TMIP Webinar Series

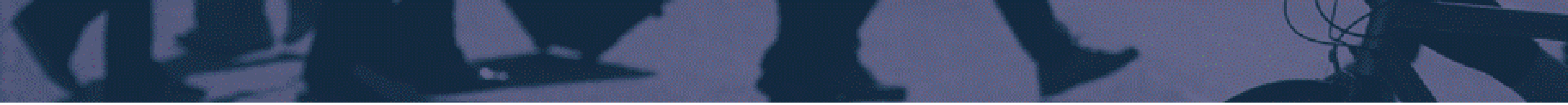
# Activity-Based Modeling

## Session 2: Institutional Issues for Managers

The Travel Model Improvement Program

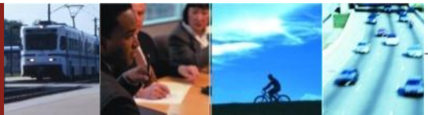
Speakers: John Gliebe and Rosella Picado

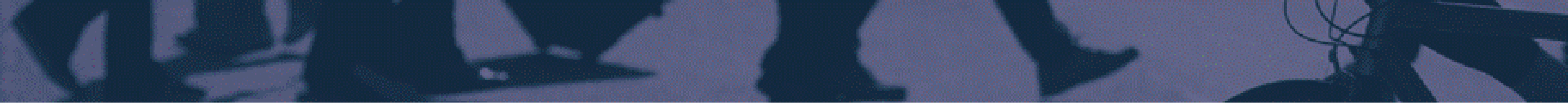
February 23, 2012



# Acknowledgments

*This presentation was prepared through the collaborative efforts of Resource Systems Group, Inc. and Parsons Brinckerhoff.*





# 2012 Activity-Based Modeling Webinar Series

| | |
|---|---|
| **Executive and Management Sessions** | |
| Executive Perspective | February 2 |
| Institutional Topics for Managers | February 23 |
| Technical Issues for Managers | March 15 |
| **Technical Sessions** | |
| Activity-Based Model Framework | April 5 |
| Population Synthesis and Household Evolution | April 26 |
| Accessibility and Treatment of Space | May 17 |
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| Scheduling and Time of Day Choice | July 19 |
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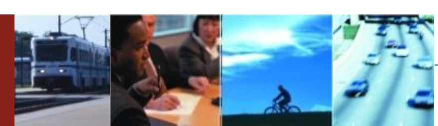
| Network Integration | August 30 |
| Forecasting, Performance Measures and Software | September 20 |





# Learning Outcomes

- Typical motivations and concerns of agencies considering an activity-based model
- Familiarity with the evolution of activity-based models in the U.S.
- Development options for migrating from 4-step to activity-based models
- Resources needed to implement an activity-based model program
- Experience with stakeholder acceptance and use

