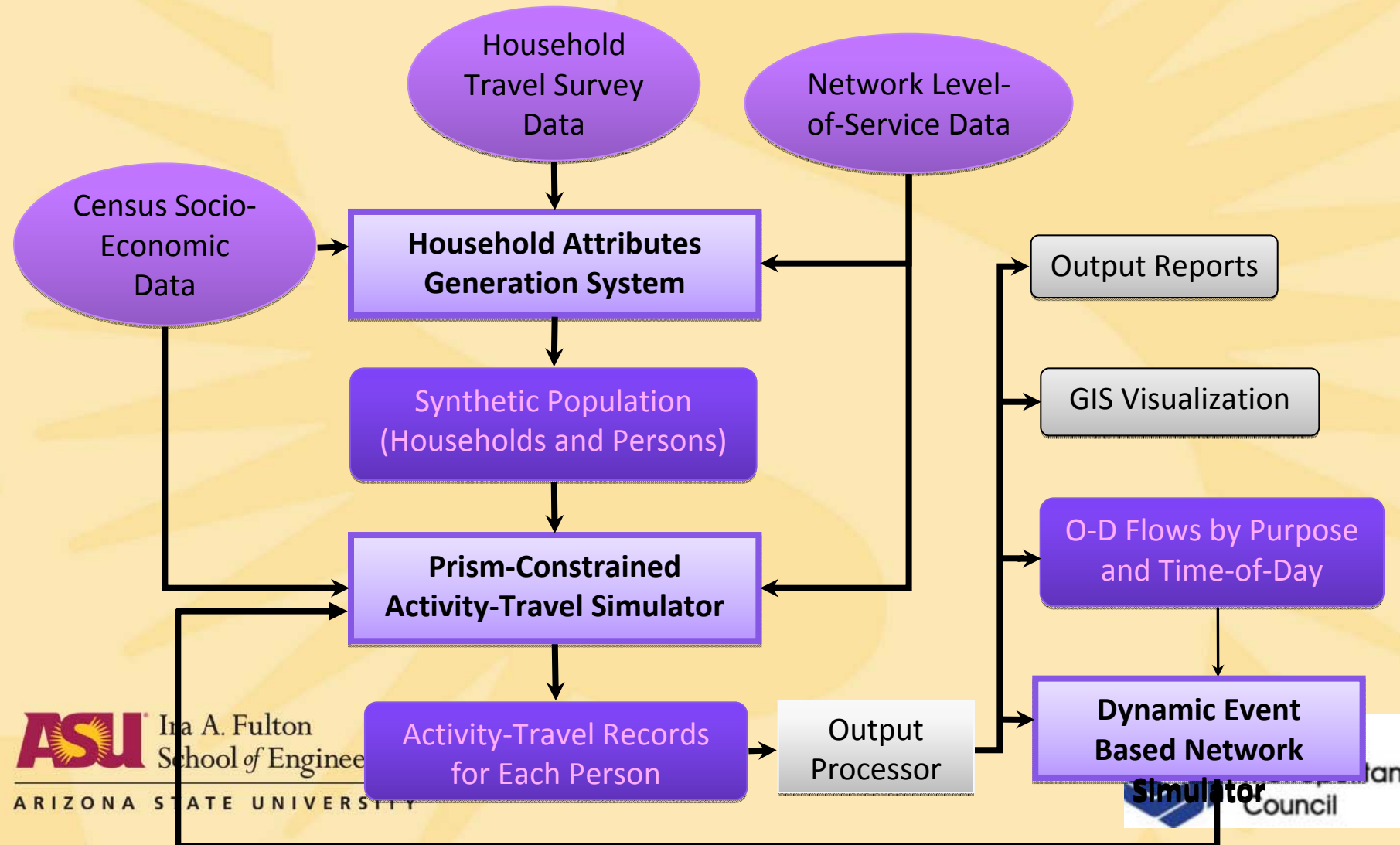
- Exact trip durations not known until trips are completed
- Need to consider issues of unmet mobility
  - An agent may be late for work, cannot finish errand, cannot return home, etc.
  - Prism constraints may not always be satisfied
  - Prism constraints increasingly fuzzy? (technology effects)



# Activity-Based Model Systems

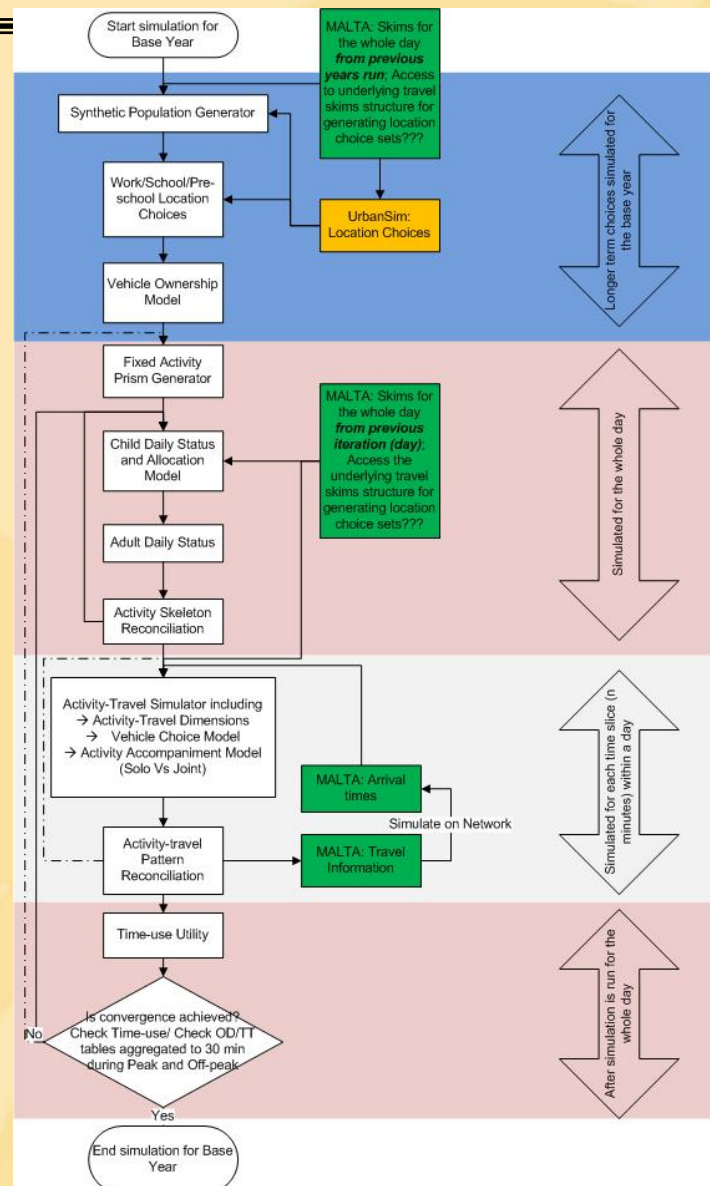
- Numerous activity-based model systems developed in research arena
- Models have matured to varying degrees
  - Attempt to incorporate aspects of behavior highlighted in presentation

# Activity-Mobility Simulator (AMOS, FAMOS)

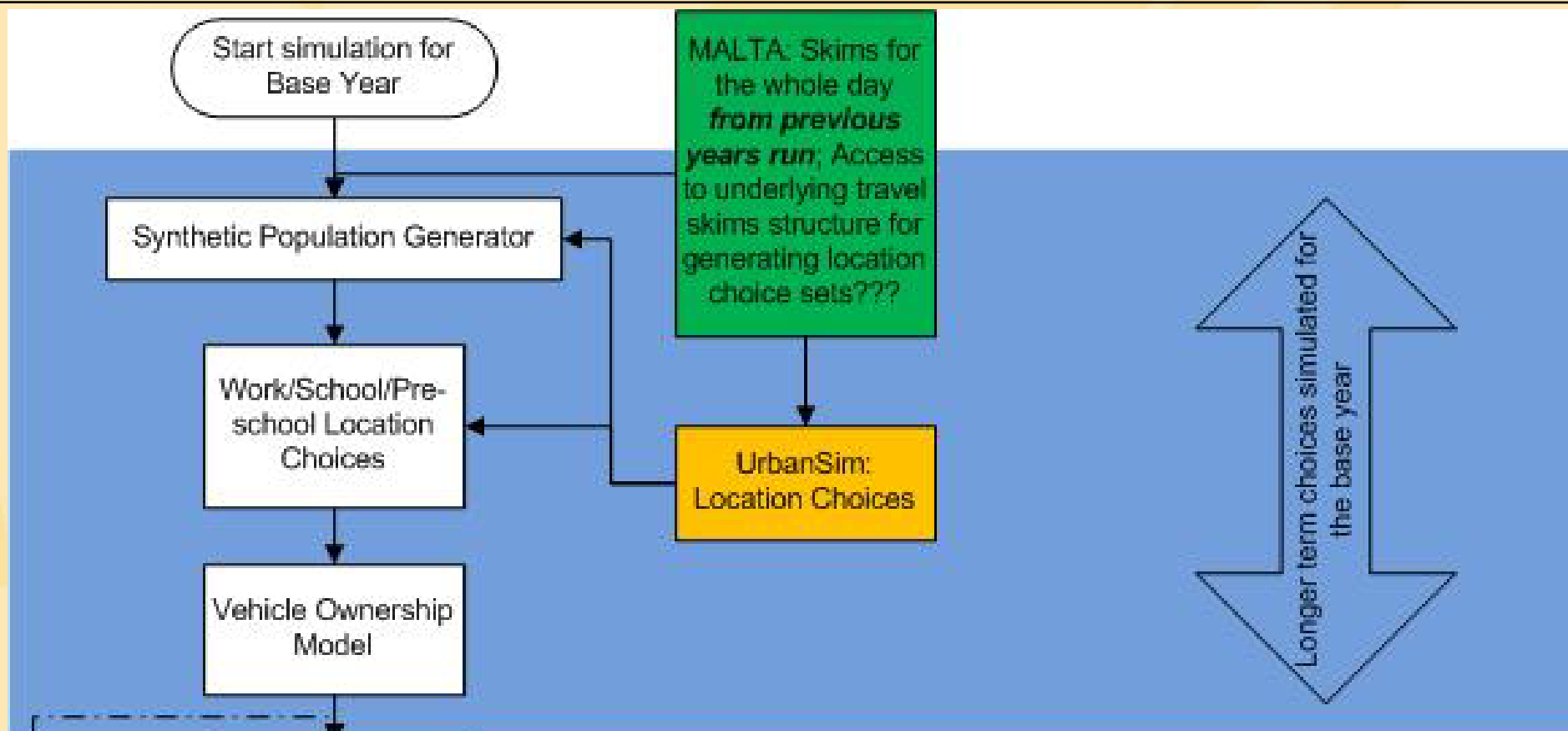




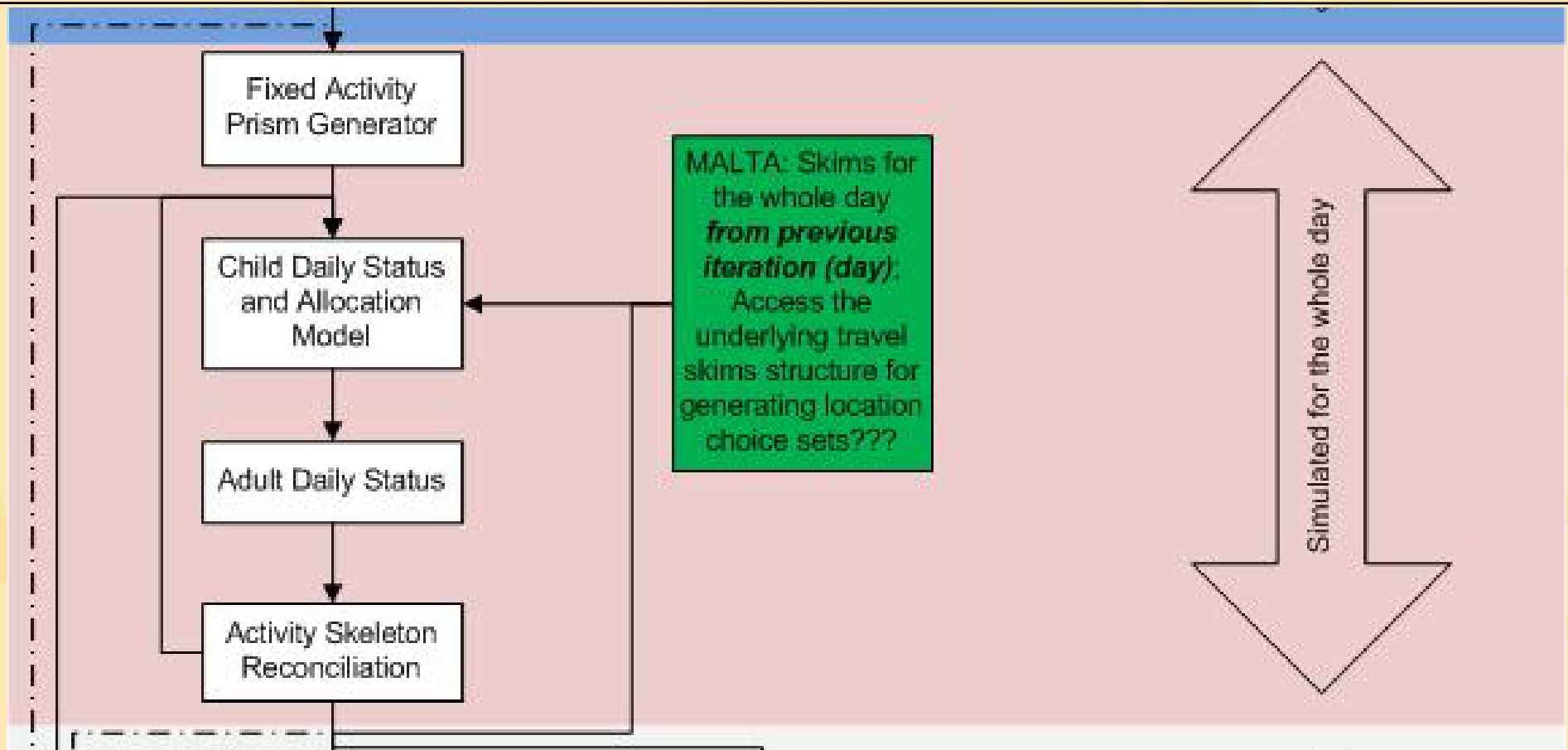
# Model Design: SimTRAVEL



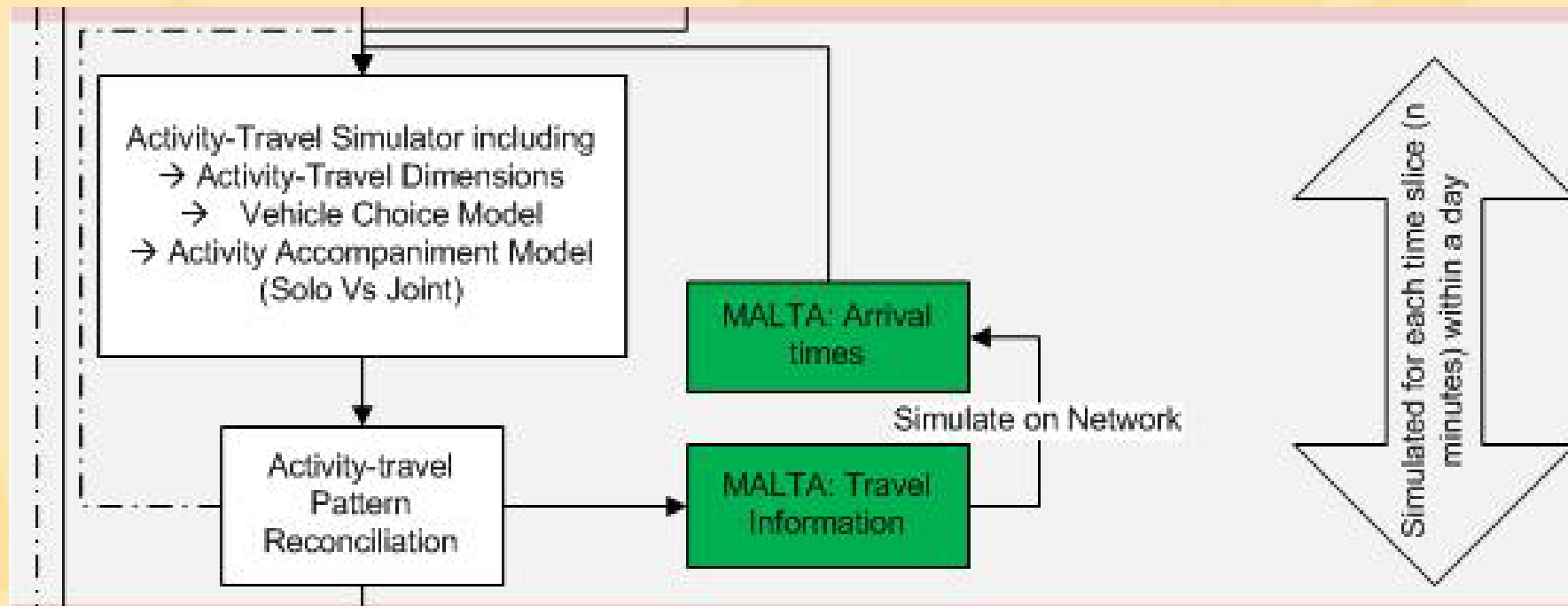
# Model Design



# Model Design



# Model Design

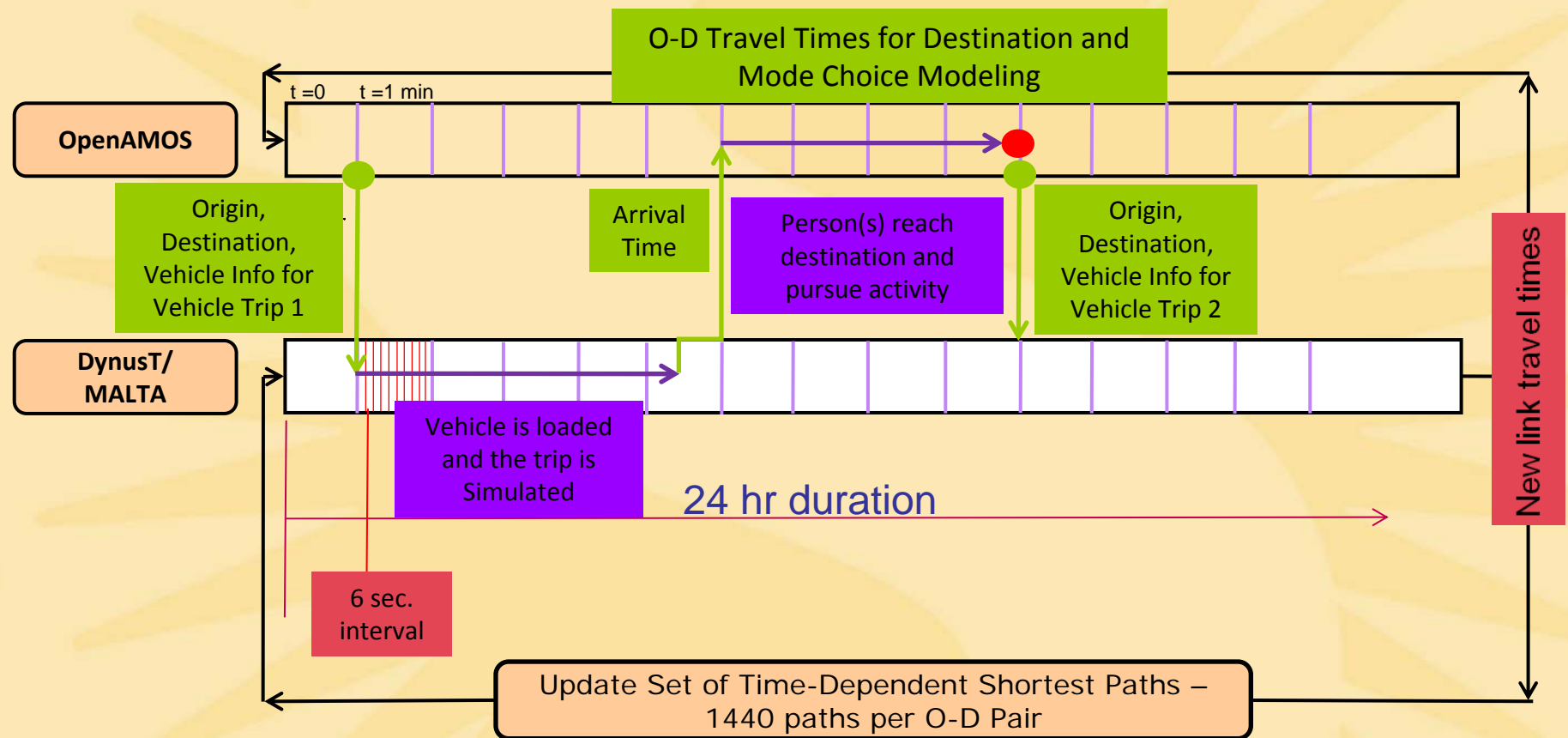


SimTRAVEL: Simulator of Transport, Routes, Activities, Vehicles, Emissions, and Land

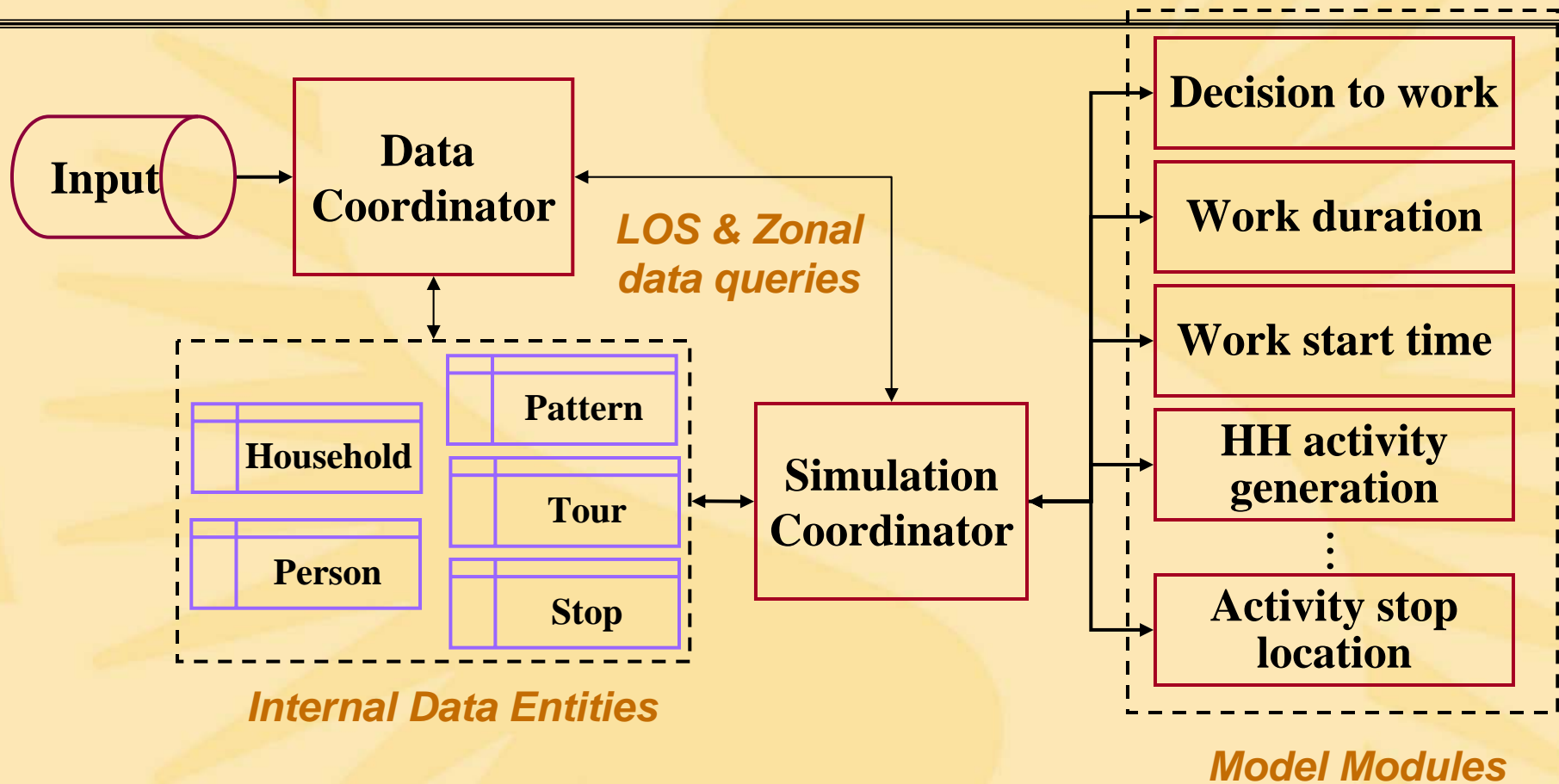
Funded by FHWA through Exploratory Advanced Research Program