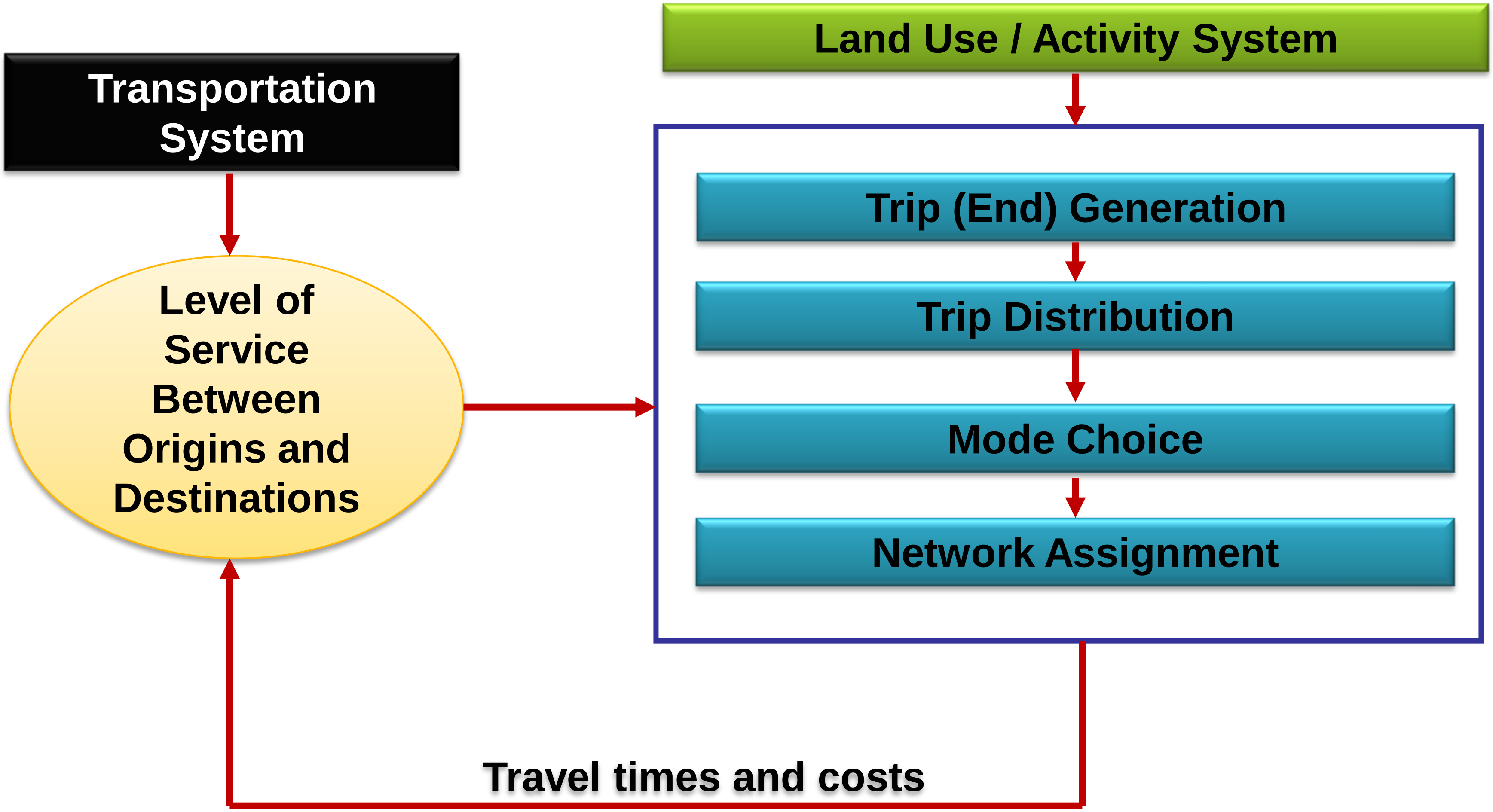
# Terminology

- Upfront model development
- Phased model development
- Transferred model development