# Integrated Model: Supply and Demand



# CEMDAP (Bhat)



# CEMDAP: Model Components

## Application of the Generation-Allocation Model System

Work and school activity participation and timing decisions



Children's travel needs and allocation of escort responsibilities to parents



Independent activity participation decisions



## Application of the Scheduling Model System

Work-to-home and home-to-work commute characteristics



Drop-off tour of the nonworker escorting children to school



Pick-up tour of the nonworker escorting children from school



School-to-home and home-to-school commutes



Joint tour of the adult pursuing discretionary activity with children



Independent home-based and work-based tours for each worker

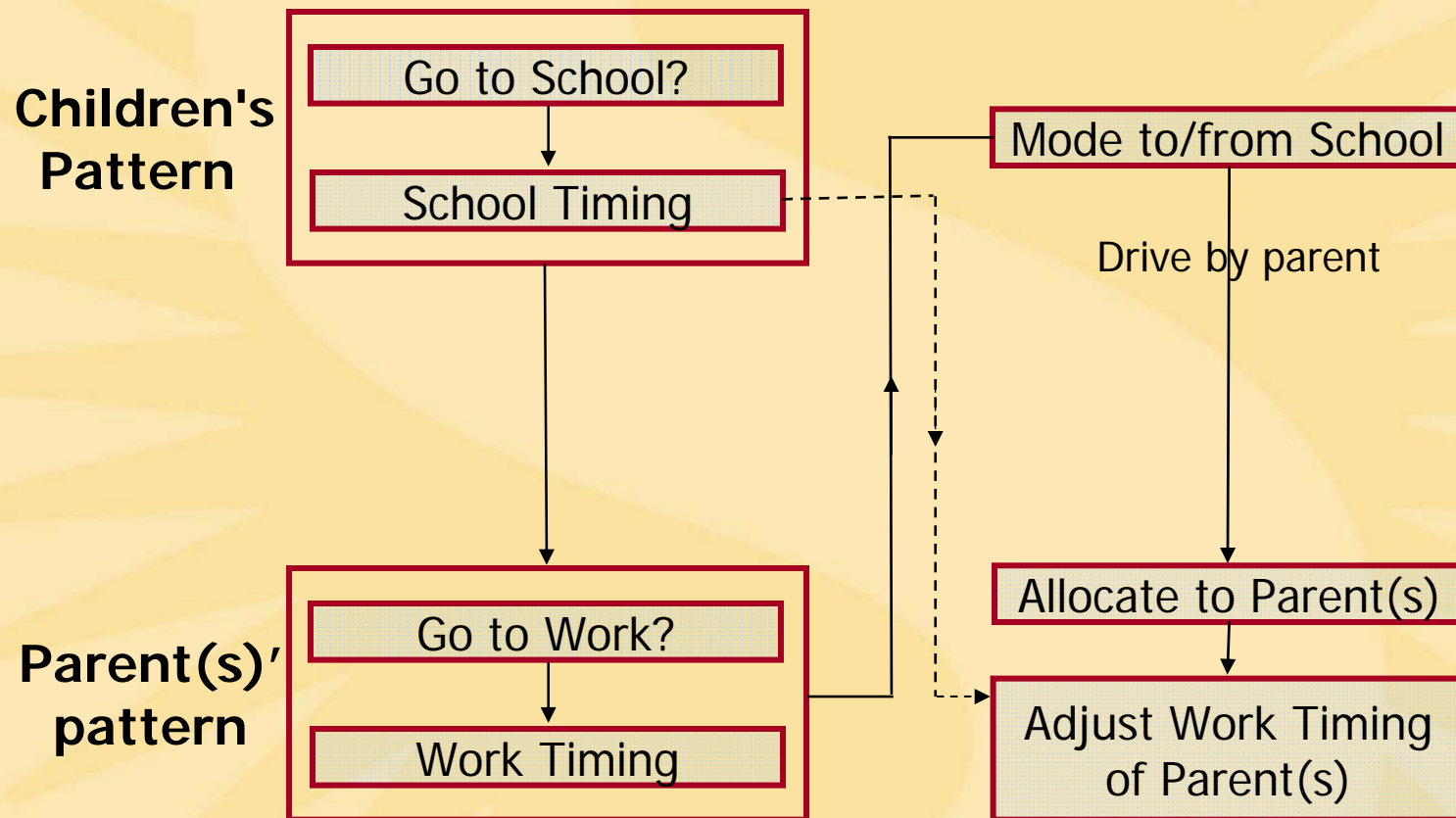


Independent home-based tours for each non-worker



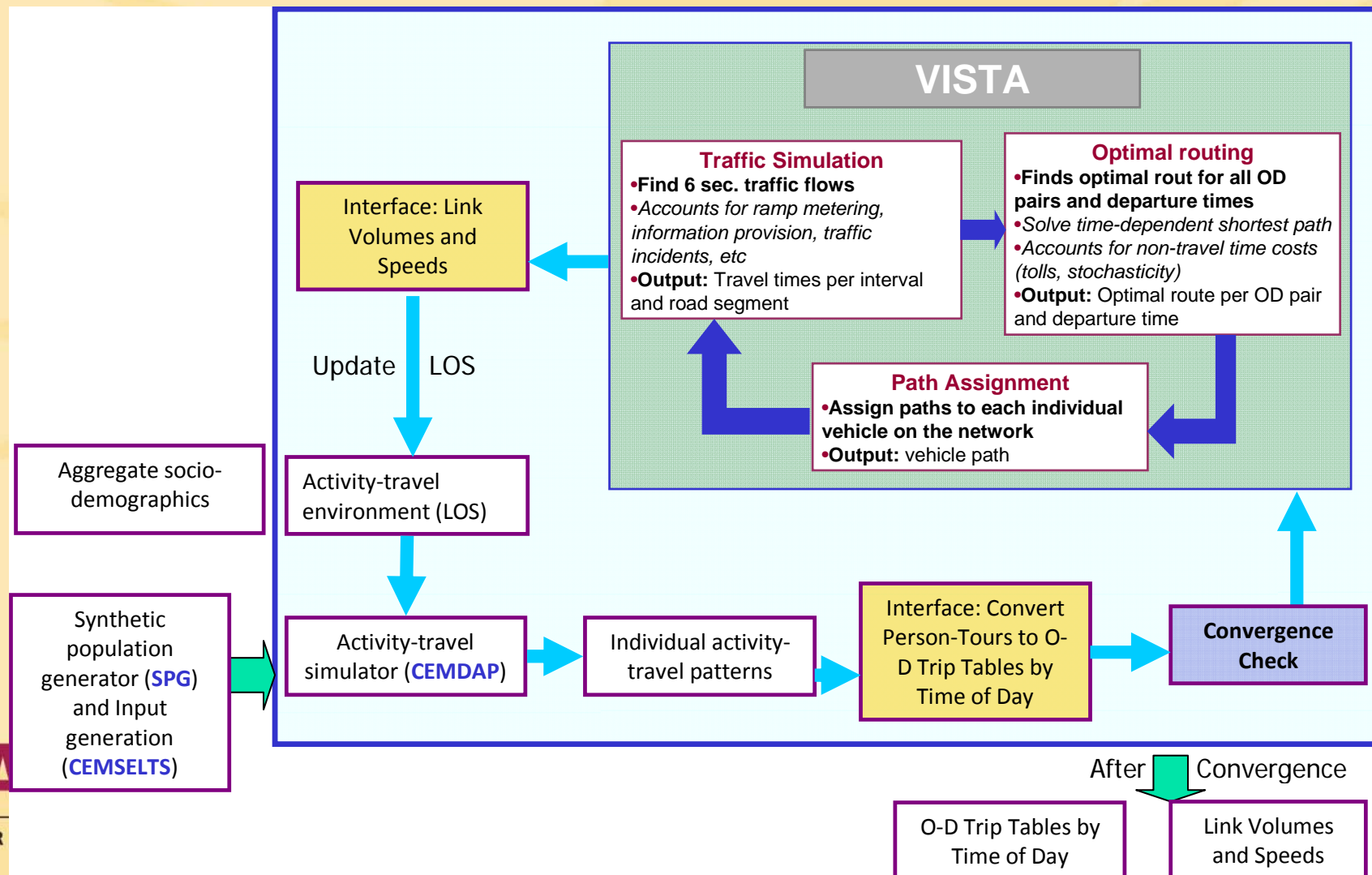
Independent discretionary activity tour for each child

# CEMDAP: Parent-Child Interaction





# Integrated Activity-Travel Demand and Dynamic Traffic Assignment Model System (CEMDAP-VISTA: Bhat/Waller)



# SimAGENT for SCAG

## ADAPTED CEMDAP MODEL

Forecasting (including demographics)

Networks & Attributes

Models/Zones & Attributes

Population in Zones (centroids)

Accessibility (aggregate)

External Trips

Airports & Ports

All Other (commercial)

Population Synthesis: PopGen

Long Term Choices

Daily Allocation

Daily Scheduling

Person Daily Tours-stops & trips

REPORT

Passenger & Highway and Transit

Origin – Destination Trip Interchange Matrices

Post Processor

Network Assignment

EMFAC





# SimAGENT

Simulator of Activities, Greenhouse Emissions, Networks, and Travel

- Address provisions/mandates of SB375
  - Requires metropolitan planning organizations (MPOs) to include sustainable communities strategies (SCS) for the purpose of reducing greenhouse gas emissions
- Address wide range of policies, e.g.:
  - Economic analysis: location-based welfare, wages, and exports
  - Equity analysis: change in welfare by household income class
  - Evaluate the energy use and GHGs produced by households and workers in building space
  - Comprehensively evaluate economic development impacts
  - Evaluate time-of-day roadway tolls

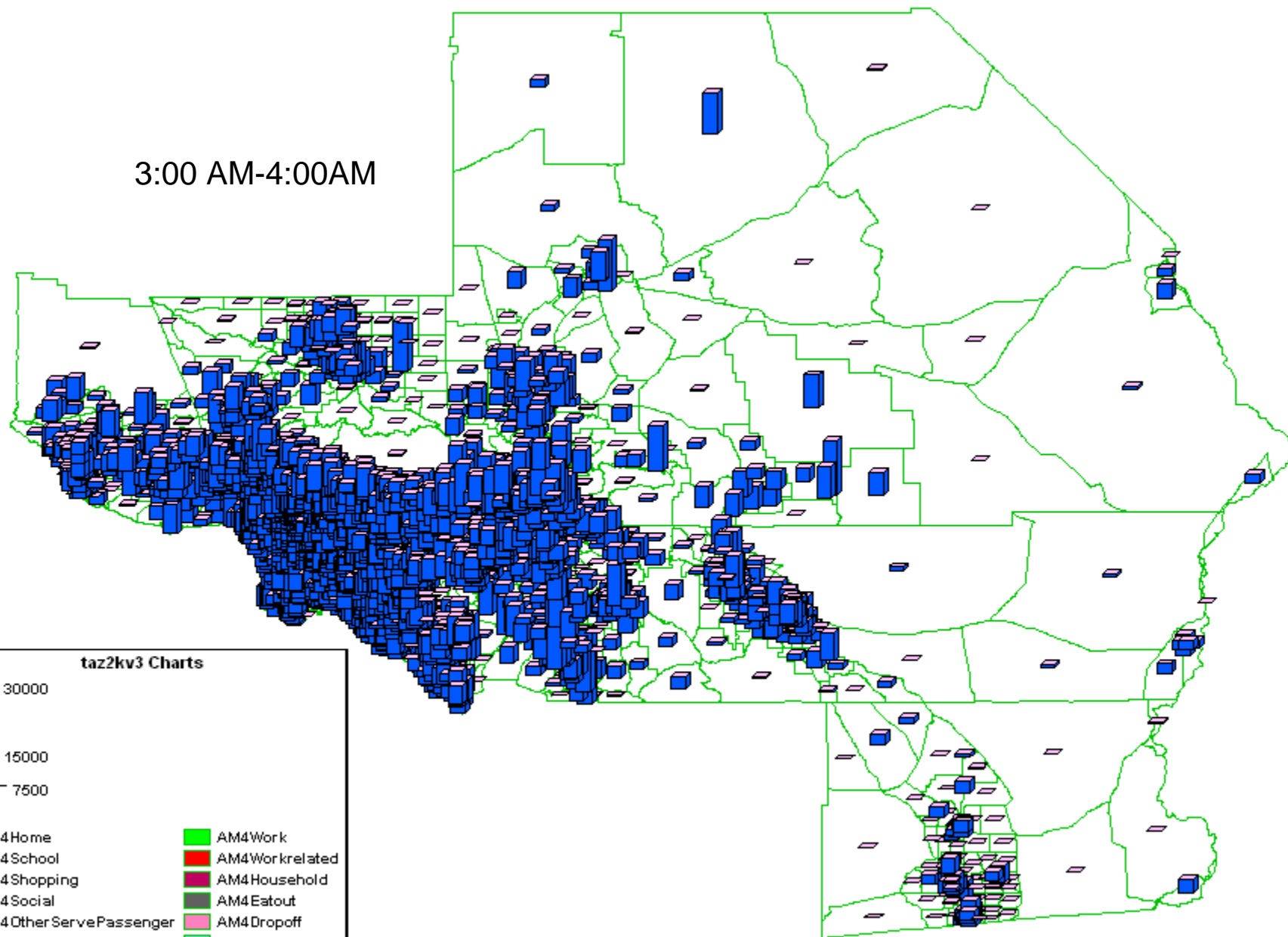


# SimAGENT Phased Implementation Plan for SCAG

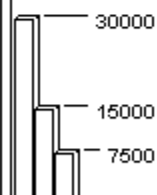
Phase	Title	Description
1	Model Development Plan and Strategy	Work closely with SCAG staff to finalize model development plan, model structure, model implementation path, and software and data requirements and specifications
2	Development and Implementation of SimAGENT Version 1	Adapt CEMDAP to SCAG region Add Synthetic Population Generator Compare to 2003 Trip-Based Model Extensive Validation and Sensitivity Testing Conduct Hands-on Staff Training Sessions Estimate GHG using EMFAC
3	Development and Implementation of SimAGENT Version 2	Enhanced CEMDAP Model Specifications More Detailed Spatial/Network Resolution Full Incorporation of Time-Space Concepts Extensive Validation and Sensitivity Testing
4	Training and Reports	Submission of Final Deliverables Conduct Hands-on Staff Training Sessions



3:00 AM-4:00AM



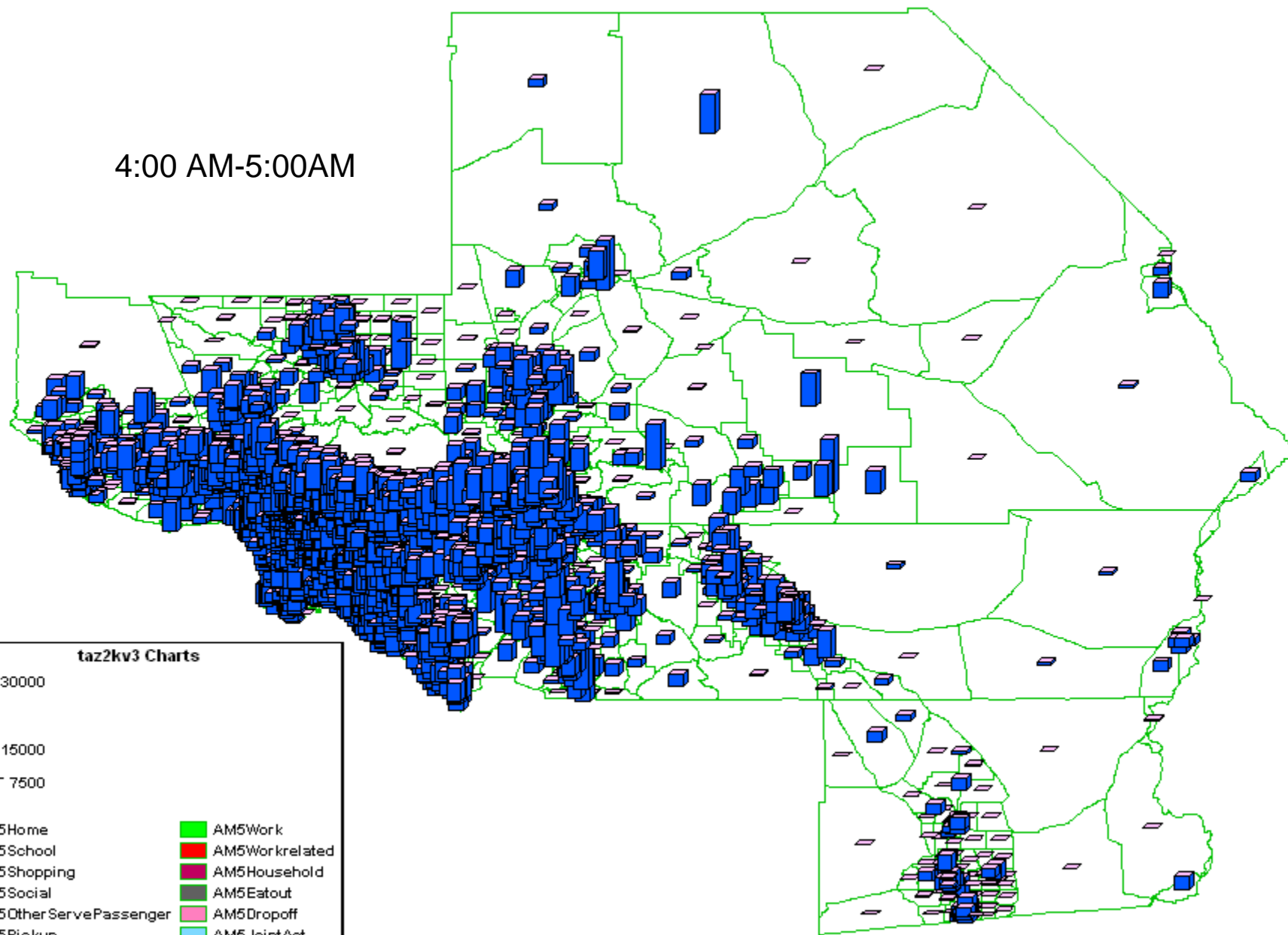
taz2kv3 Charts



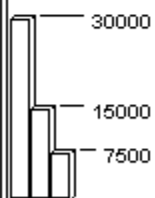
- |                        |                |
|------------------------|----------------|
| AM4Home                | AM4Work        |
| AM4School              | AM4Workrelated |
| AM4Shopping            | AM4Household   |
| AM4Social              | AM4Eatout      |
| AM4OtherServePassenger | AM4Dropoff     |
| AM4Pickup              | AM4JointAct    |
| AM4IndependentAct      |                |

0 15 30 45  
Miles

4:00 AM-5:00AM



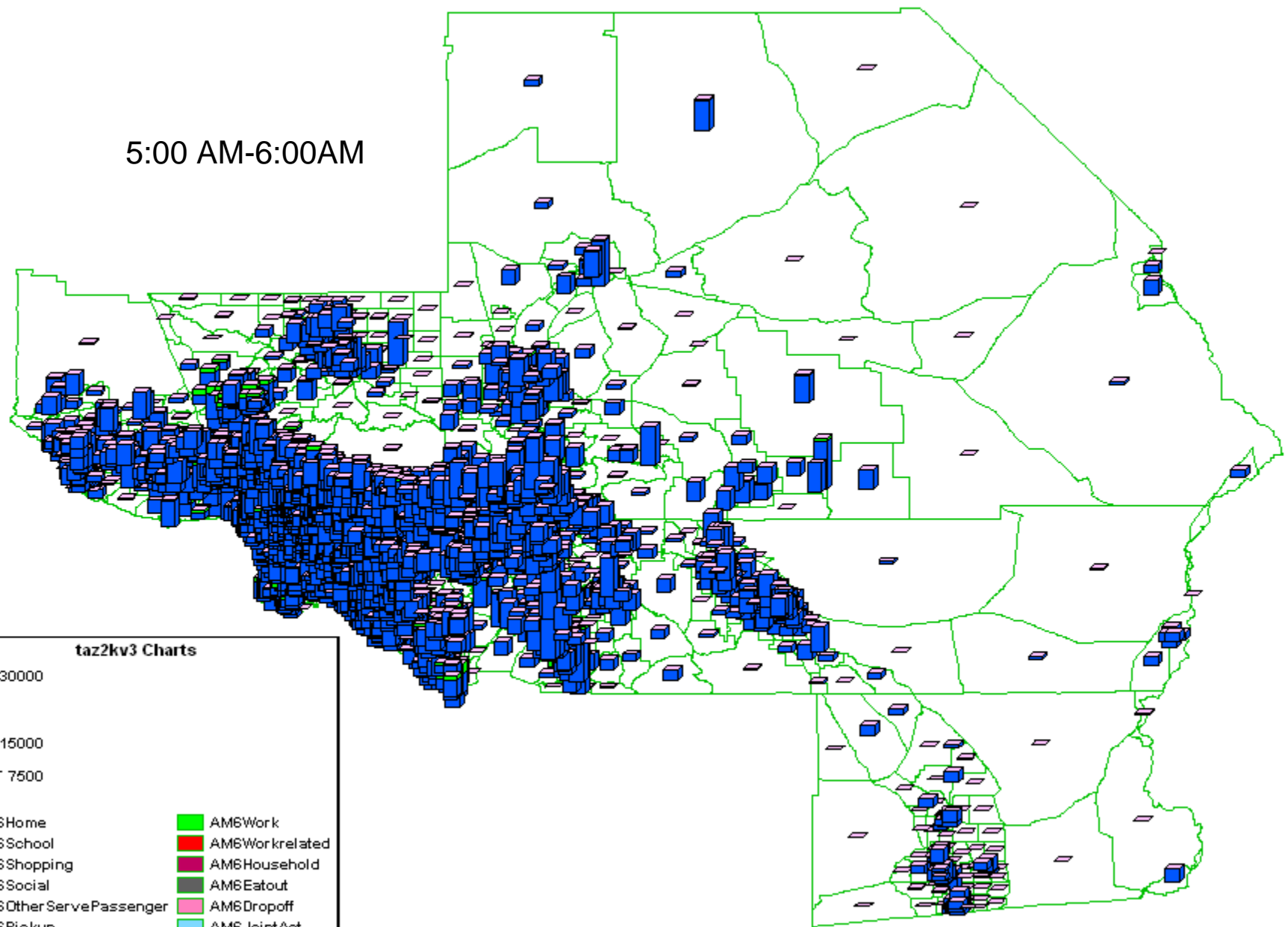
taz2kv3 Charts



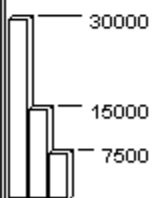
- |                        |                |
|------------------------|----------------|
| AM5Home                | AM5Work        |
| AM5School              | AM5Workrelated |
| AM5Shopping            | AM5Household   |
| AM5Social              | AM5Eatout      |
| AM5OtherServePassenger | AM5Dropoff     |
| AM5Pickup              | AM5JointAct    |
| AM5IndependentAct      |                |