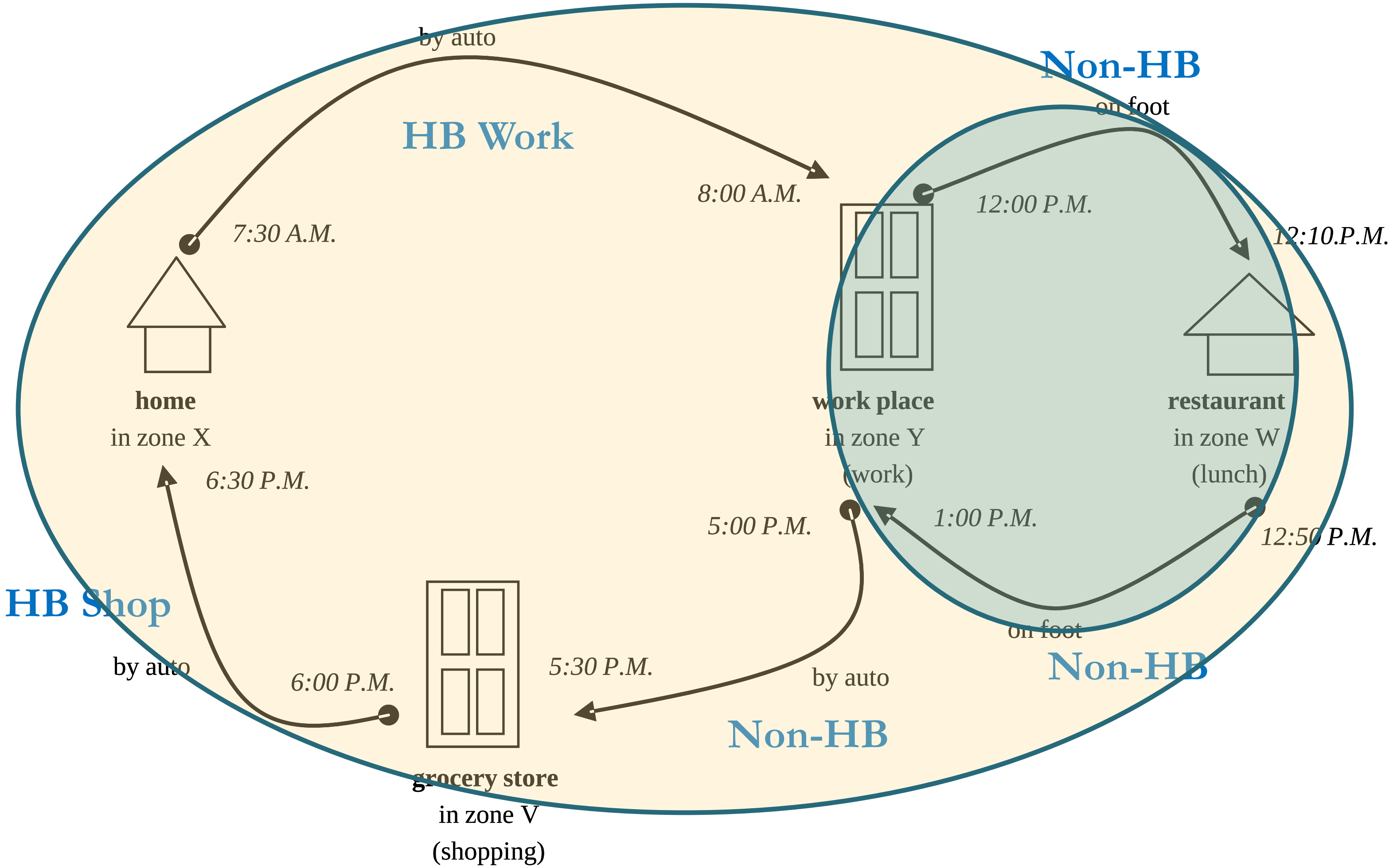
# Universal Transportation Modeling System (UTMS)

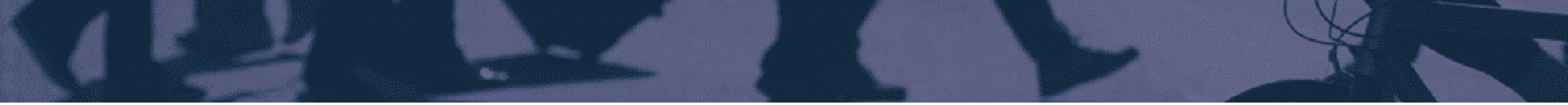
- Developed in 1950s
- "4-step process"
- Limited by data availability and computing power
- Primary applications were planning for highway capacity--emphasis on vehicle trips and flows
- Reliance on simplified trip-based approach
- Aggregate relationships

# Trip-Based Models Today: Advanced UTMS



# Modeling a “Day in the Life”…

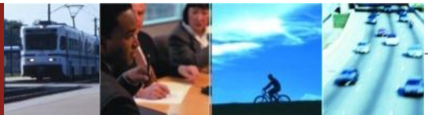




# Why activity-based models?

- **Activity-based models provide more information than trip-based models**
- **Intuitive models of behavior**
  - Consideration of individuals, not just groups of households
  - Tour concepts (how trips are actually organized and scheduled)
  - Spatial, temporal, modal consistency between trips in the same day
  - Motivation for travel in activity participation (substitution between travel and other means of meeting personal and household needs)
  - Interpersonal linkages and obligations
  - Effects of accessibility (urban form) on travel generation
  - Long-term and short-term decision perspectives represented





# Why activity-based models?

- *Policy questions related to willingness or ability to pay*
  - Fuel prices, mileage taxes and other operating costs
  - Parking costs
    - duration-based fees, employer subsidies
  - Road pricing
    - Variable time-of-day tolls (congestion/time of day)
    - Area pricing
    - HOT/HOV lanes
  - Transit fare policies (individual discounts, monthly passes, etc.)
  - Environmental justice
    - Impacts on minority or disadvantaged populations