0 15 30 45  
Miles

5:00 AM-6:00AM



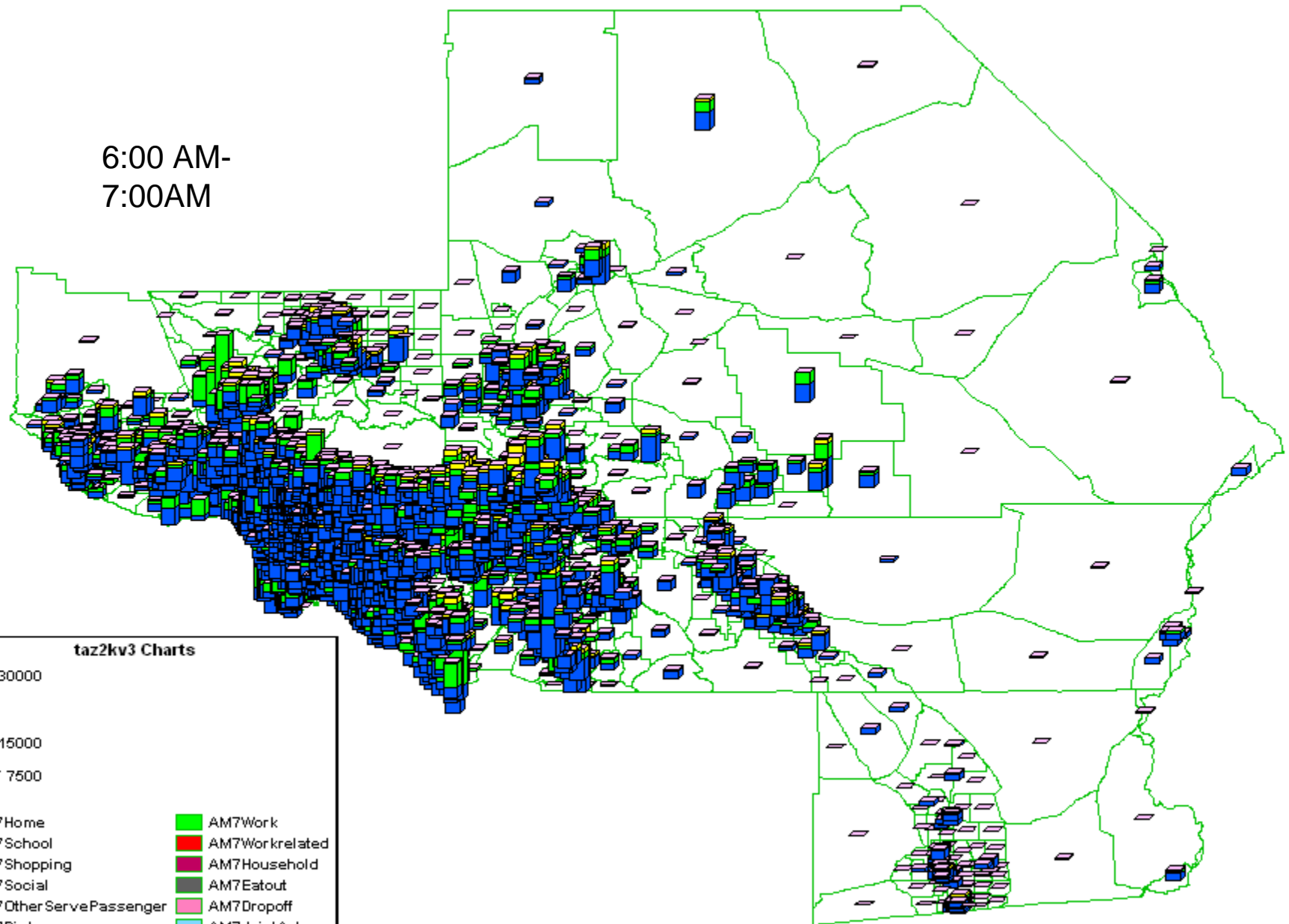
taz2kv3 Charts



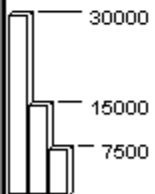
- |                         |                |
|-------------------------|----------------|
| AM6Home                 | AM6Work        |
| AM6School               | AM6Workrelated |
| AM6Shopping             | AM6Household   |
| AM6Social               | AM6Eatout      |
| AM6Other ServePassenger | AM6Dropoff     |
| AM6Pickup               | AM6JointAct    |
| AM6IndependentAct       |                |

0 15 30 45  
Miles

6:00 AM-  
7:00AM



taz2kv3 Charts

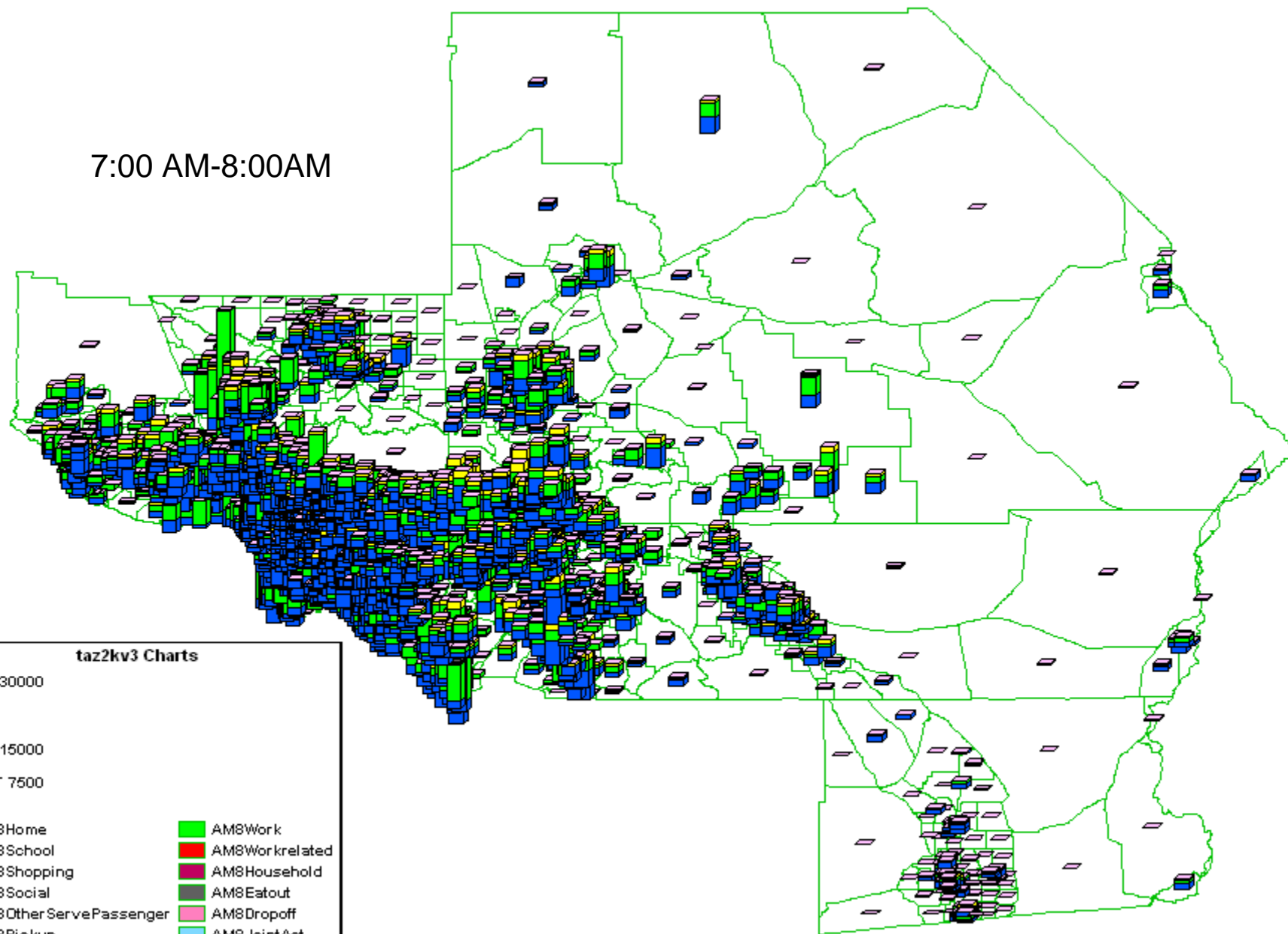


- |                        |                |
|------------------------|----------------|
| AM7Home                | AM7Work        |
| AM7School              | AM7Workrelated |
| AM7Shopping            | AM7Household   |
| AM7Social              | AM7Eatout      |
| AM7OtherServePassenger | AM7Dropoff     |
| AM7Pickup              | AM7JointAct    |
| AM7IndependentAct      |                |

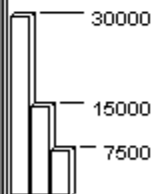
0 15 30 45  
Miles



7:00 AM-8:00AM



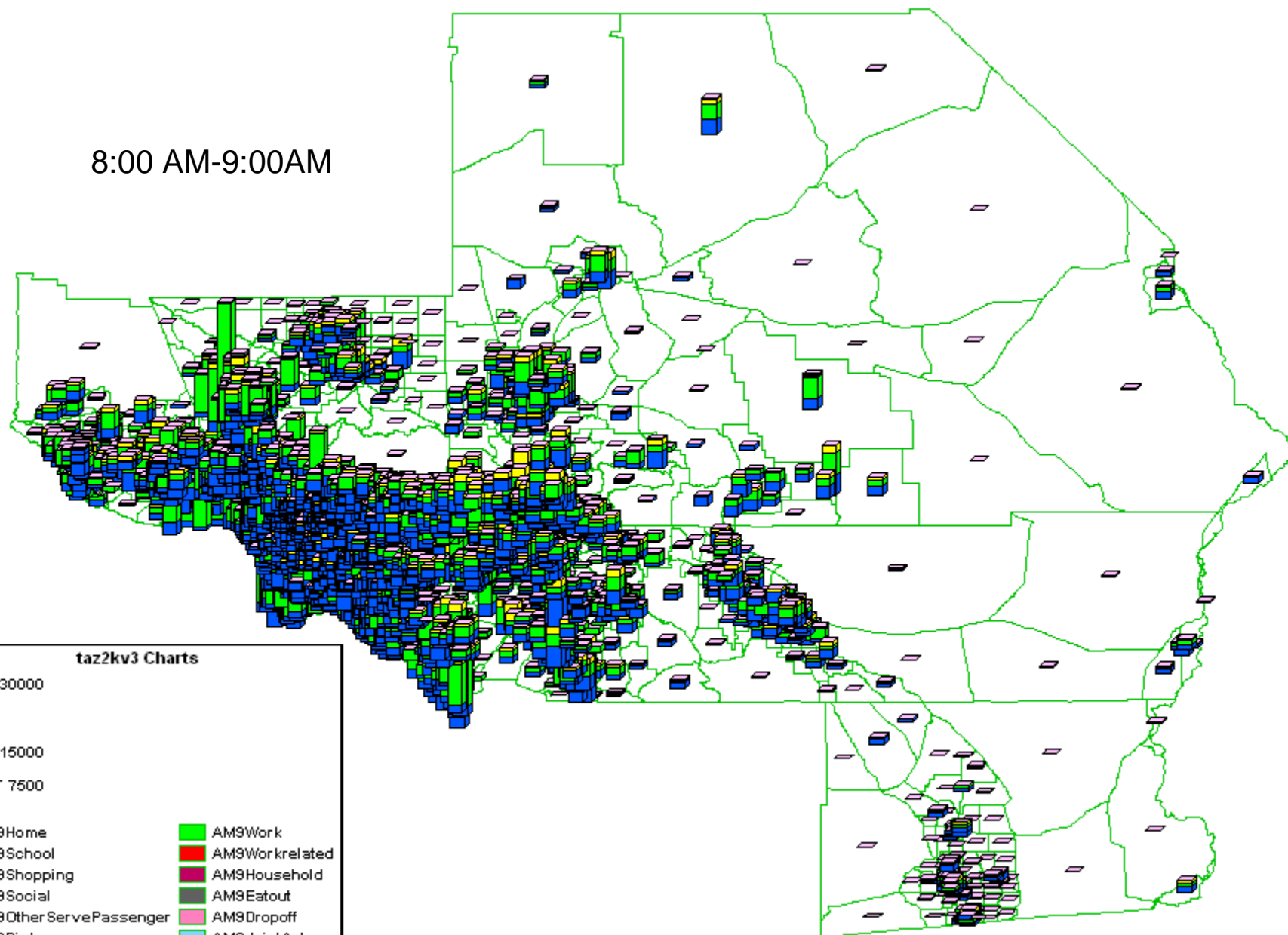
taz2kv3 Charts



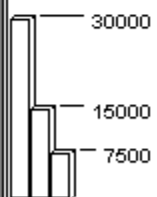
- |                          |                |
|--------------------------|----------------|
| AM8Home                  | AM8Work        |
| AM8School                | AM8Workrelated |
| AM8Shopping              | AM8Household   |
| AM8Social                | AM8Eatout      |
| AM8Other Serve Passenger | AM8Dropoff     |
| AM8Pickup                | AM8JointAct    |
| AM8IndependentAct        |                |

0 15 30 45  
Miles

8:00 AM-9:00AM



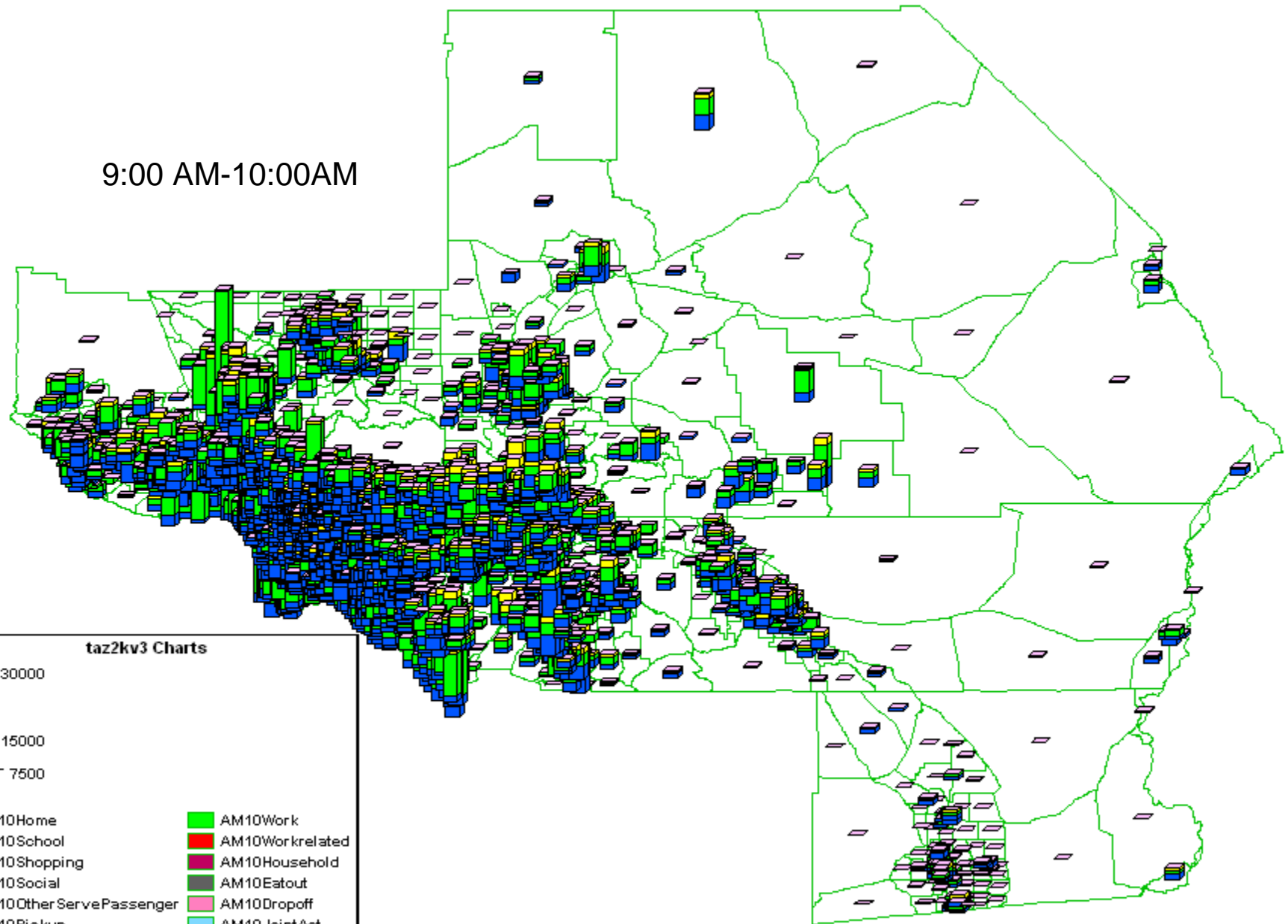
taz2kv3 Charts



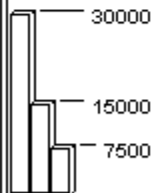
- |                         |                |
|-------------------------|----------------|
| AM9Home                 | AM9Work        |
| AM9School               | AM9Workrelated |
| AM9Shopping             | AM9Household   |
| AM9Social               | AM9Eatout      |
| AM9Other ServePassenger | AM9Dropoff     |
| AM9Pickup               | AM9JointAct    |
| AM9IndependentAct       |                |

0 15 30 45  
Miles

9:00 AM-10:00AM



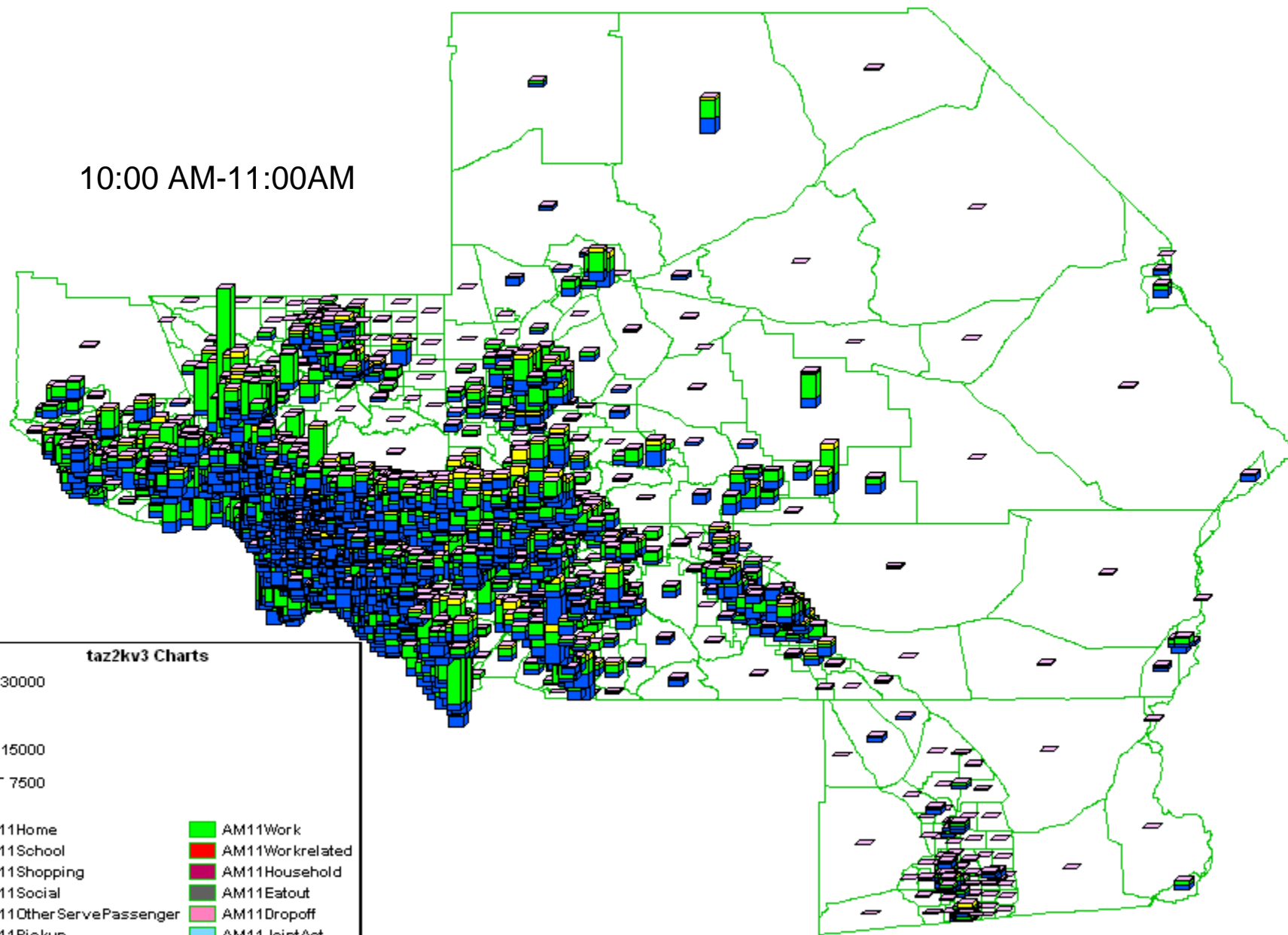
taz2kv3 Charts



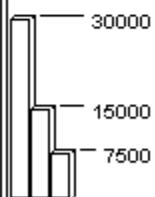
- |                         |                 |
|-------------------------|-----------------|
| AM10Home                | AM10Work        |
| AM10School              | AM10Workrelated |
| AM10Shopping            | AM10Household   |
| AM10Social              | AM10Eatout      |
| AM10OtherServePassenger | AM10Dropoff     |
| AM10Pickup              | AM10JointAct    |
| AM10IndependentAct      |                 |