# Why activity-based models?

- *Policies that involve coordination between individuals and time-sensitive scheduling constraints*
  - Demographic changes
    - Household size and composition
    - Planning to support aging populations
  - New commuting options
    - Telecommuting
    - Compressed work schedule
    - Carpool/shared-ride arrangements
  - Parking
    - Capacity constraints/restrictions
    - Park-and-ride lot utilization rates and supply

# What is the right tool for the job?

**Simpler models work best for simple, narrowly defined problems, e.g.**

Highway Capacity Project → 4-Step Planning Model → Highway Performance

**More sophisticated models are needed for more complex problems, e.g.**

Congestion Pricing Policy → Activity-based Model → Traffic and Revenue from Tolling

# What are the consequences of not using the "best tool for the job?"

- Credibility
  - For complex problems, the modeling system may not be appropriately sensitive and may produce counter-intuitive outputs

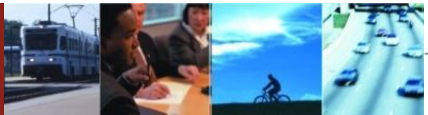
    … or it might produce the right aggregate response, but you have no way of knowing how individuals are affected

    … or have trouble explaining the results
  - Potential for legal challenges based on methodology
  - Perception that you may not be using the best tools available
    - What are they using in the neighboring state?

# Uncertainties of Implementing Activity-Based Models

- Cost
  - Can it be developed affordably?
  - Can we afford to maintain it?
- Resources
  - Will it require special technical skills that are difficult to find in-house?
  - How long will it take to develop?
  - Will it have a negative impact on agency productivity (longer run times, more maintenance, diverted resources)?





# Uncertainties of Implementing Activity-Based Models

- Data
  - Will it require additional data collection?
    - Household diary surveys
    - Detailed land use/parcel level data
    - Additional traffic counts, boardings, etc. for calibration and validation
    - Parking supply data
    - Socio-economic data

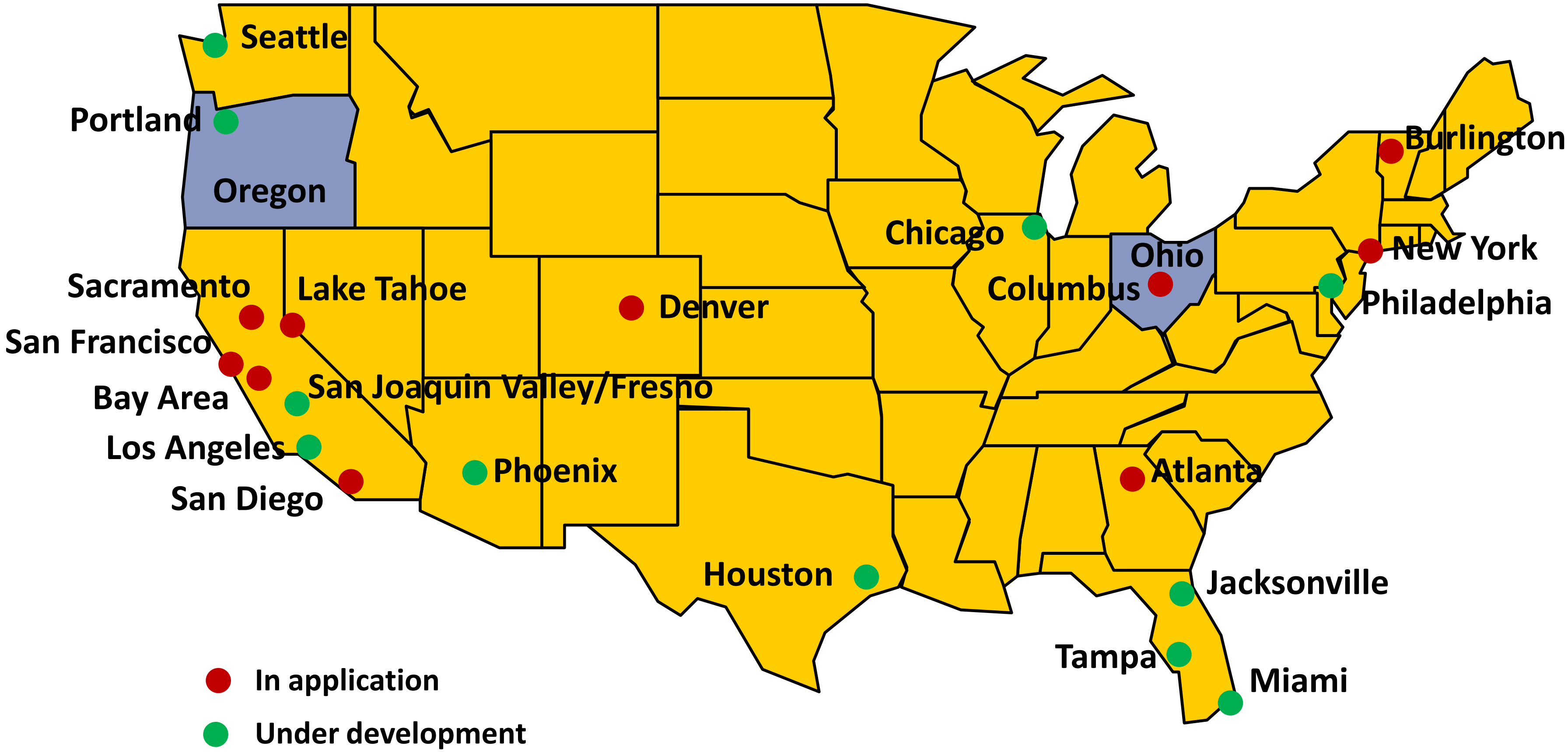
# Uncertainties of Implementing Activity-Based Models

- Quality
  - Will it have the desired sensitivity to justify the investment?
  - Will the methods used in an activity-based model be accepted in tightly regulated modeling contexts:
    - EPA conformity, FTA New Starts, NEPA alternatives analysis, LRP?
    - Will the agency still need to maintain a separate trip-based model?

# Uncertainties of Implementing Activity-Based Models

- User Experience
  - What is the learning curve?
  - Will the application software be user friendly?
  - Will it be comprehensible and easy to explain to stakeholders?
  - Can the detailed output of an activity-based model be transformed into transparent and concise decision-supporting formats?
  - Will constituent agencies and consultants be able to use it?
    - Transit agencies, DOT partners, municipalities, local consultants

# Activity Modeling Systems in the U.S.



# Shift in Travel Modeling Paradigm

- 35 largest MPOs (1 million +) in US:
  - 17 of them have developed or are developing an activity-based model
  - All large-scale model development projects in the last 5 years were activity-based models
- State-wide strategic decisions to move to an activity-based model
  - Ohio
  - California
  - Florida

# Implemented U.S. activity-based models

- San-Francisco County, CA (SFCTA) – in practice since 2001
- New York, NY (NYMTC) – in practice since 2002
- Columbus, OH (MORPC) – in practice since 2004
- Lake Tahoe, NV (TMPO) – in practice since 2006
- Sacramento, CA (SACOG) – in practice since 2008
- Oregon DOT – in practice since 2008
- Ohio DOT – in practice since 2009
- Atlanta, GA (ARC) – in practice since 2009
- San-Francisco Bay Area, CA (MTC) – in practice since 2010
- Denver, CO (DRCOG) – in practice since 2010
- Burlington, VT (CCMPO) – completed in 2011
- San-Diego, CA (SANDAG) – completed in 2011

# Models currently under development in the U.S

- Seattle, WA (PSRC) – started in 2008
- Portland, OR (Metro) – started in 2008
- Los-Angeles, CA (SCAG) – started in 2009
- Phoenix, AZ (MAG) – started in 2009
- Chicago, IL (CMAP) – started in 2010
- Miami, FL (SERPM) – started in 2011
- Houston, TX (HGCOG) – started in 2011
- Jacksonville, FL (NFTPO) – started in 2011
- Tampa, FL (FDOT District 7) – started in 2011
- Philadelphia, PA (DVRPC) – started in 2012

# Common Features of Activity-based Models

- Synthetic population generators
- Long-term, mobility models for work, school locations, auto availability
- Models that generate tours, sub-tours and stops on tours
- Models that choose destinations within a tour context
- Models that choose modes within a tour context
- Models that choose starting and ending times for tours and/or activities
- Simulation methods to generate outcomes