0 15 30 45  
Miles

10:00 AM-11:00AM



taz2kv3 Charts

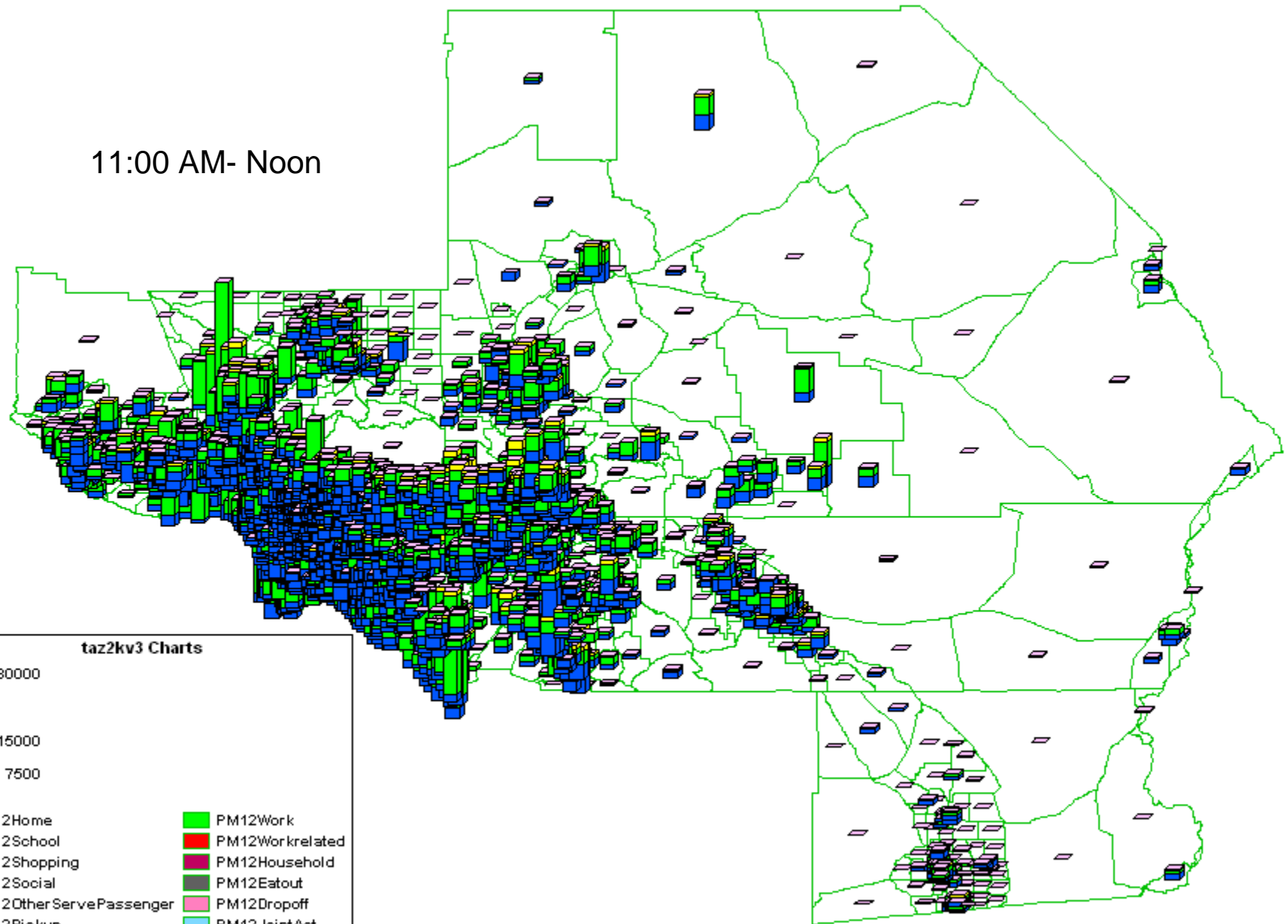


- |                         |                 |
|-------------------------|-----------------|
| AM11Home                | AM11Work        |
| AM11School              | AM11Workrelated |
| AM11Shopping            | AM11Household   |
| AM11Social              | AM11Eatout      |
| AM11OtherServePassenger | AM11Dropoff     |
| AM11Pickup              | AM11JointAct    |
| AM11IndependentAct      |                 |

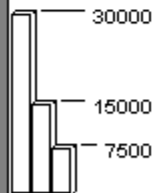
0 15 30 45  
Miles



11:00 AM- Noon



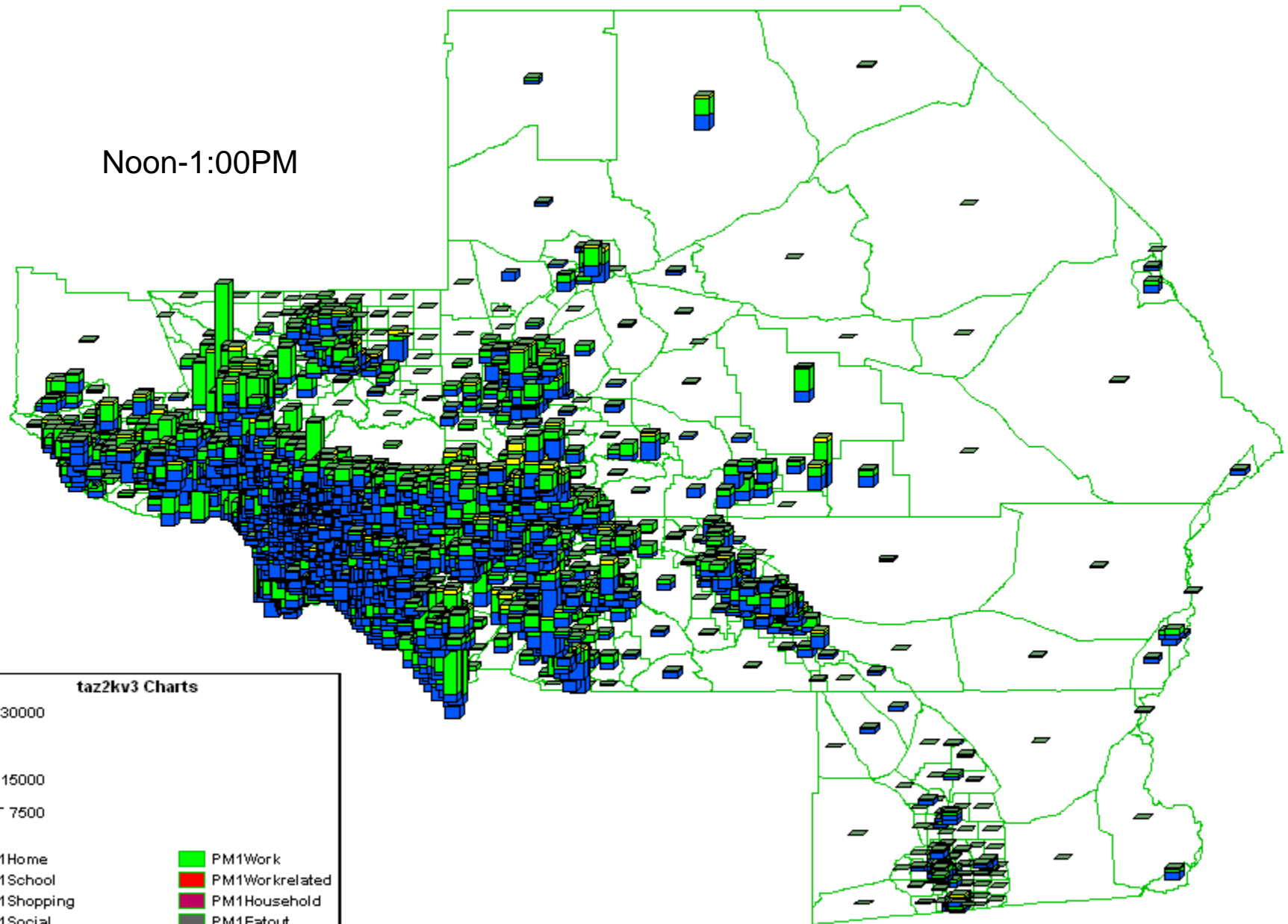
taz2kv3 Charts



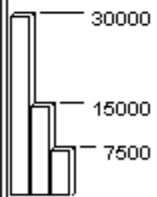
- |                          |                 |
|--------------------------|-----------------|
| PM12Home                 | PM12Work        |
| PM12School               | PM12Workrelated |
| PM12Shopping             | PM12Household   |
| PM12Social               | PM12Eatout      |
| PM12Other ServePassenger | PM12Dropoff     |
| PM12Pickup               | PM12JointAct    |
| PM12IndependentAct       |                 |

0 15 30 45  
Miles

Noon-1:00PM



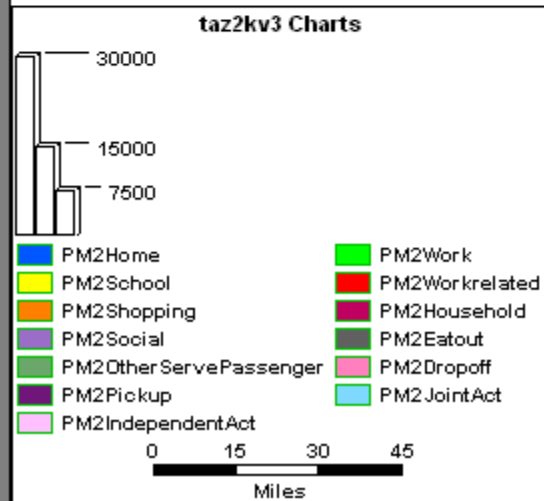
taz2kv3 Charts



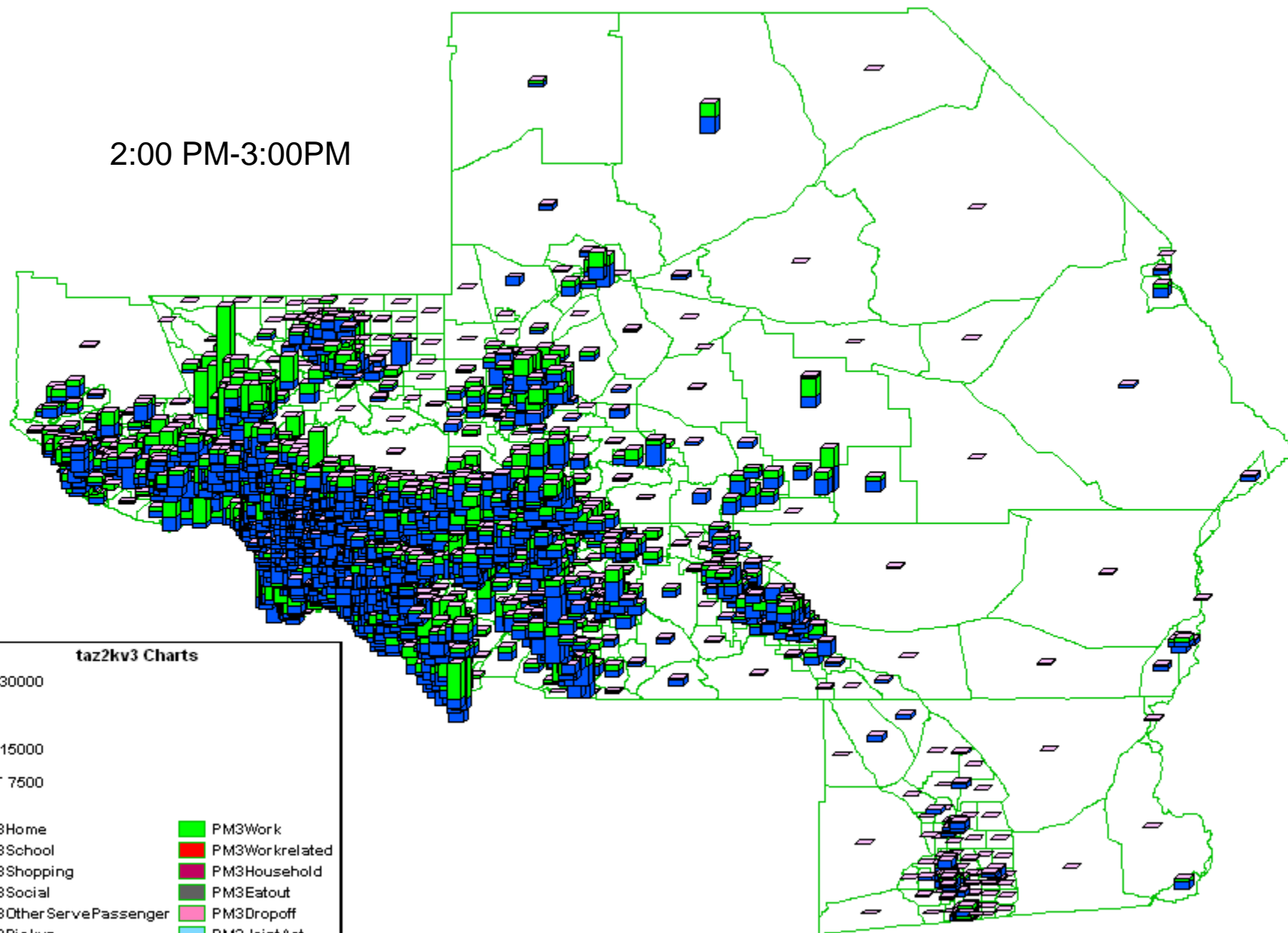
- |                        |                |
|------------------------|----------------|
| PM1Home                | PM1Work        |
| PM1School              | PM1Workrelated |
| PM1Shopping            | PM1Household   |
| PM1Social              | PM1Eatout      |
| PM1OtherServePassenger |                |

0 15 30 45  
Miles

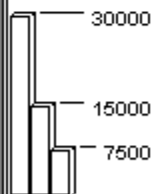
1:00 PM-2:00PM



2:00 PM-3:00PM



taz2kv3 Charts

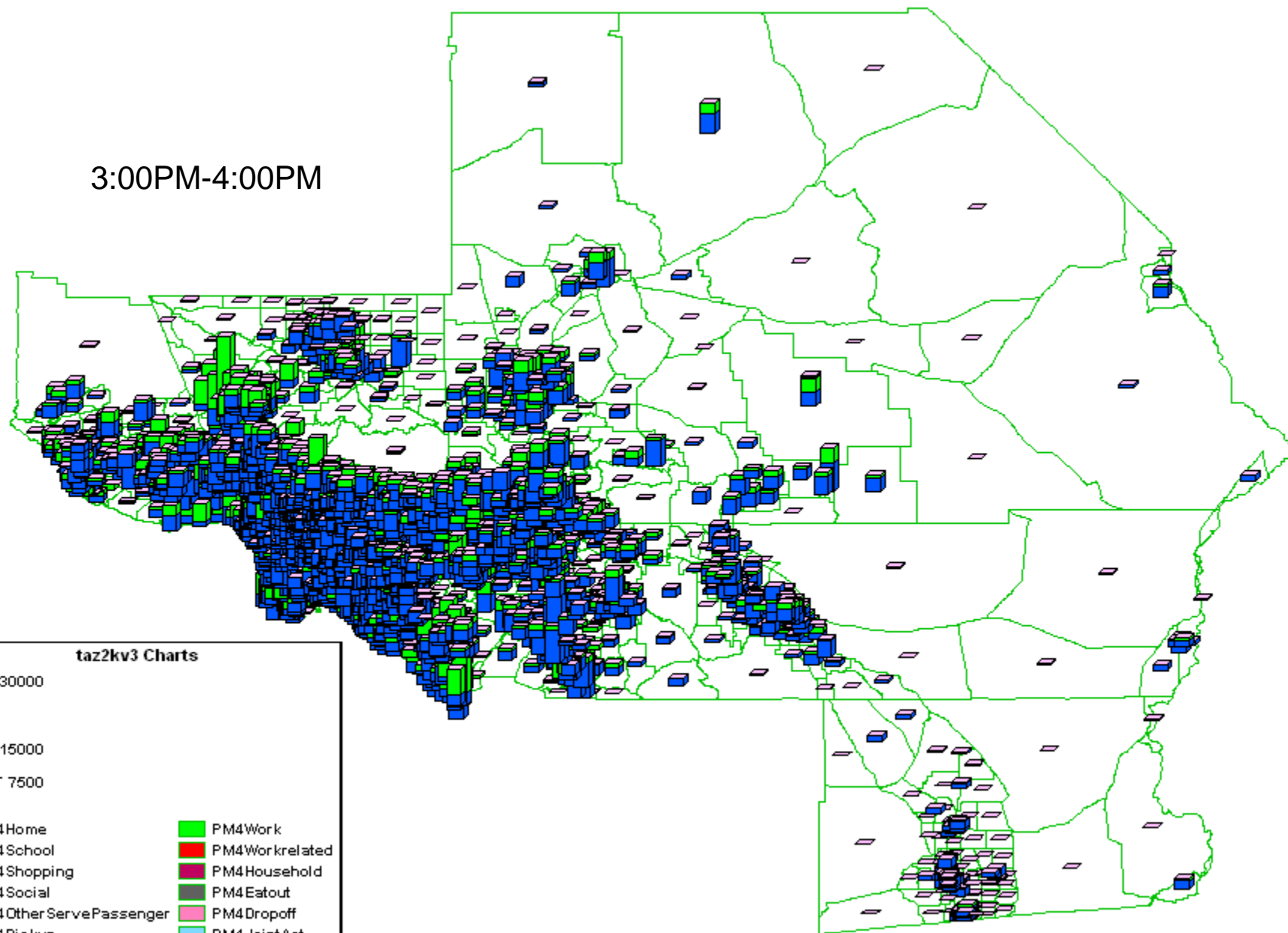


- |                         |                |
|-------------------------|----------------|
| PM3Home                 | PM3Work        |
| PM3School               | PM3Workrelated |
| PM3Shopping             | PM3Household   |
| PM3Social               | PM3Eatout      |
| PM3Other ServePassenger | PM3Dropoff     |
| PM3Pickup               | PM3JointAct    |
| PM3IndependentAct       |                |

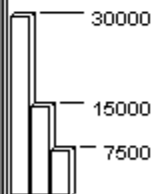
0 15 30 45  
Miles



3:00PM-4:00PM



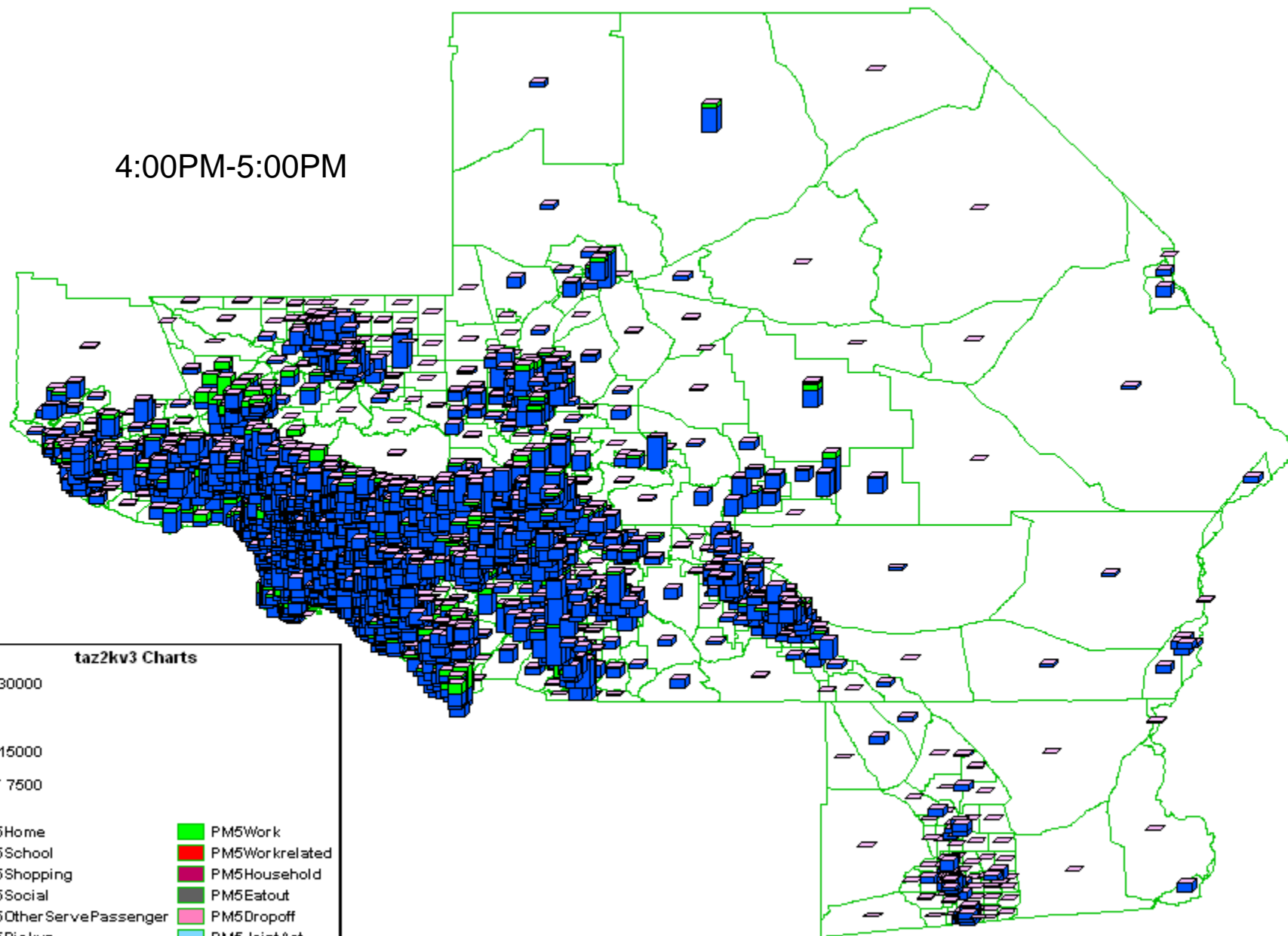
taz2kv3 Charts



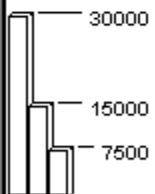
- |                        |                |
|------------------------|----------------|
| PM4Home                | PM4Work        |
| PM4School              | PM4Workrelated |
| PM4Shopping            | PM4Household   |
| PM4Social              | PM4Eatout      |
| PM4OtherServePassenger | PM4Dropoff     |
| PM4Pickup              | PM4JointAct    |
| PM4IndependentAct      |                |

0 15 30 45  
Miles

4:00PM-5:00PM



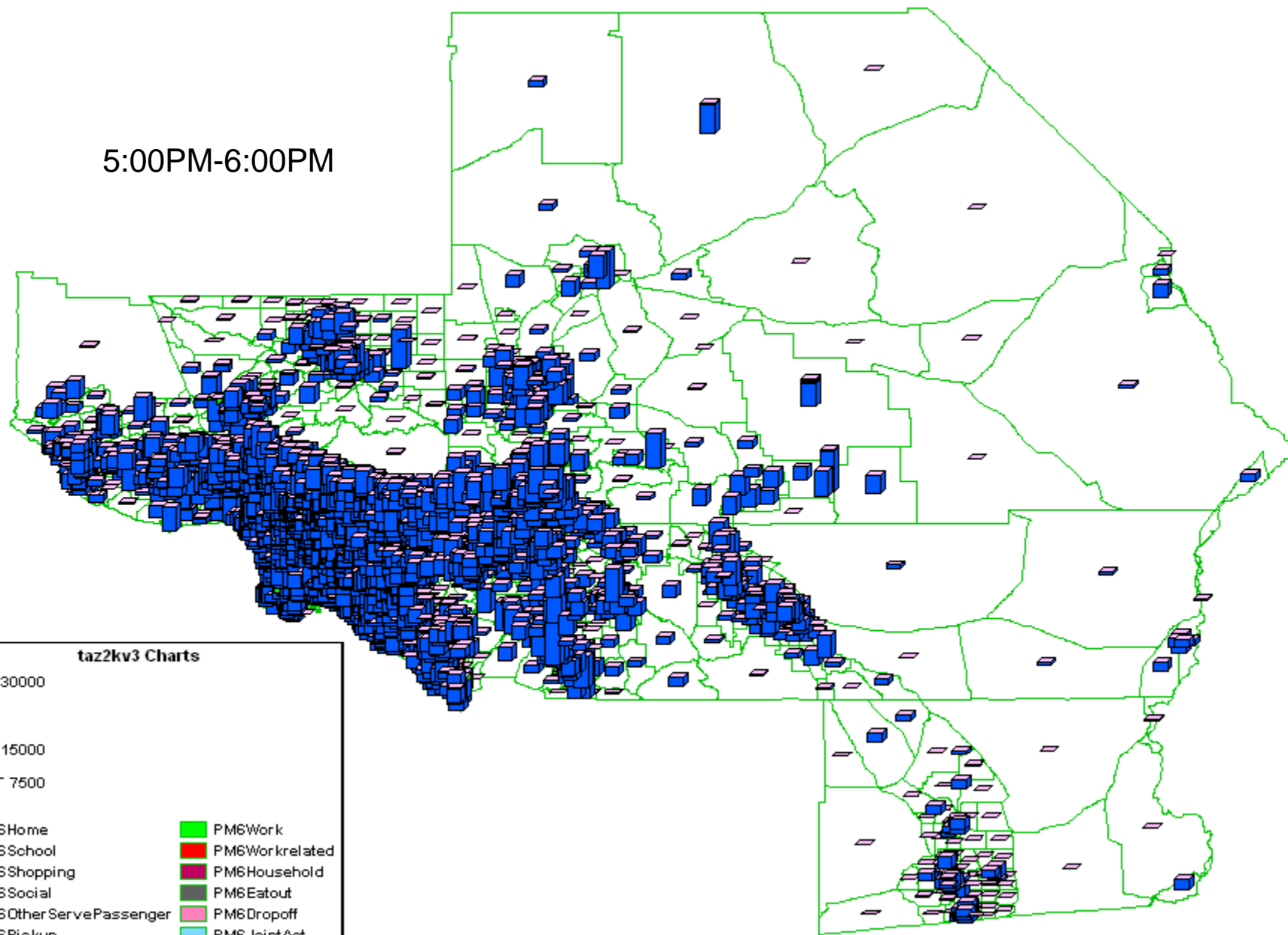
taz2kv3 Charts



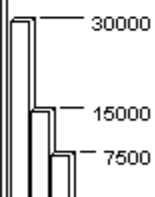
- |                        |                |
|------------------------|----------------|
| PM5Home                | PM5Work        |
| PM5School              | PM5Workrelated |
| PM5Shopping            | PM5Household   |
| PM5Social              | PM5Eatout      |
| PM5OtherServePassenger | PM5Dropoff     |
| PM5Pickup              | PM5JointAct    |
| PM5IndependentAct      |                |