# Tour Modeling Dimensions

Tour primary destination
↓
Tour time-of-day
↓
Entire-tour mode
↓
Stop frequency
↓
Stop location
↓
Trip mode
↓
Trip departure time

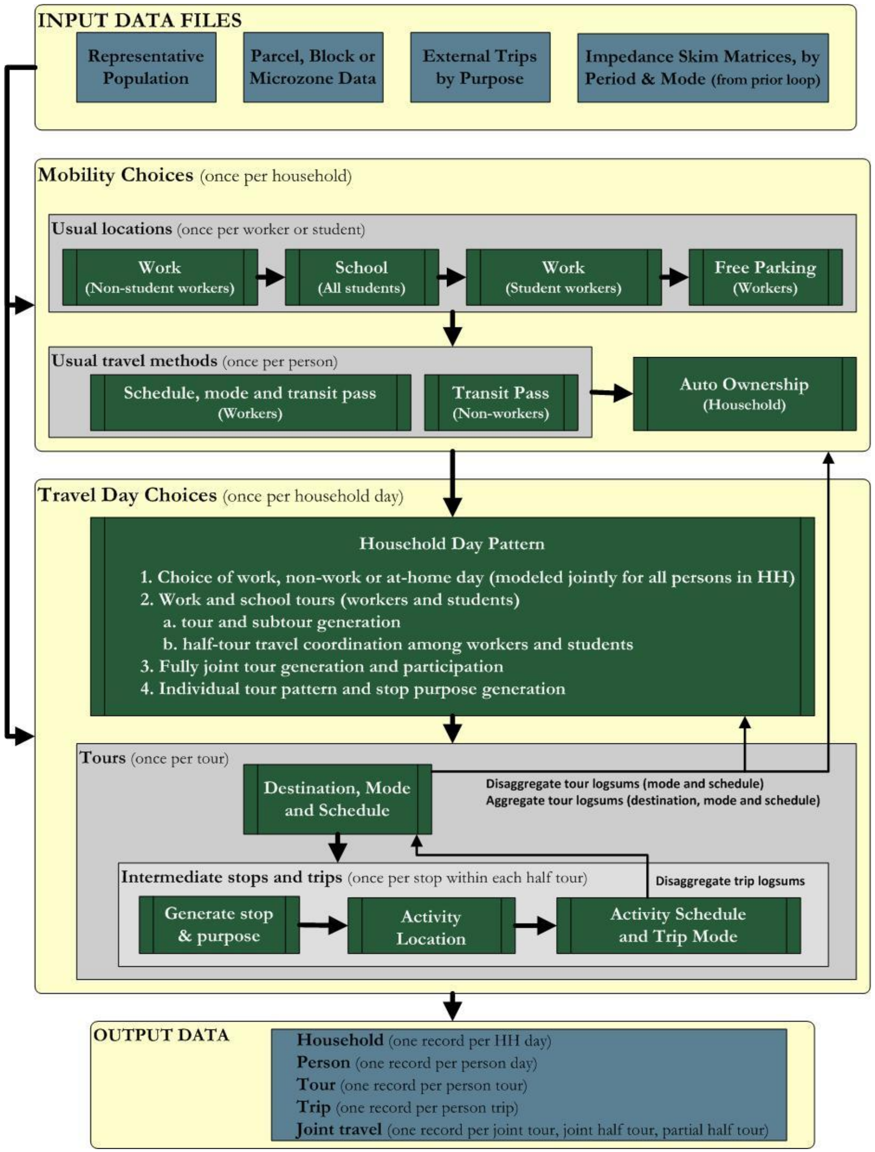
Mode choice composite utilities (OD-accessibility)

Accessibility of potential activity sites along the route between the primary destination and home

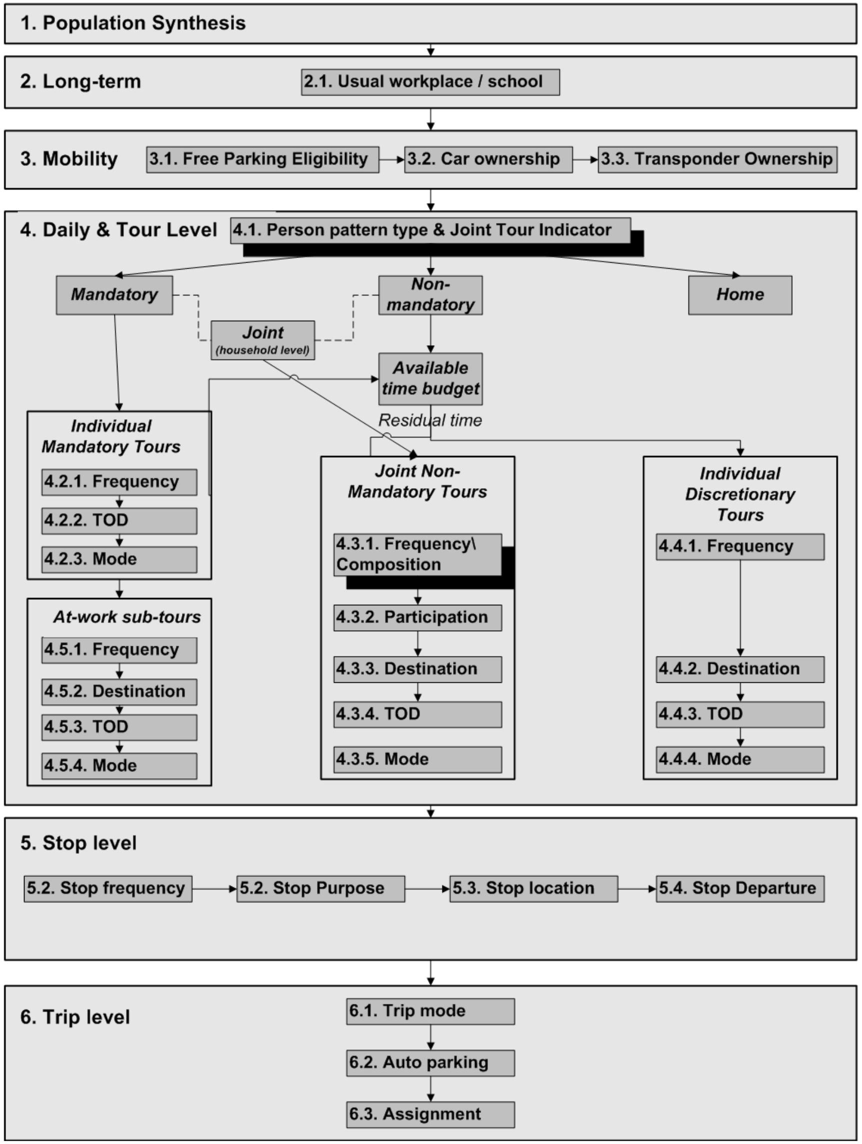
# Evolutionary Trends in Activity-Based Models

- Early fundamentals
  - Generation and scheduling of tours and daily activity patterns
- Adding spatial detail
  - Sub-zonal level land use detail to support analysis of land use and pedestrian accessibility (parcels, micro-zones)
- Adding inter-personal coordination
  - Intra-household activity generation and scheduling
- Adding temporal resolution and dynamics
  - More time slices, moving toward pseudo continuous time representation (better for modeling time-sensitive costs)

## DaySim

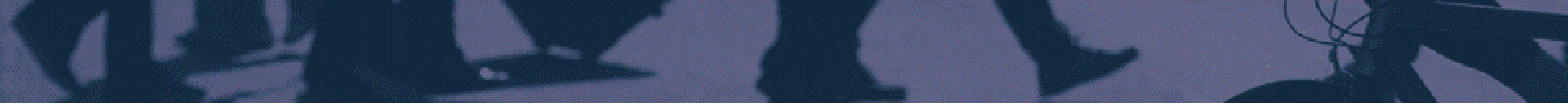



## CT-RAMP



# Similarities to Trip-Based Models

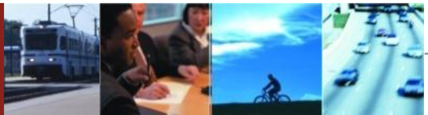
- Network assignment algorithms, skims and software
  - But perhaps more assignment time periods
- Socio-economic and land use inputs
  - But perhaps at more disaggregate spatial units
- Auxiliary travel markets:
  - Trucks and other commercial vehicle movements
  - Airport and visitor trips
  - IE/EI/EE trips