0 15 30 45  
Miles

5:00PM-6:00PM



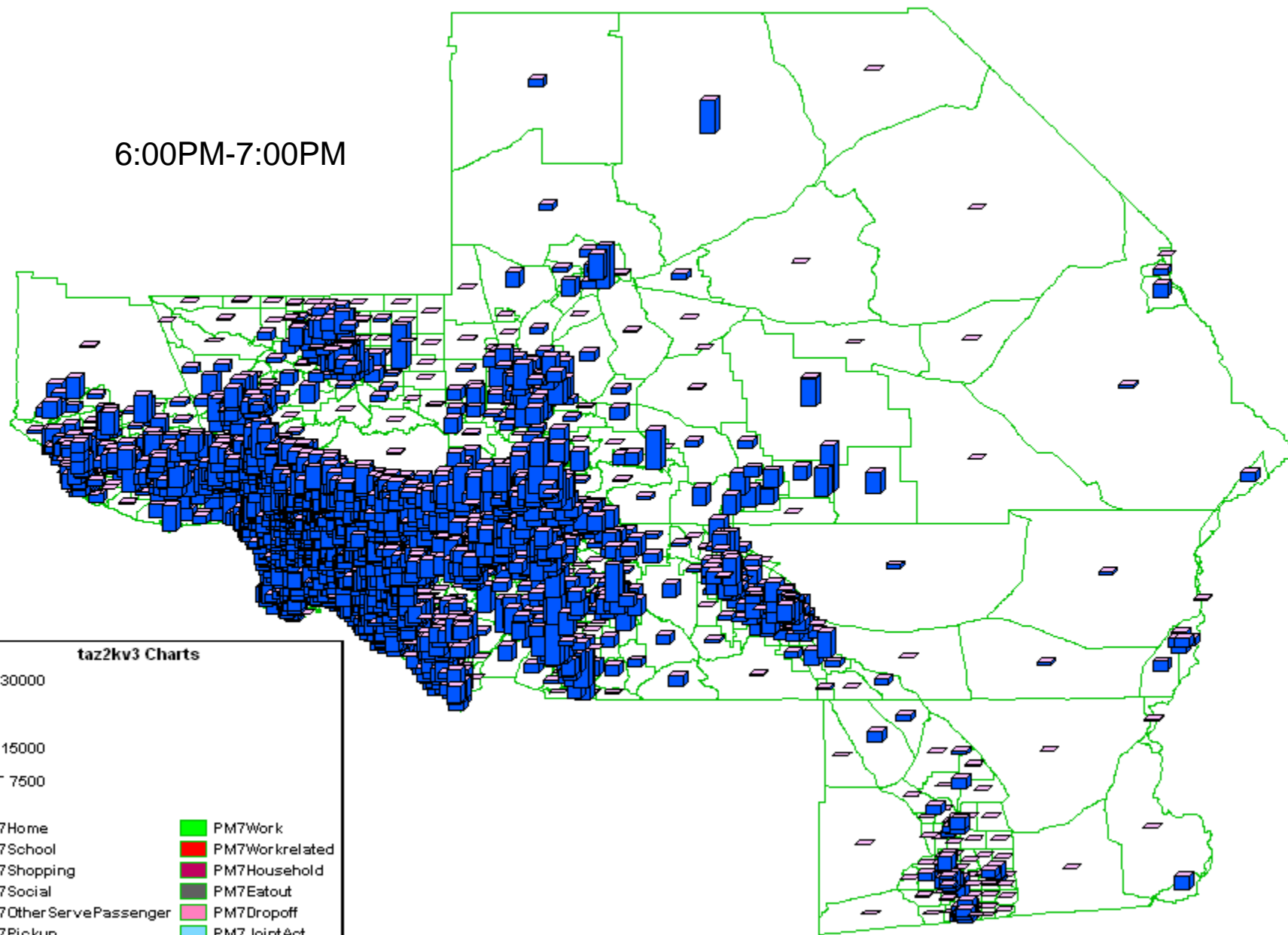
taz2kv3 Charts



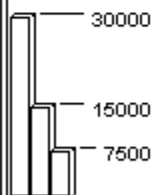
- |                        |                |
|------------------------|----------------|
| PM6Home                | PM6Work        |
| PM6School              | PM6Workrelated |
| PM6Shopping            | PM6Household   |
| PM6Social              | PM6Eatout      |
| PM6OtherServePassenger | PM6Dropoff     |
| PM6Pickup              | PM6JointAct    |
| PM6IndependentAct      |                |

0 15 30 45  
Miles

6:00PM-7:00PM



taz2kv3 Charts

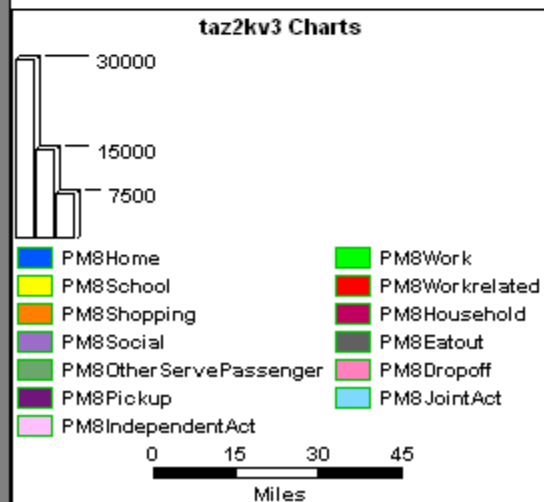


- |                        |                |
|------------------------|----------------|
| PM7Home                | PM7Work        |
| PM7School              | PM7Workrelated |
| PM7Shopping            | PM7Household   |
| PM7Social              | PM7Eatout      |
| PM7OtherServePassenger | PM7Dropoff     |
| PM7Pickup              | PM7JointAct    |
| PM7IndependentAct      |                |

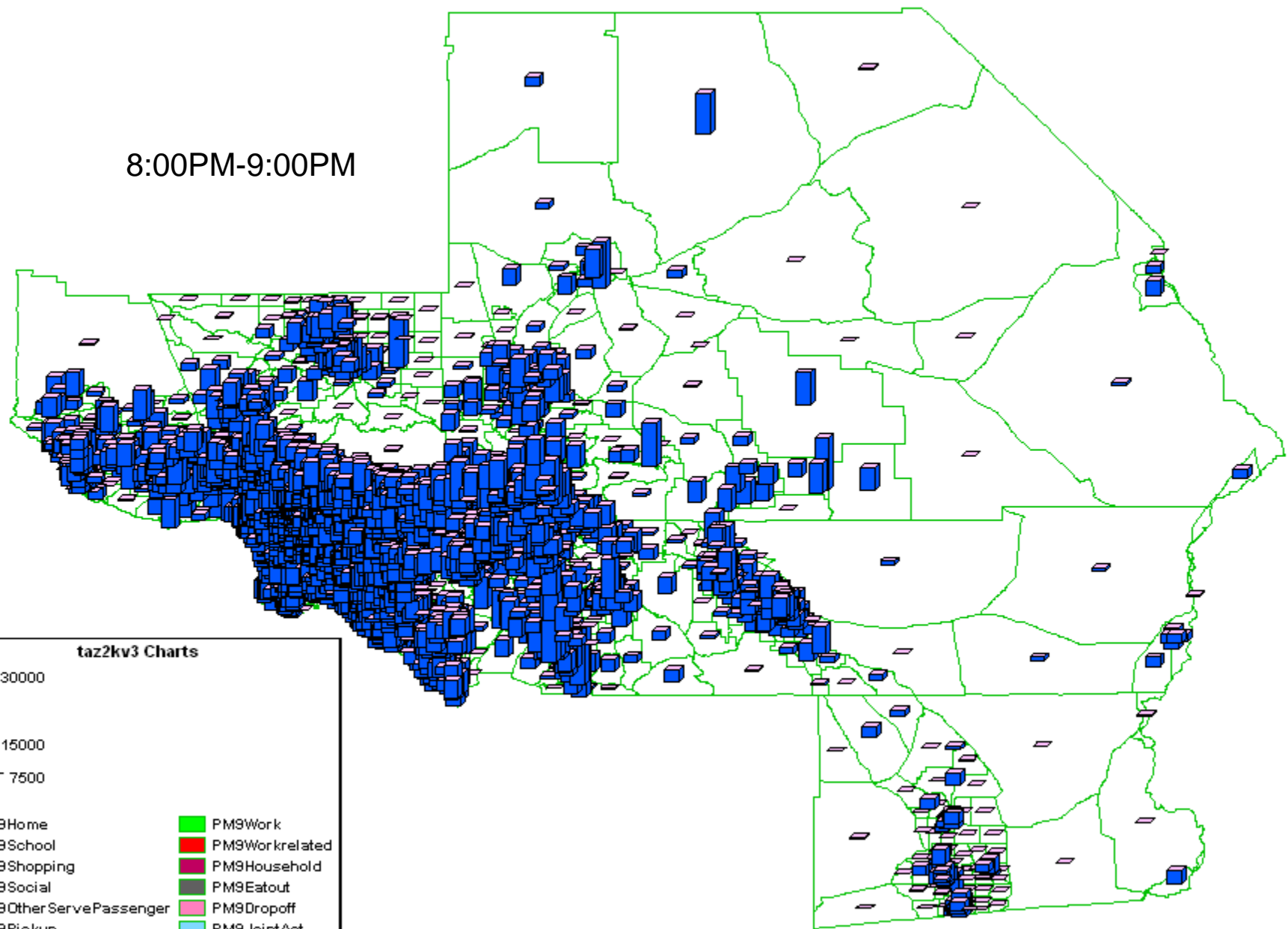
0 15 30 45  
Miles



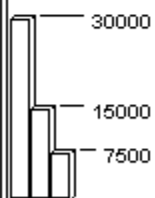
7:00PM-8:00PM



8:00PM-9:00PM



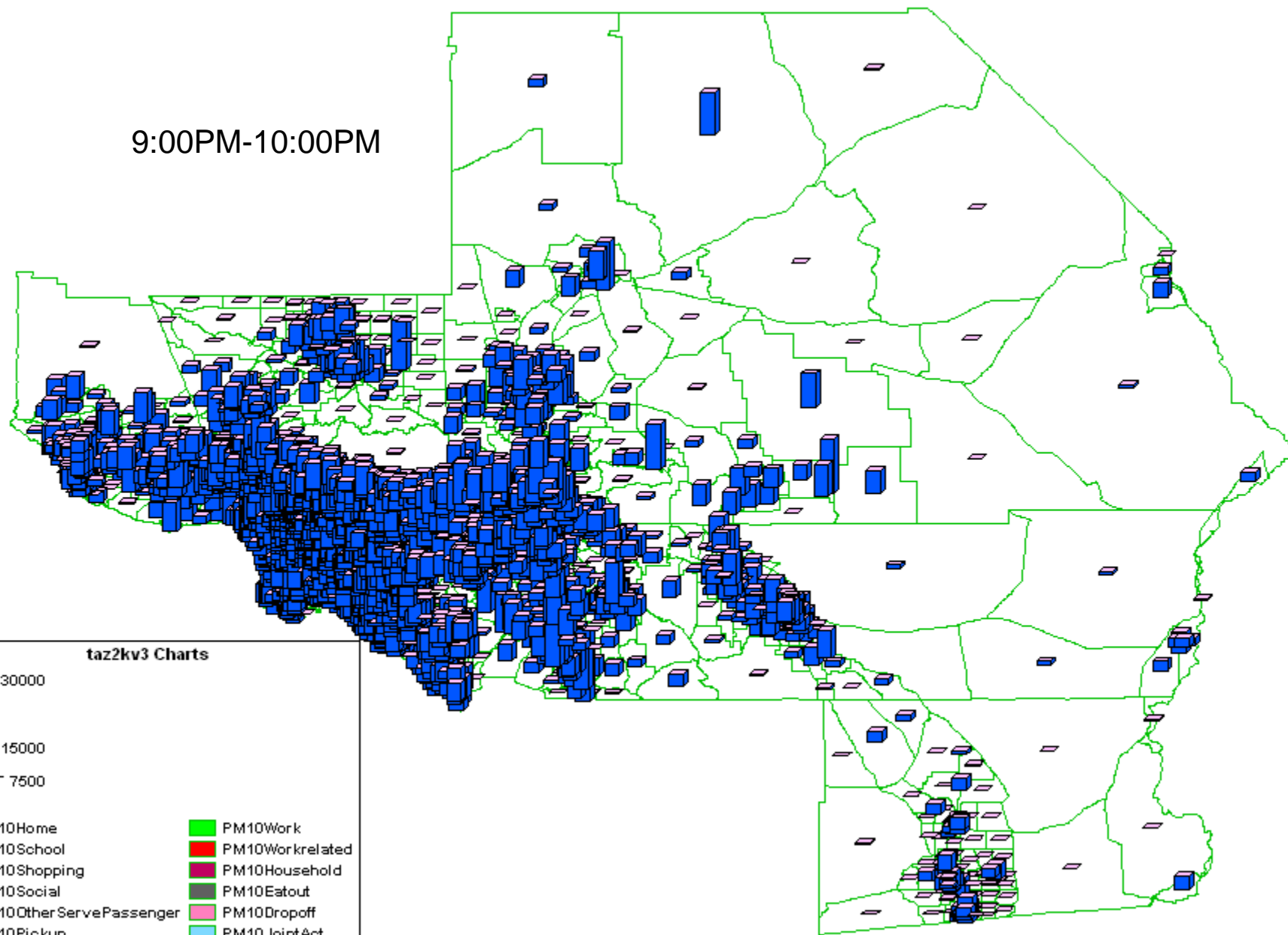
taz2kv3 Charts



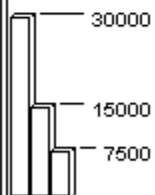
- PM9Home
- PM9School
- PM9Shopping
- PM9Social
- PM9OtherServePassenger
- PM9Pickup
- PM9IndependentAct
- PM9Work
- PM9Workrelated
- PM9Household
- PM9Eatout
- PM9Dropoff
- PM9JointAct

0 15 30 45  
Miles

9:00PM-10:00PM



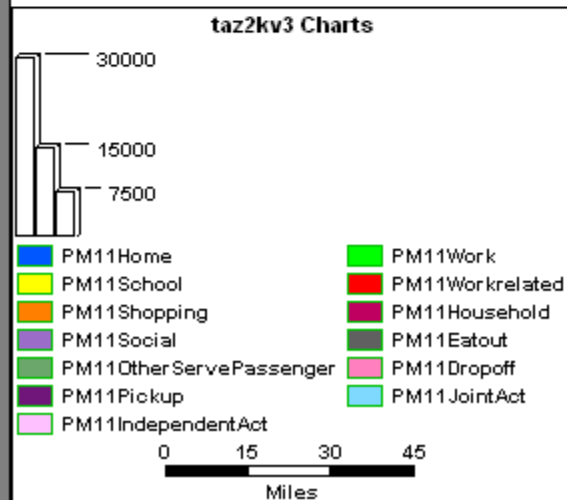
taz2kv3 Charts



- |                         |                 |
|-------------------------|-----------------|
| PM10Home                | PM10Work        |
| PM10School              | PM10Workrelated |
| PM10Shopping            | PM10Household   |
| PM10Social              | PM10Eatout      |
| PM10OtherServePassenger | PM10Dropoff     |
| PM10Pickup              | PM10JointAct    |
| PM10IndependentAct      |                 |

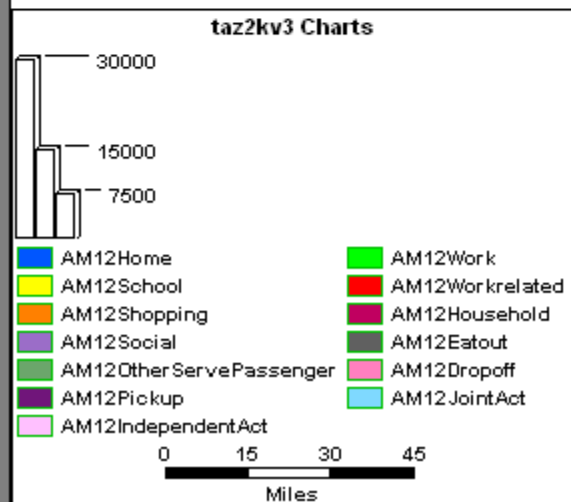
0 15 30 45  
Miles

10:00PM-11:00PM

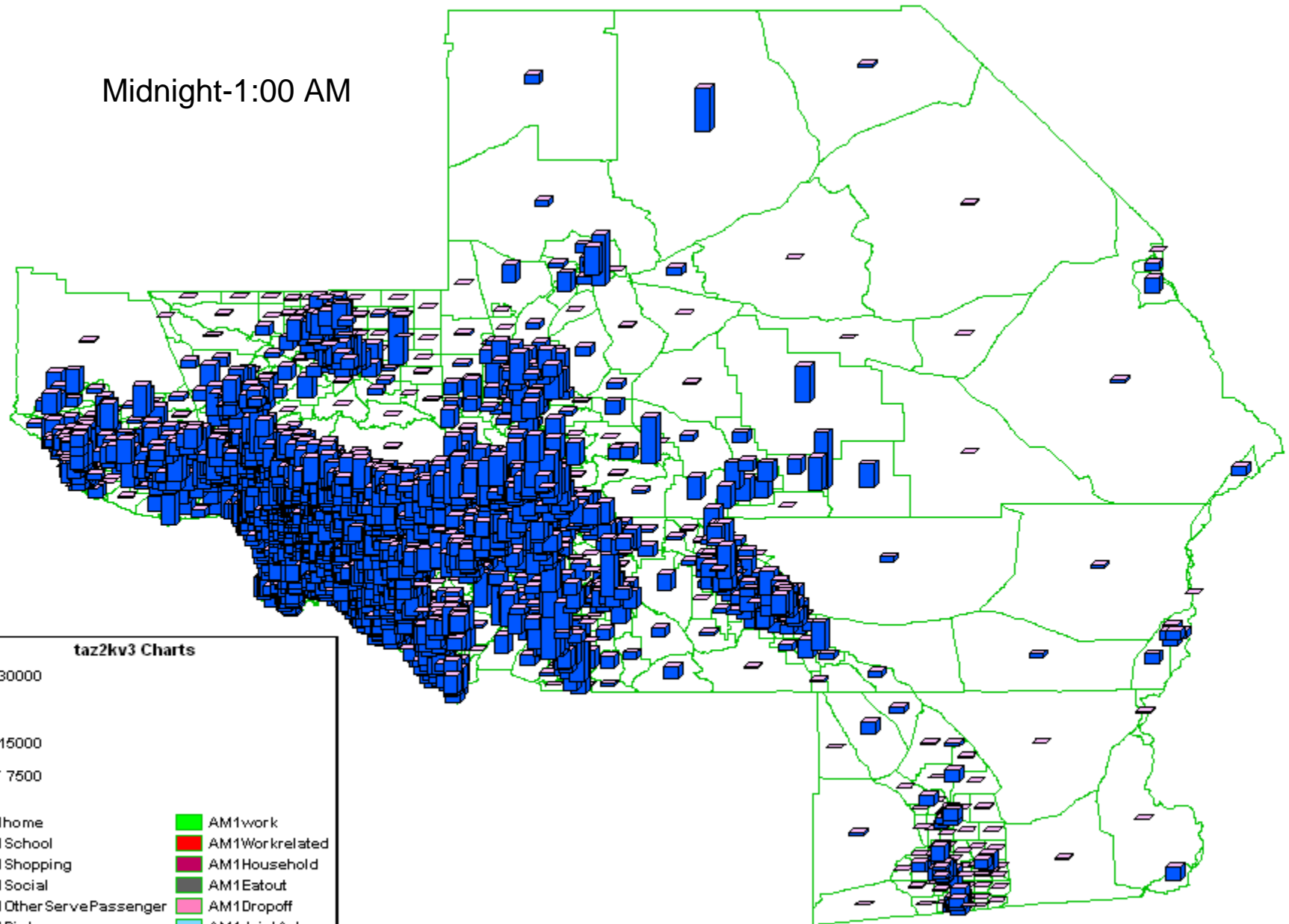




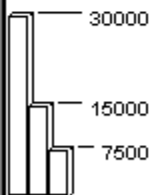
11:00PM-Midnight



Midnight-1:00 AM



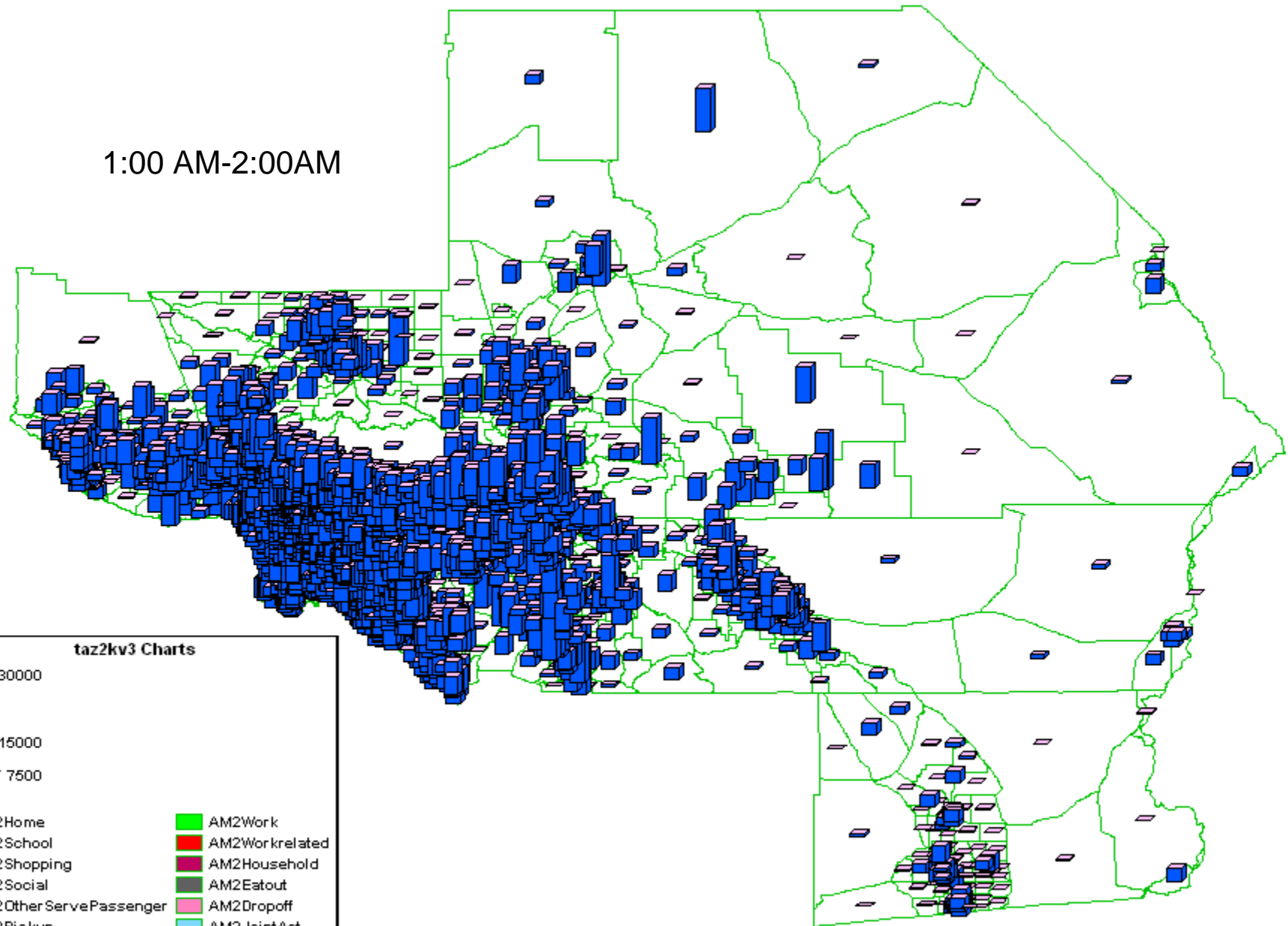
taz2kv3 Charts



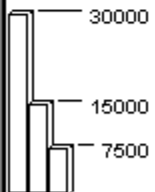
- |                        |                |
|------------------------|----------------|
| AM1home                | AM1work        |
| AM1School              | AM1Workrelated |
| AM1Shopping            | AM1Household   |
| AM1Social              | AM1Eatout      |
| AM1OtherServePassenger | AM1Dropoff     |
| AM1Pickup              | AM1JointAct    |
| AM1IndependentAct      |                |

0 15 30 45  
Miles

1:00 AM-2:00AM



taz2kv3 Charts



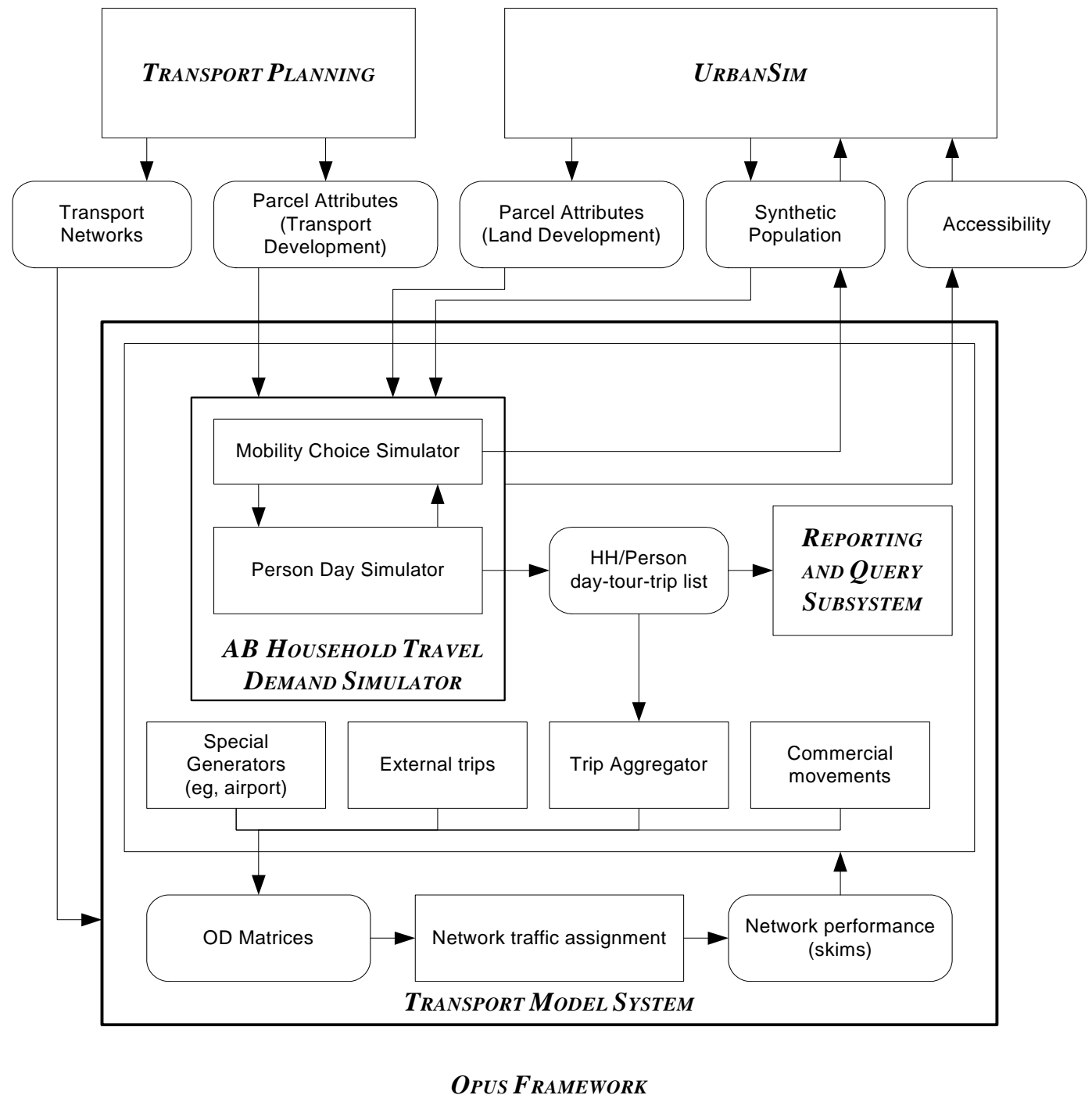
- |                        |                |
|------------------------|----------------|
| AM2Home                | AM2Work        |
| AM2School              | AM2Workrelated |
| AM2Shopping            | AM2Household   |
| AM2Social              | AM2Eatout      |
| AM2OtherServePassenger | AM2Dropoff     |
| AM2Pickup              | AM2JointAct    |
| AM2IndependentAct      |                |

0 15 30 45  
Miles



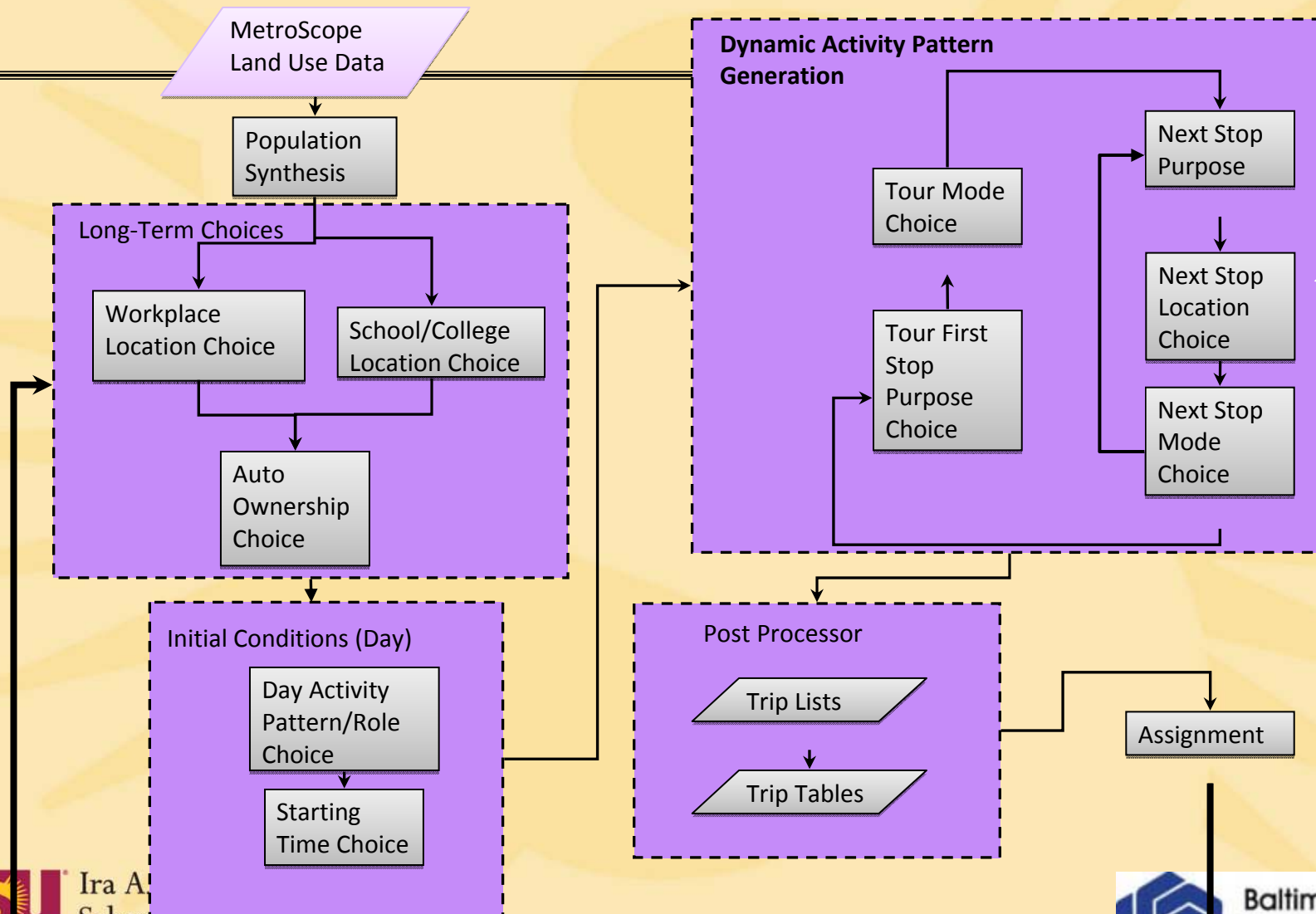
# PSRC Model Design

(Bowman, Bradley, Castiglione)





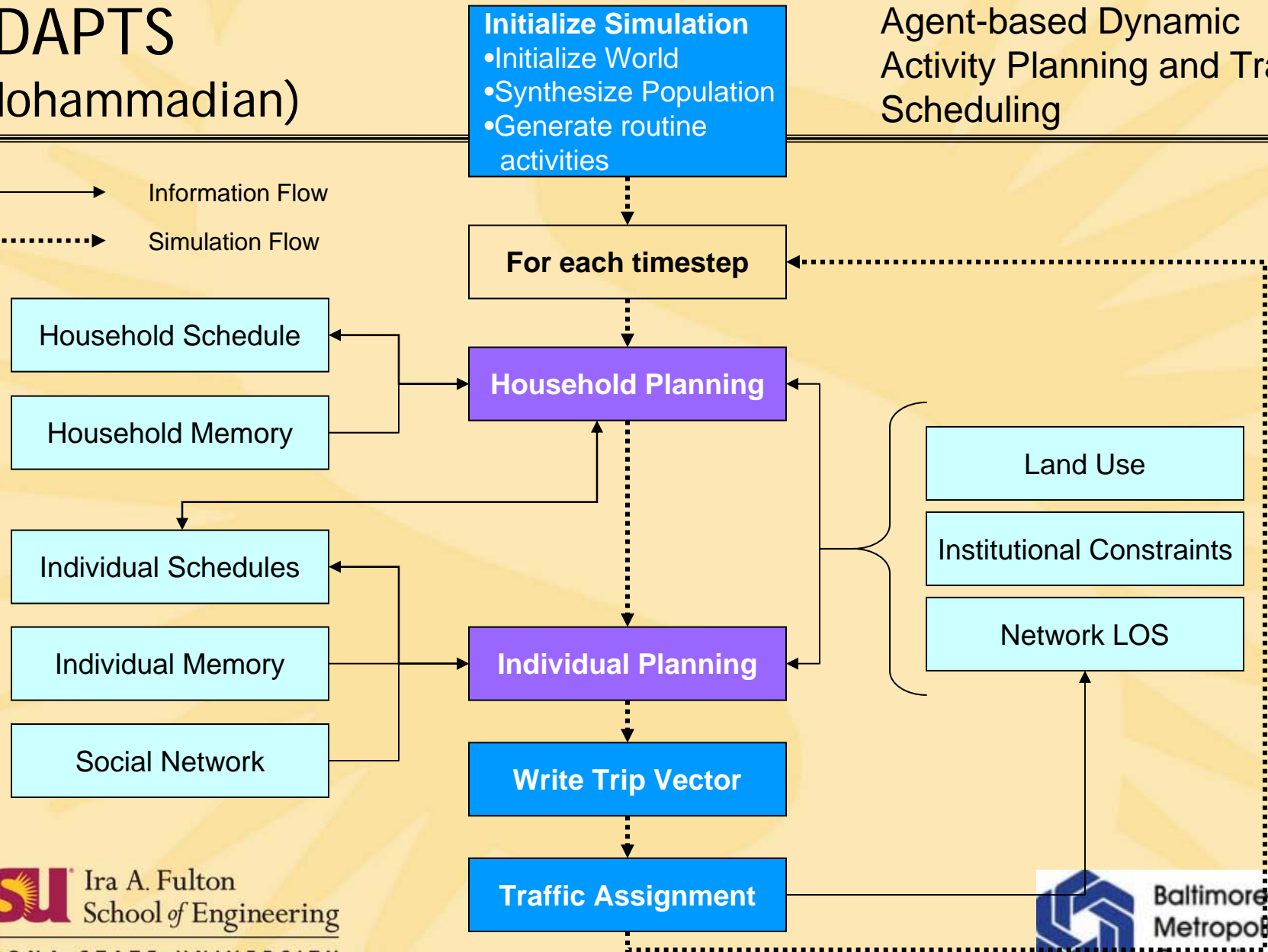
# Activity-Based Model System - DASH(Gliebe)



# ADAPTS (Mohammadian)

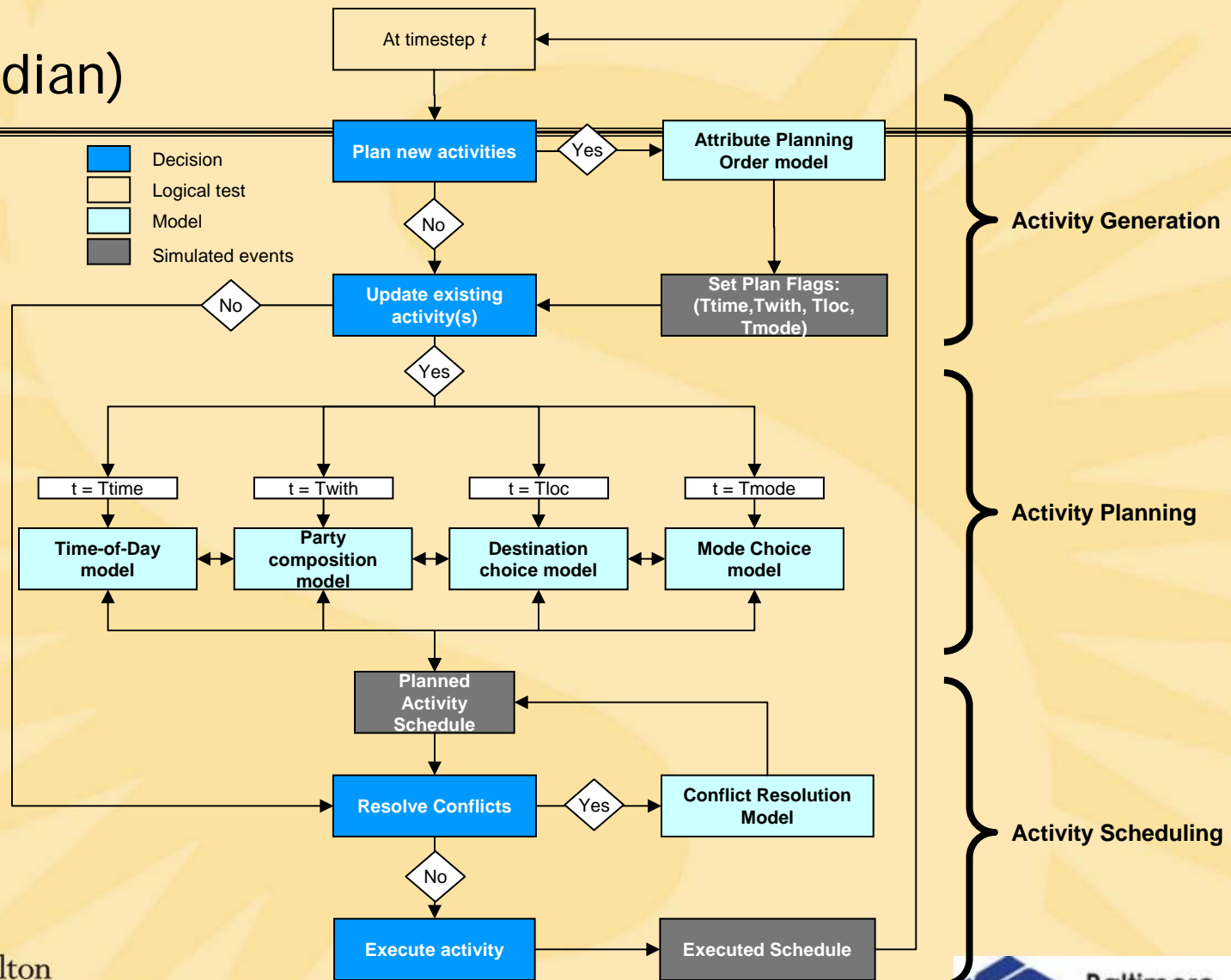
Agent-based Dynamic  
Activity Planning and Travel  
Scheduling

—————> Information Flow  
 .....> Simulation Flow



# ADAPTS

(Mohammadian)





# ALBATROSS (Timmermans/Arentze)

- A learning-based activity-based travel model system
- Employs theories of choice heuristics to represent behavioral processes
- Decision tree approaches used to formalize heuristics and predict choice behavior
- Explicit consideration of multitude of constraints



# ALBATROSS (Timmermans/Arentze)

- *Albatross* assumes that choice behavior is based on **rules** that are formed and **continuously adapted** through learning
- Individual interacts with the environment (reinforcement learning) or communicates with others (social learning)
- *Albatross* is based on a learning theory which implies that rules governing choice behavior are:
  - **heuristic**
  - **context-dependent**
  - **adaptive in nature**





# ALBATROSS (Timmermans/Arentze)

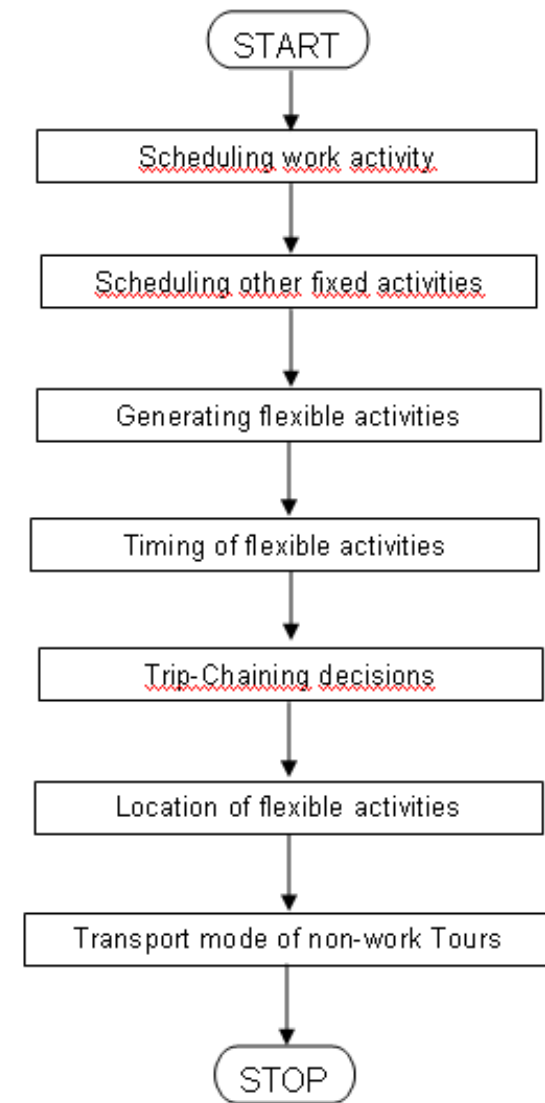
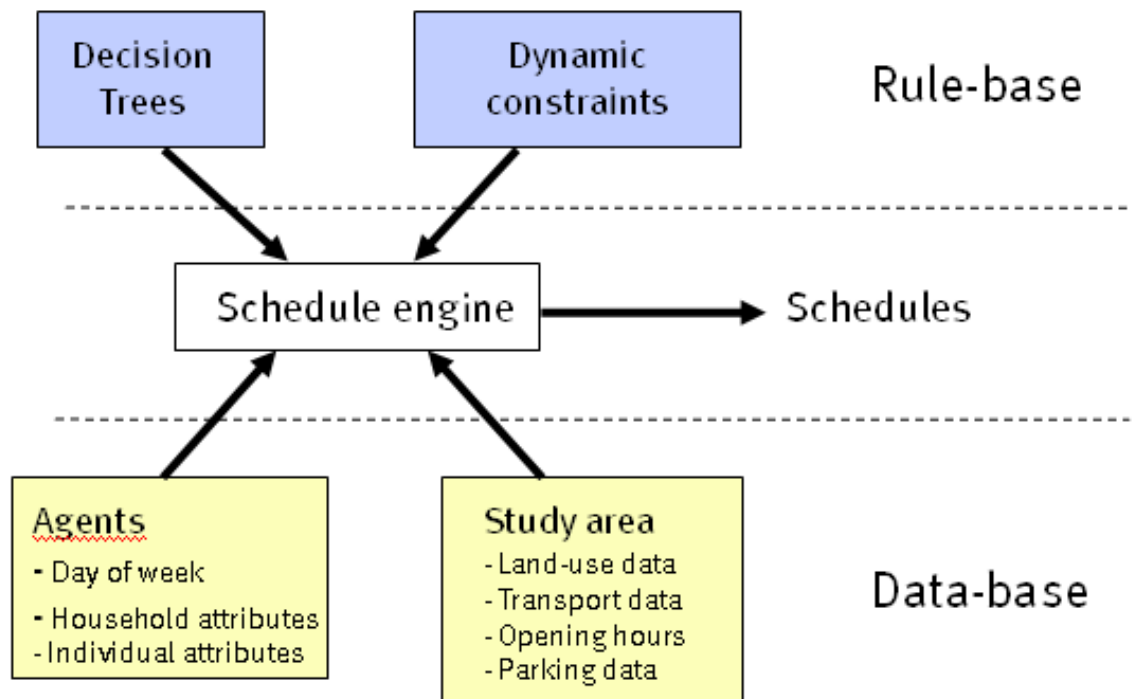
a-priori  
defined

- Components:
  - a model of the sequential decision making process
  - models to compute dynamic constraints on choice options

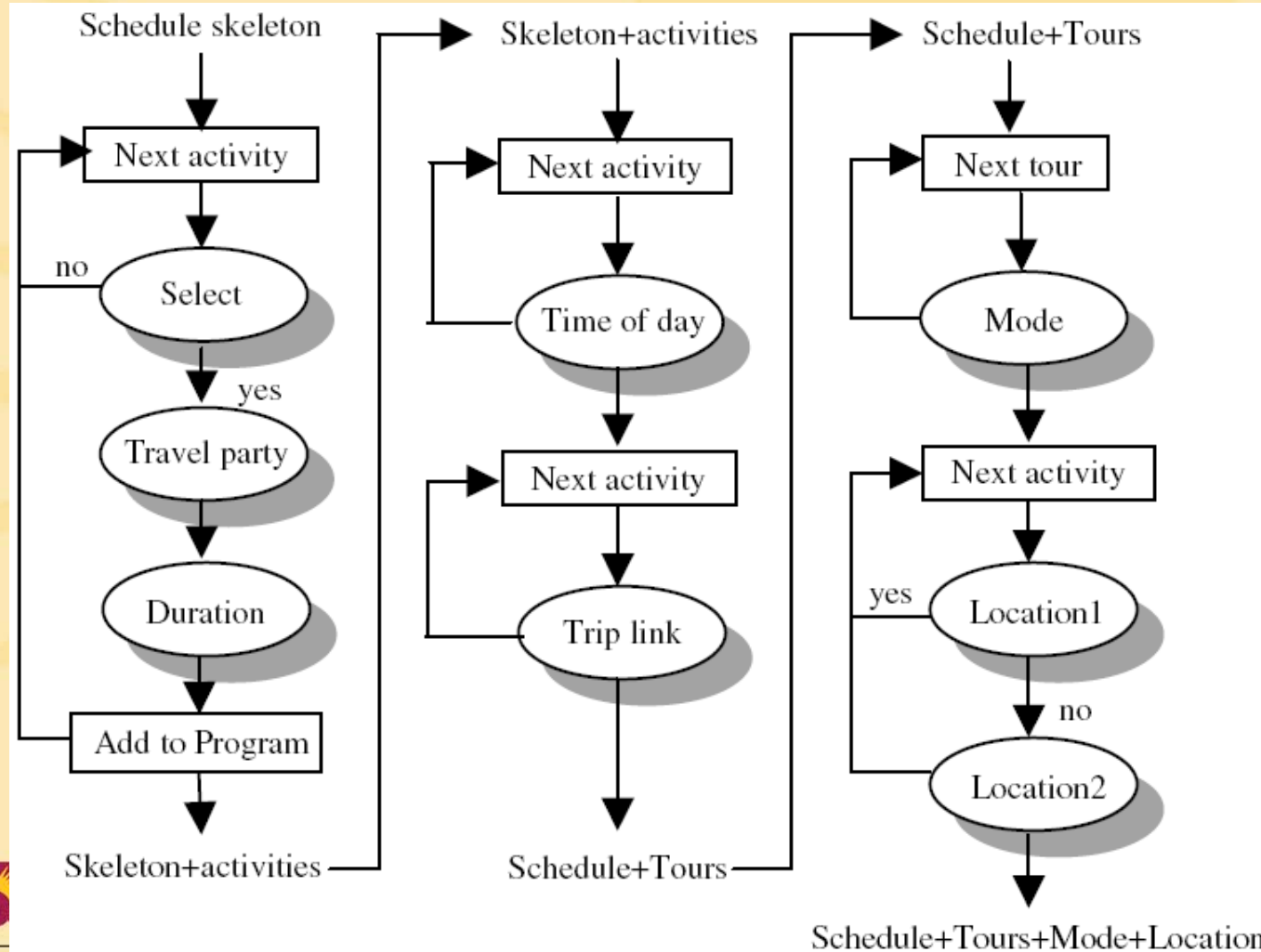
derived from  
observed  
choice  
behavior

- A set of decision trees representing choice behavior of individuals related to each step in the process model

# ALBATROSS (Timmermans/Arentze)



# ALBATROSS (Timmermans/Arentze)



# ALBATROSS (Timmermans/Arentze)

## Rule-Based Heuristics

Let  $L$  be the choice set for the given activity defined by Eqs. (1)–(4),  $L^+ \subseteq L$  be the subset of non-inferior locations,  $t_l^t$  be the travel time to location  $l$ ,  $r_1 < r_2 < r_3 < \dots < r_m$  be pre-defined critical travel times of increasing lengths,  $R_r \subseteq L$  be the subset of locations reachable within travel time  $r$ . Then, the heuristics can be written as

- $h_1$  : choose location  $l$  if  $l \in L^+ \wedge t_l^t = \min_{l' \in L} (t_{l'}^t)$
- $h_2$  : choose location  $l$  if  $l \in L^+ \wedge o_l = \max_{l' \in L} (o_{l'})$
- $h_{3,1}$  : choose location  $l$  if  $l \in L^+ \wedge l \in R_1 \wedge o_l = \max_{l' \in R_1} (o_{l'})$
- $h_{3,2}$  : choose location  $l$  if  $l \in L^+ \wedge l \in R_2 \wedge o_l = \max_{l' \in R_2} (o_{l'})$
- ...
- $h_{3,m}$  : choose location  $l$  if  $l \in L^+ \wedge l \in R_m \wedge o_l = \max_{l' \in R_m} (o_{l'})$
- $h_4$  : use some other heuristic



# ALBATROSS (Timmermans/Arentze)

## Classification of Activities

### Fixed activities

Work/school  
Bring or get persons or goods  
Medical visits  
Personal business (a rest category)  
Sleep and eat

### Flexible activities

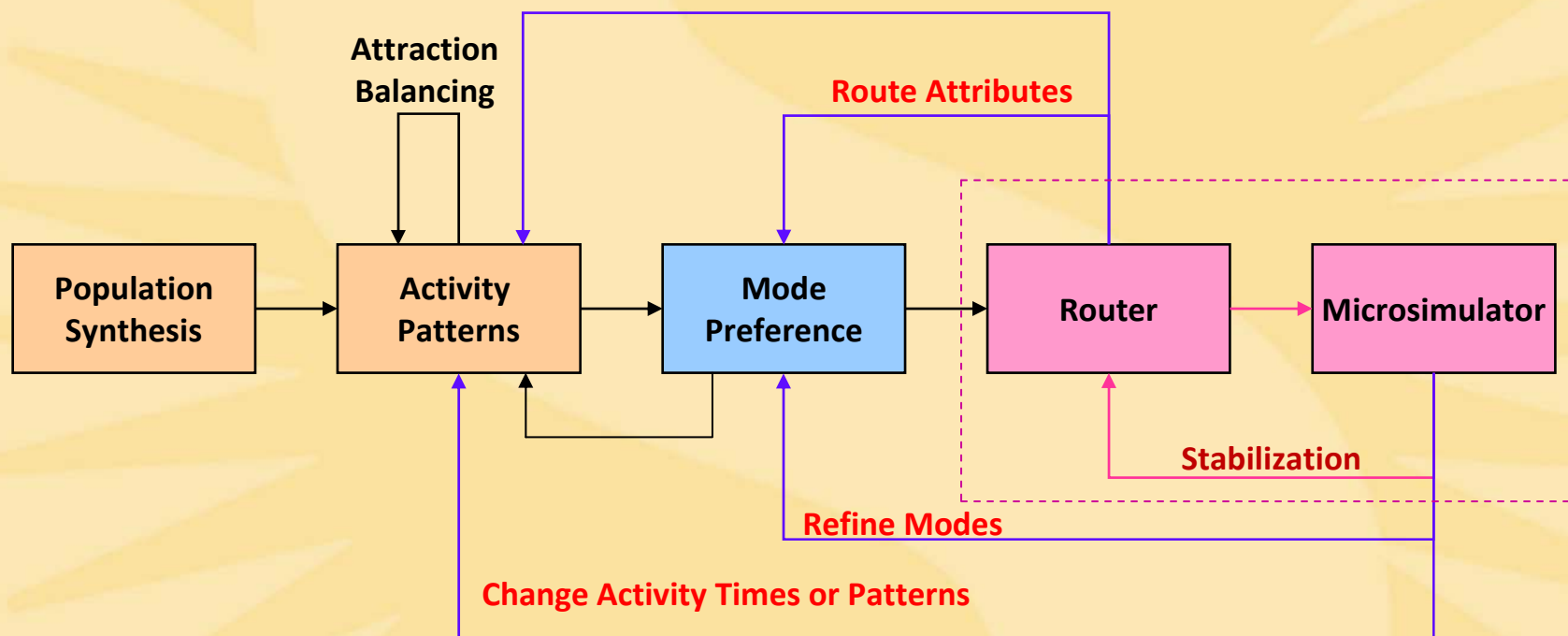
Daily shopping  
Service related activities (post office, bank etc.)  
Non-daily shopping  
Social activities (visiting friends, relatives etc.)  
Leisure activities (sports, concert, library, restaurant etc.)  
Home-based activities (other than sleep and eat)



# TRANSIMS (FHWA/LANL)

- Transportation Analysis and Simulation System
- Generates and simulates activity/travel patterns for individuals in a region over a 24 hour period
- Supports highly detailed road and transit networks
- Time dependent link delays are considered for routing trips through the network

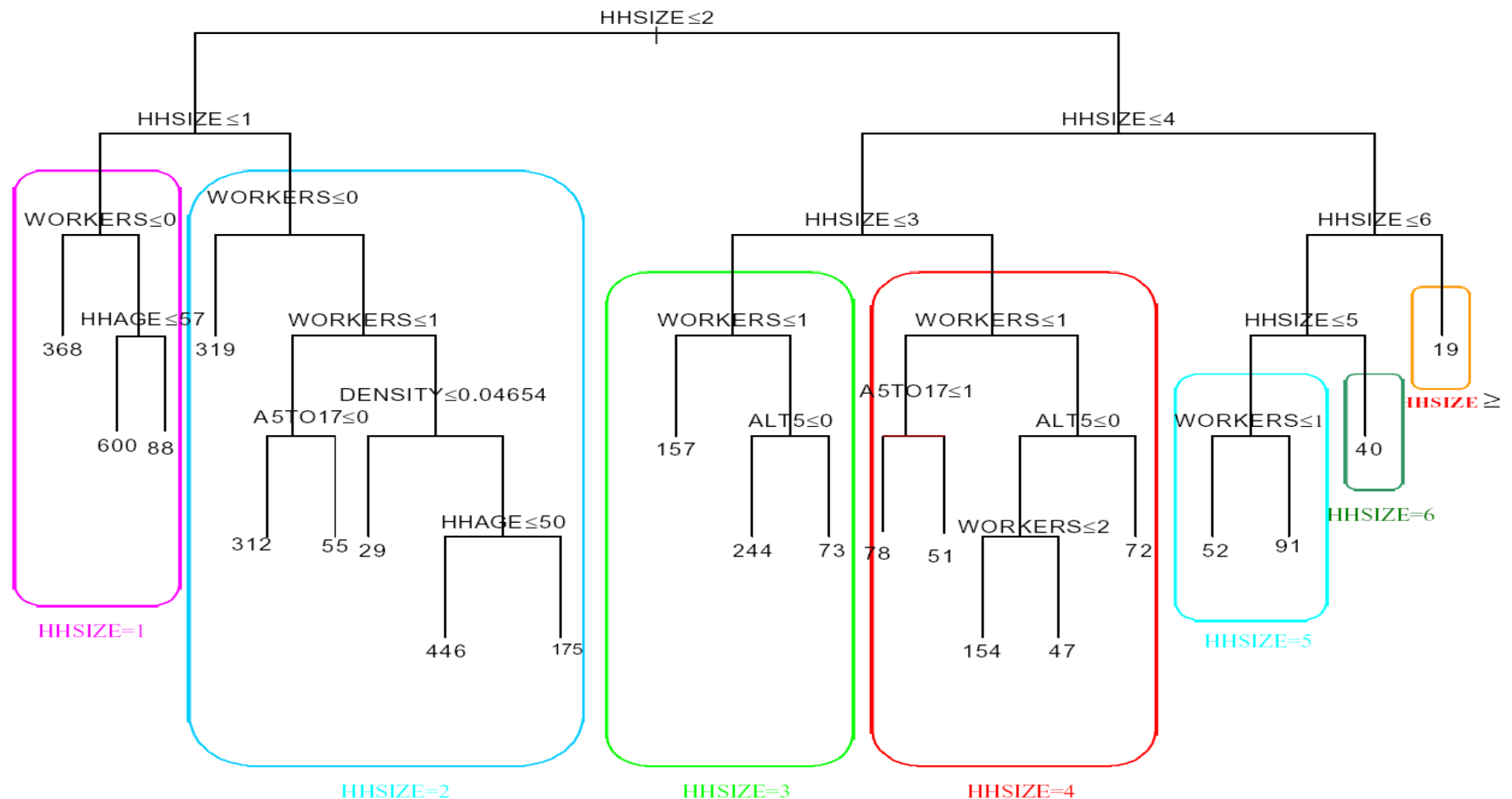
# TRANSIMS: Framework



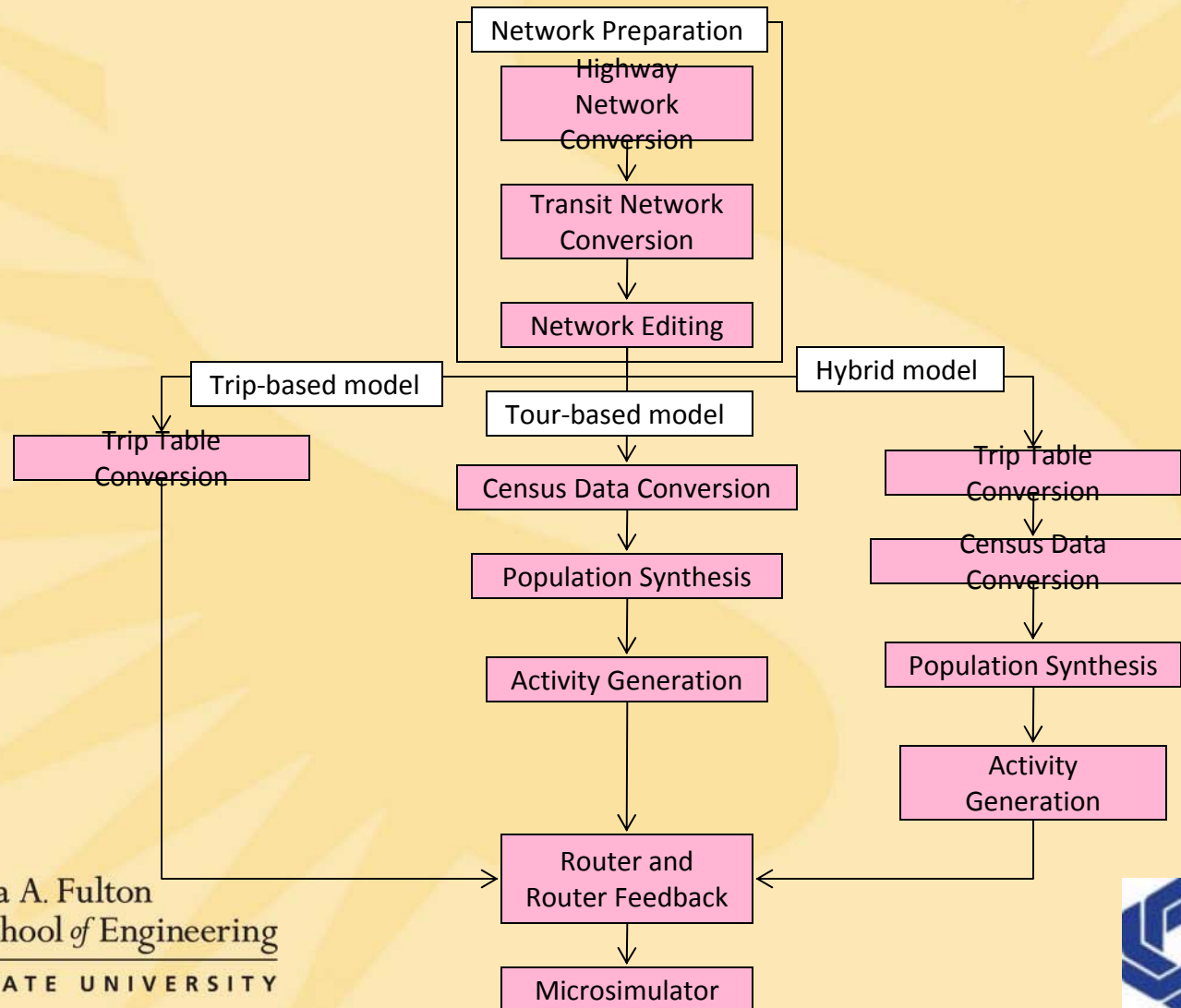
# TRANSIMS: Activity Generator

- Generates activity engagement patterns for each member of a household over a 24-hour period
- Out-of-home activity locations determined using a destination choice model
- Activity engagement patterns generated by sampling from activity patterns of individuals in a travel survey
  - In the current implementation, Classification and Regression Trees are used

# TRANSIMS: Activity Generator (continued)

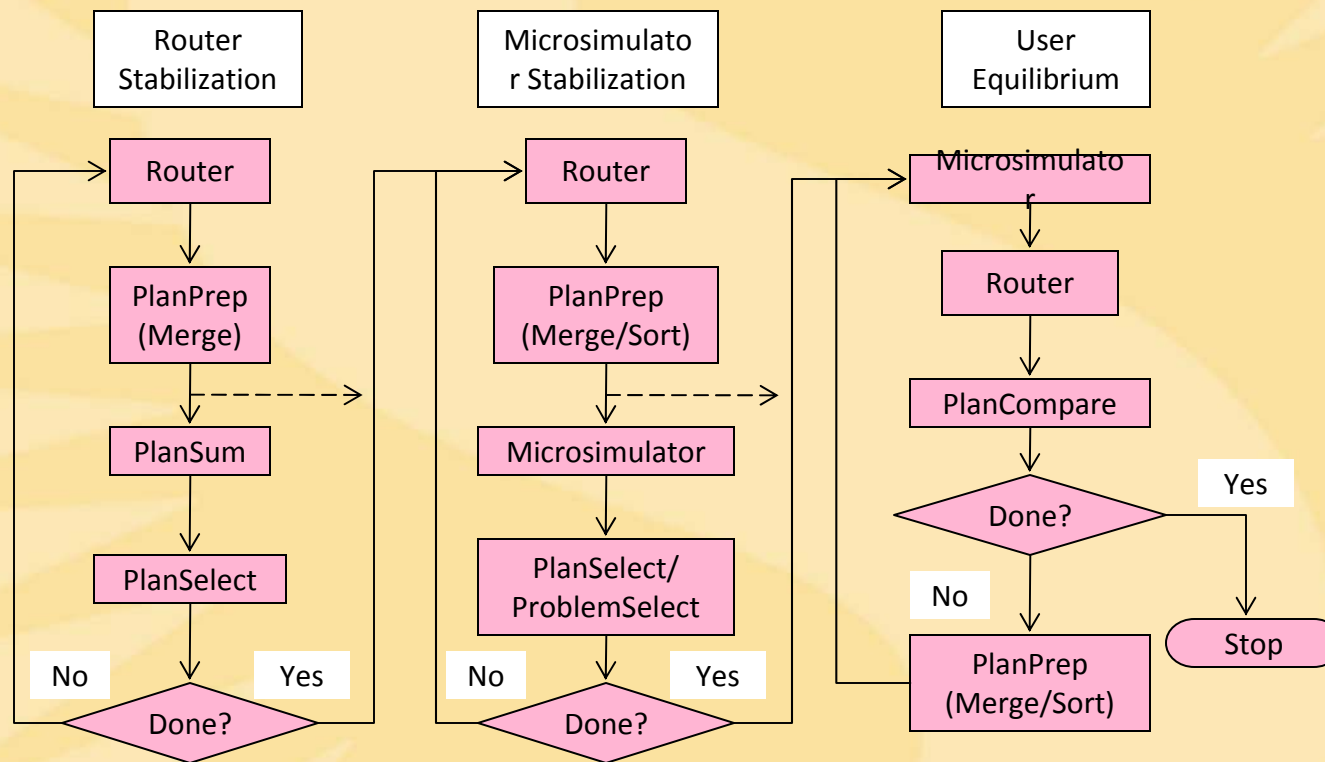


# TRANSIMS: Application





# TRANSIMS: Feedback Processes



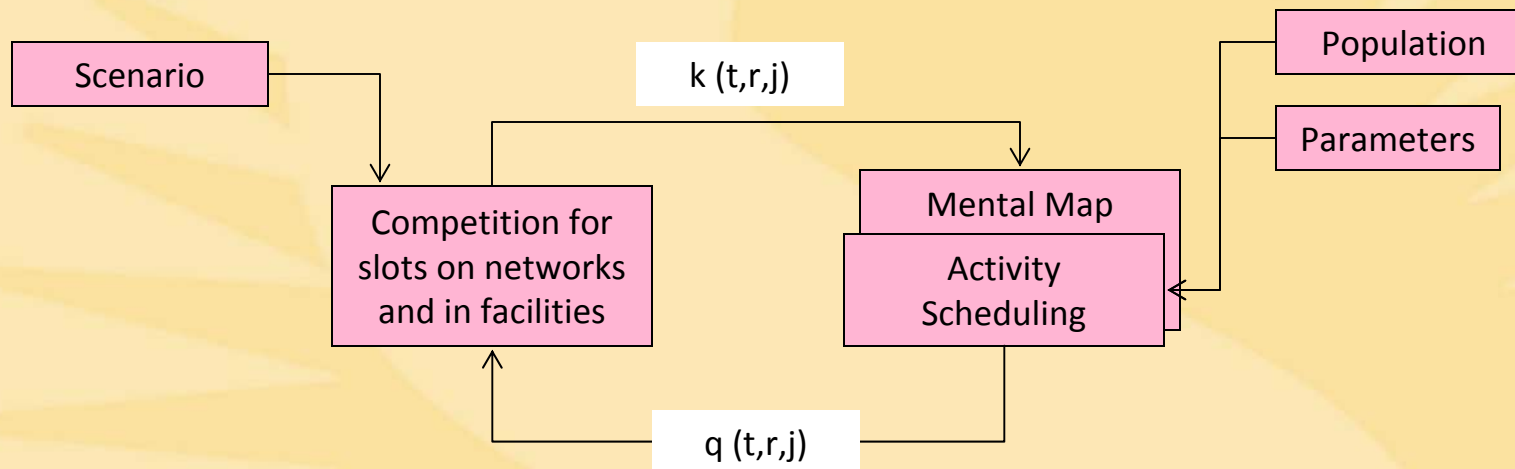
# MATSIM-T (Axhausen/Nagel)

- Multi-Agent Transport Simulation Toolkit
- Iterative agent-based traffic simulation framework
- Only autos are simulated
- Involves two main components
  - Agent generation (grouped as households)
  - Activity Scheduling

# MATSim-T: Scheduling Tasks

Task	Frequency per run	Model type
Number, sequence and type of activities	Once	Conditional probability
Start and duration of activities	Per iteration	Best response model (GA-based optimizer)
Composition of the group undertaking the activity	---	---
Expenditure and its allocation among the participants	---	---
Secondary location choice	Once	Imputed (Proportional to size and distance)
Mode/vehicle choice	Per iteration	Imputed (Chain based MNL)

# MATSim-T: Framework



- Travel demand  $q$  is generated and microsimulated
- Resulting generalized costs  $k$  are used to adjust schedules, capacities and prices of facilities
- Route ( $r$ ) adaptation process also extends towards time choice ( $t$ ), mode choice, location choice ( $j$ ), etc

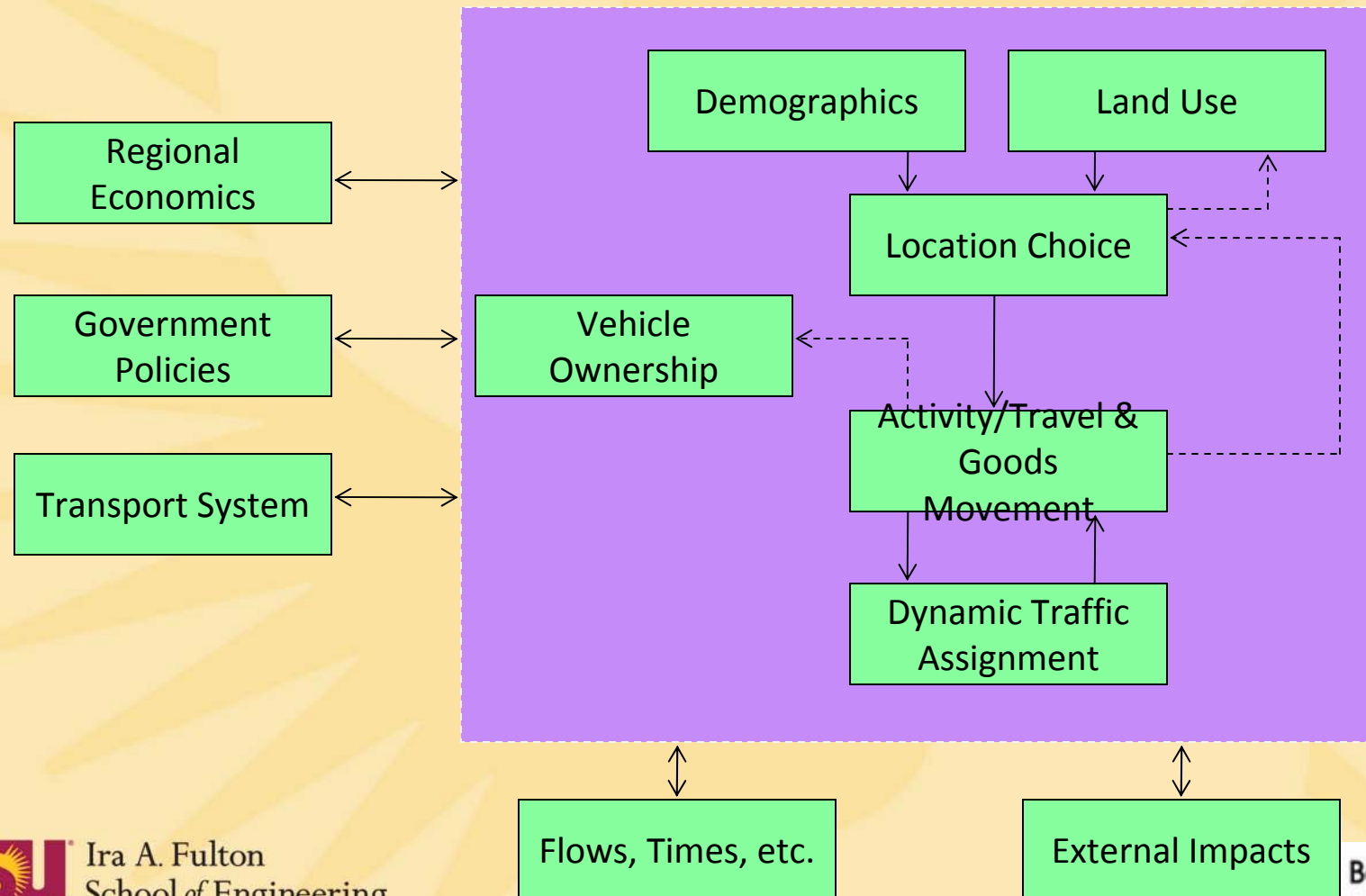


# ILUTE (Miller)

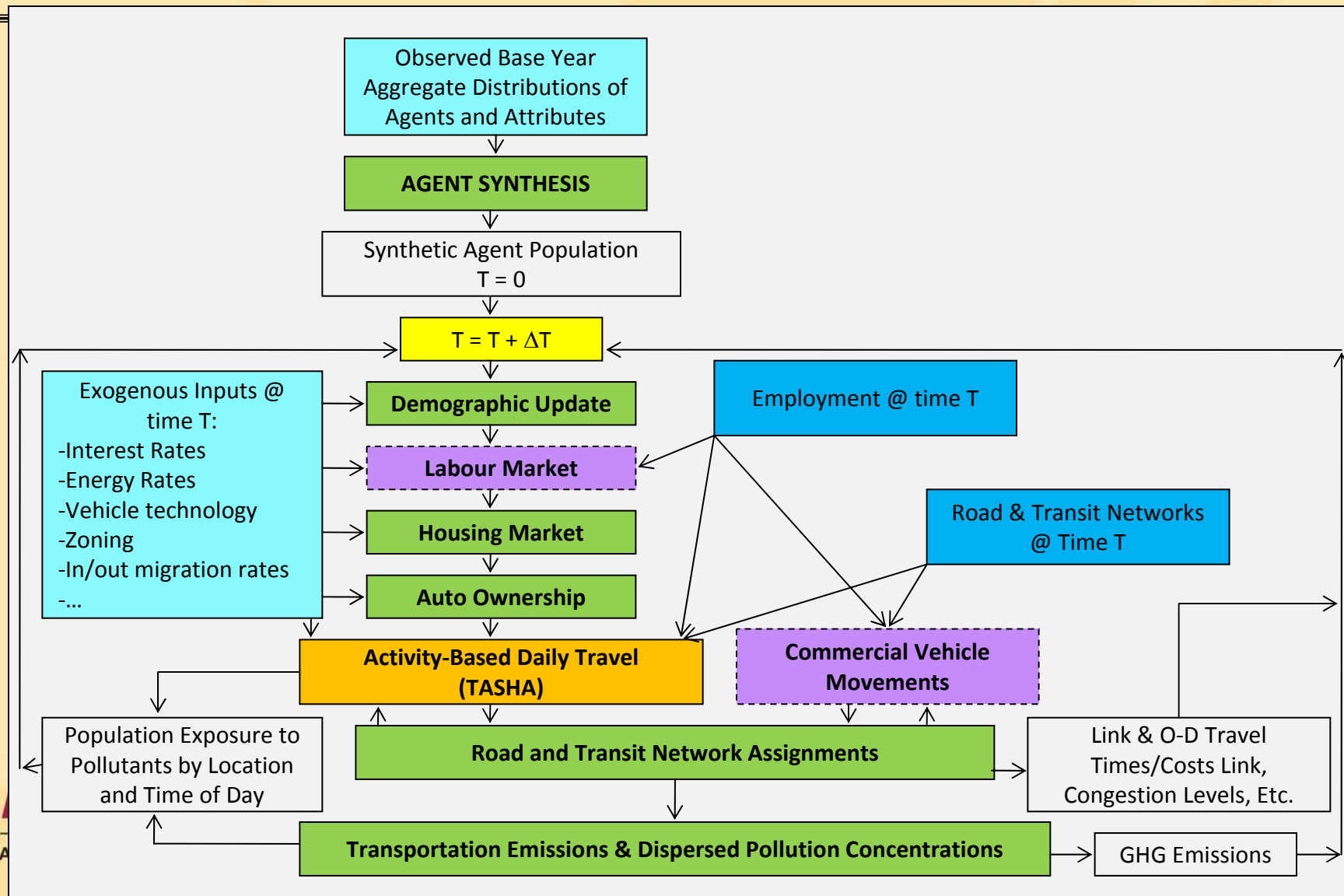
- Integrated Land Use, Transportation, Environment (ILUTE) model system
- ILUTE mainly tries to model the “spatial markets and the persons’ daily decision-making within a household-based context”
- Simulates the evolution of agents and objects over time
  - Agents and objects include individuals, transportation networks, the built environment, the economy, and the job market



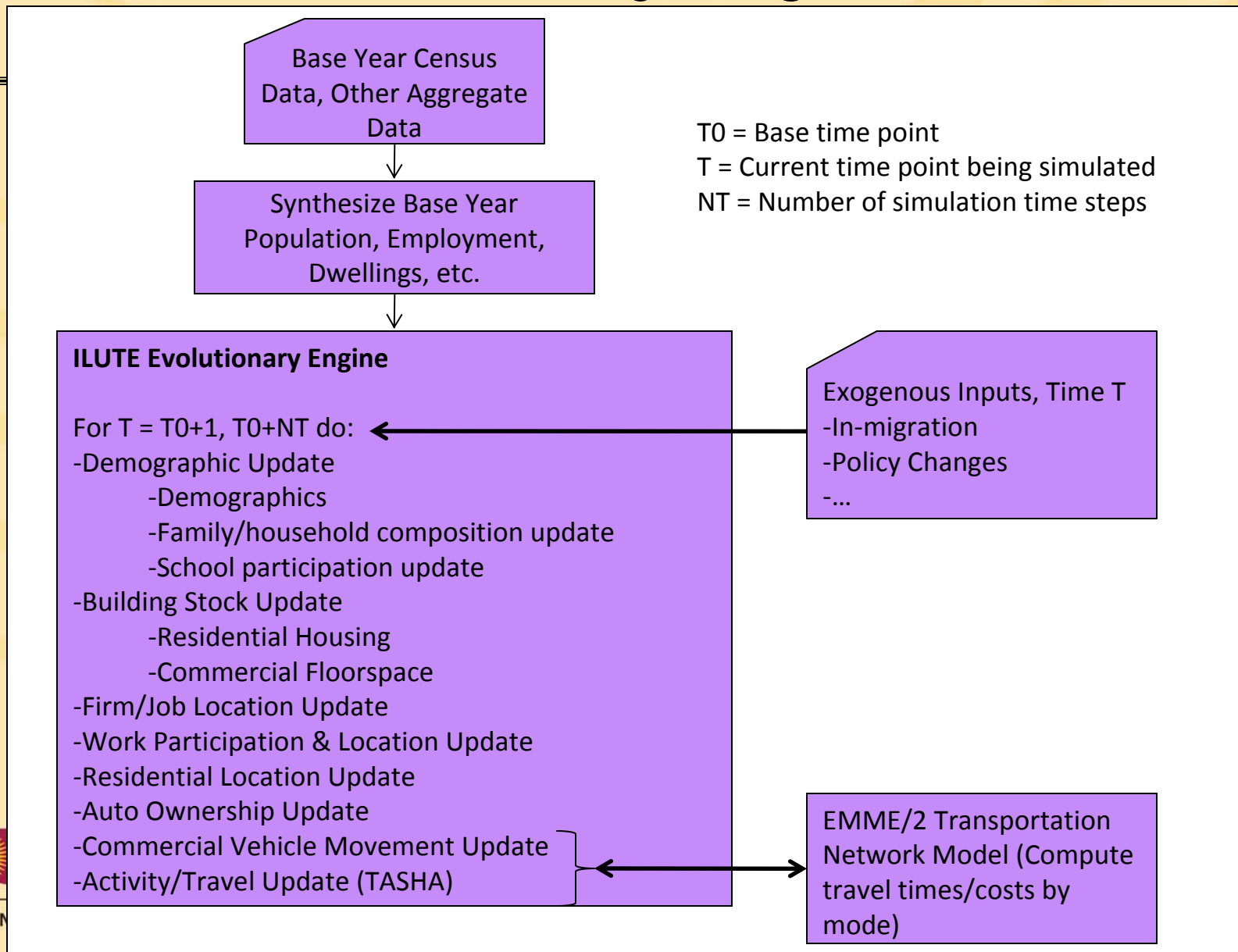
# ILUTE: Framework



# ILUTE: Structure and Current Implementation



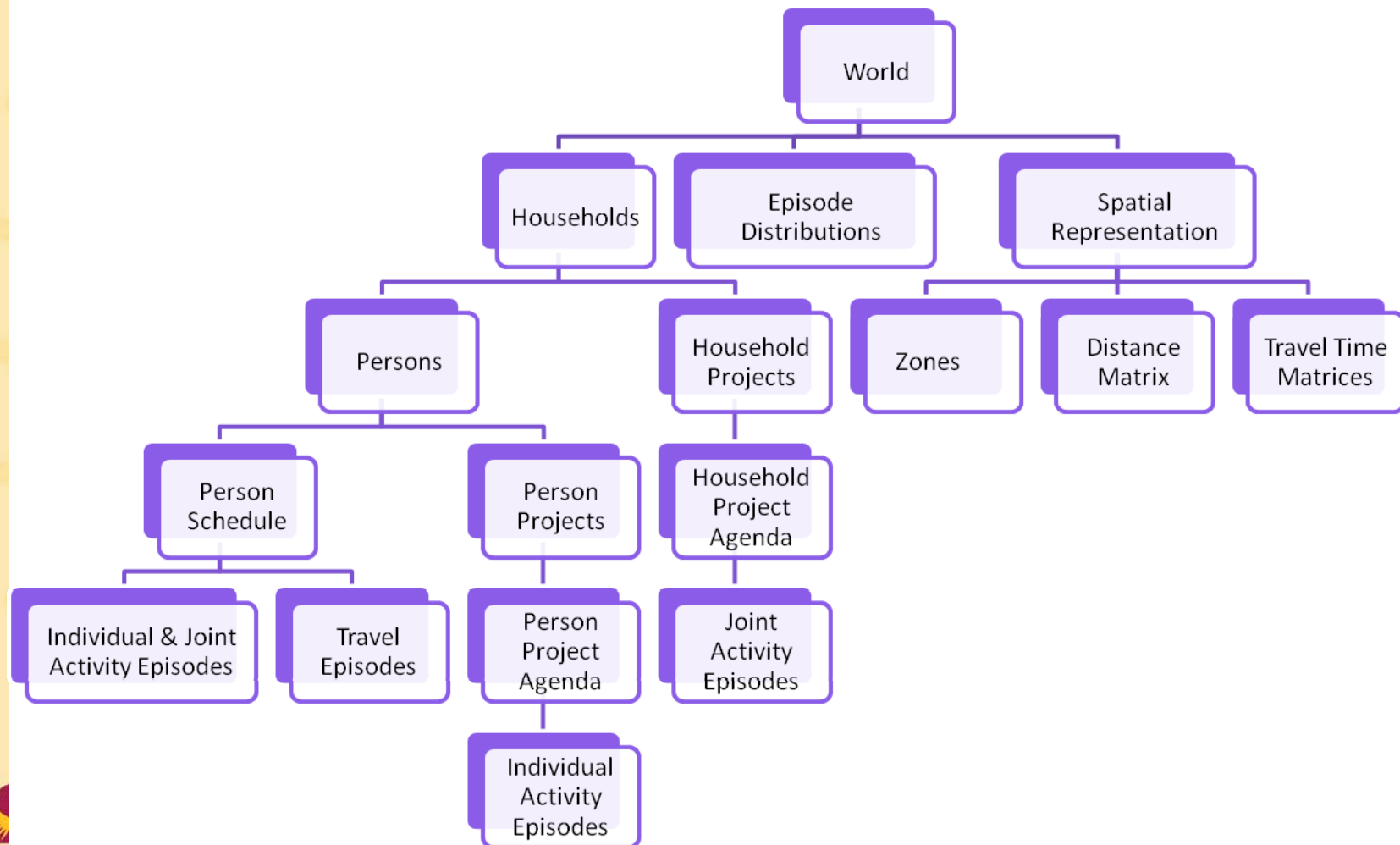
# ILUTE: Evolutionary Engine



# TASHA (Miller/Roorda)

- Travel/Activity Scheduler for Household Agents
- Simulates out-of-home activity and travel patterns for individuals recognizing household-level interactions and constraints
- TASHA uses the concept of *project* introduced by Axhausen (1998)
- TASHA comprises of:
  - An activity episode generator
  - An activity scheduler
  - A random utility tour-based mode choice model

# TASHA: Class Structure and Project Definitions

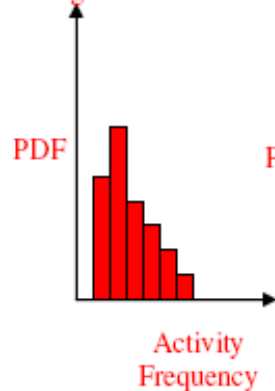




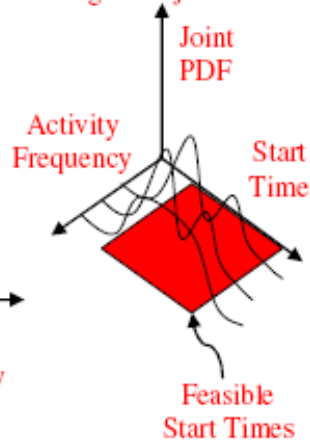
# TASHA: Activity Generation, Scheduling and Mode Choice

## Activity Episode Frequency, Start Time and Duration Generation

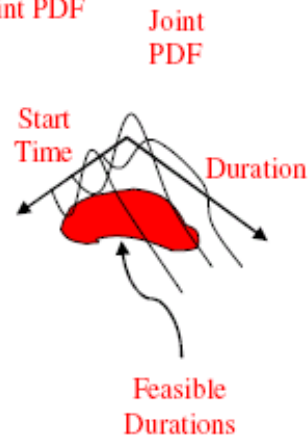
(a) Draw activity frequency from marginal PDF



(b) Draw activity start time from feasible region in joint PDF



(c) Draw activity Duration from feasible region in joint PDF



## Trip-Chain (Tour) Based Mode Choice

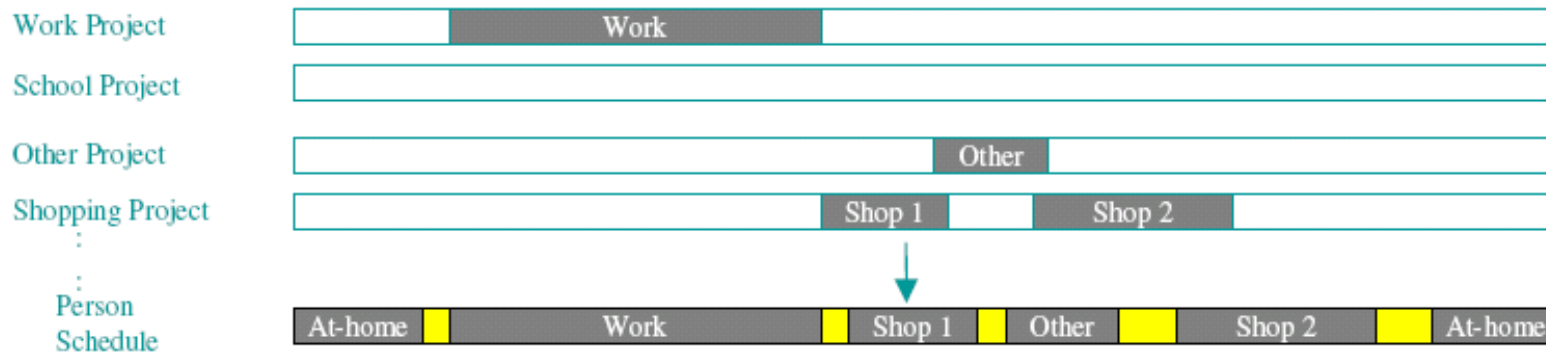
Chain c  
Trips 1, ...,  $T_c$

**Auto-Drive Chain**  
All trips made by auto-drive mode

**Non-Drive Chain**

Trip 1 Mode  
Trip 2 Mode  
...  
Trip  $T_c$  Mode

## Scheduling Activity Episodes into a Daily Schedule



□ = "Gap" in Project Agenda

■ = Activity Episode

■ = Travel Episode

# Time Use Utility Measures

- Time use allocation is central to the activity-based modeling paradigm
- Offers strong framework for analyzing measures of welfare that people derive from their activity-travel patterns
- Address social equity and quality of life issues

# Formulation of Time Use Utility Measure

## ➤ Utility formulation

$$U_q = [x_q \beta + \gamma \ln(S_q + 1) + \varepsilon_q] \ln(T_q + 1)$$

$U_q$  is utility derived from activity of type  $q$

$T_q$  is cumulative daily time expenditure on activity of type  $q$

$S_q$  is cumulative daily time expenditure on travel for activity of type  $q$

$x_q$  is a vector of covariates affecting utility  $U_q$

$\gamma$  is a scalar coefficient associated with  $\ln(S_q + 1)$

$\beta$  is a vector of coefficients associated with  $x_q$

$\varepsilon_q$  is an i.i.d. random error term in  $U_q$ .

# Formulation of Time Use Utility Measure

## ➤ Utility formulation

$$U_s = \ln(T_s + 1)$$

Maximize 
$$U = \sum_q U_q + U_s$$

Subject to 
$$\sum_q T_q + \sum_q S_q + T_s = T_f$$

$U_s$  is the utility derived from sleep

$U$  is the total utility derived from the time use pattern

$T_s$  is cumulative daily time expenditure on sleep

$T_f$  is the total time available in a day.



# Baseline Activity Pattern

Activity Type	Daily Duration (min)
Sleep	472
In-home maintenance	202
Out-of-home maintenance	53
Travel for out-of-home maintenance	37
In-home discretionary	166
Out-of-home discretionary	76
Travel for out-of-home discretionary	16
<i>Commute time (round trip)</i>	<i>60</i>





# Modified Activity Pattern: After Telecommuting

Activity Type	Daily Duration (min)
Sleep	492 (+20)
In-home maintenance	202
Out-of-home maintenance	53
Travel for out-of-home maintenance	37
In-home discretionary	186 (+20)
Out-of-home discretionary	90 (+14)
Travel for out-of-home discretionary	22 (+6)
<i>Commute time (round trip)</i>	<i>0</i>

# Example

- Time use utility measure formulated as a function of:
  - Socio-economic and demographic characteristics
  - Travel durations to and from activities
  - Activity durations for different activity types/episodes
- Time Use Utility before capacity enhancement = 25.570
- Time Use Utility after capacity enhancement = 27.531
- Could translate into monetary benefits
- Also examine equity across market segments

# Example

Activity Type	Utility Value Before Telecommuting	Utility Value After Telecommuting
Sleep	6.159	6.201
In-home maintenance	2.939	2.939
Out-of-home maintenance	0.777	0.777
In-home discretionary	2.882	2.946
Out-of-home discretionary	12.813	14.669
Total	25.570	27.531

# Key Considerations

- Representation of fuzzy time-space prism constraints, inter-agent interactions, and time use behavior
- Greater level of simultaneity in choice processes to reflect choice of lifestyle package
- Recognition of heterogeneity in population – behavioral structure, decision hierarchy, parameters/coefficients
  - Careful market segmentation, trip purpose definition, representation of time, space, and networks



# Key Considerations

- Central role of time and space
  - Disaggregate representation of time-space domain
  - Continuous representation of time
  - Disaggregate spatial representation
- Maximize use of information from activity-based travel model





# Things to Think About

## ➤ Feedback processes

- Feedback within activity-travel simulator from destination/mode choice to time-of-day choice to activity type/generation
- Feedback from network assignment to activity type/generation (tour stops), and mode and destination choice
- Criteria for convergence and equilibrium conditions



# Things to Think About

## ➤ Stochastic simulation

- One run represents one realization of stochastic process
- How many runs are required to achieve stable results?
- Impacts on computation time and hardware/software requirements

## ➤ Data requirements

- Travel survey data
- Multimodal network data by time of day
- Detailed land use data
- Greater level of disaggregation for activity microsimulation

# Things to Think About

- In-house resources
  - Staff training and expertise
  - Computational resources
  - Phased development plan
    - Comprehensive model design upfront with staged development and implementation schedule