# Transitioning to a More Advanced Modeling Tool

- Can one innovate incrementally?
- Are there methods that can add sensitivity to trip-based models to make them on par with activity-based models?
  - Additional market segmentation
  - TDM assumptions
  - 4D land use tool
- A more complicated trip-based model may not be worth the effort
- Adding features and segments to an existing trip-based model may become unwieldy





# Historical Approaches to Developing Activity-Based Models

- Upfront development
  - Single concerted effort, one RFP
  - Multi-stage effort, intermediate deliverables, multiple RFPs
- Phased development
  - Multi-stage effort, replace 4-step model components gradually, multiple RFPs
- Transfer and refine
  - Single or multi-stage effort to adapt an existing model to a new region

# Upfront Development – One RFP

Examples: New York (NYBPM), Columbus (MORPC), San Francisco (SFCTA), Denver (DRCOG)

- Advantages
  - Control over system design
  - Full system available
  - Cover all markets
- Disadvantages
  - New software
  - Entire budget must be committed upfront

# Upfront Development – multiple RFPs

Examples: Atlanta(ARC), Sacramento (SACOG), Phoenix (MAG)

- Advantages
  - Control over system design
  - Effort can be scaled to available funding stream
- Disadvantages
  - Additional effort to select contractors
  - Risk that effort may be put on hold if funding is not available
  - Waiting time until full model features are available

# Phased Development

Examples: San Diego (SANDAG), Seattle (PSRC)

- Advantages
  - Delay some costs until budget available
  - Resource development (data)
  - Gain familiarity with model software and operation
  - Control over system design
- Disadvantages
  - Not able to enjoy full benefits of model design until entire model is implemented

# Transfer and Refine

Examples: Lake Tahoe (TMPO), Chicago (CMAP), Jacksonville (NFTPO), SF Bay Area (MTC)

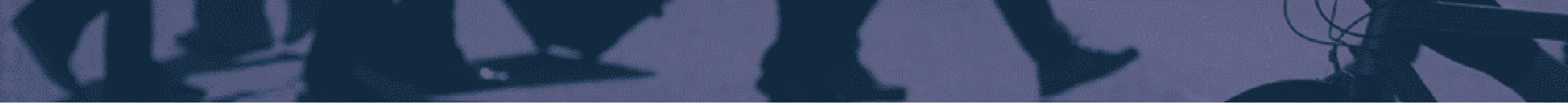
- Advantages
  - Low cost solution to get started
  - Rapid implementation
  - Focus attention on key components
  - Proven to work elsewhere
- Disadvantages
  - Delay wholesale changes to model design to future
  - Unknown a priori whether the model will transfer well
  - Unknown effort required to refine the model to an acceptable level
  - Will likely need TBM longer

# Questions and Answers

The Travel Model Improvement Program

# Resources Needed to Develop and Maintain Activity-Based Models

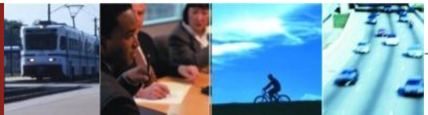
- Budget
- Development timeline
- Agency
- Software
- Hardware
- Data
- Funding mechanism



# Development Cost Drivers

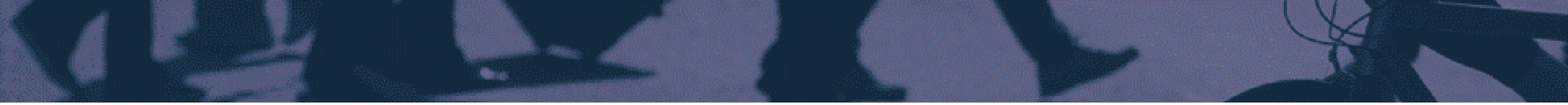
- Adopt existing paradigms or develop your own?
- Transfer of software of existing ABM or your own development?
- Full re-estimation of disaggregate models or adoption and aggregate recalibration?
- Include new, advanced features?
- Extent of data collection?
- Develop in-house or hire consultant?





# How much did it cost?

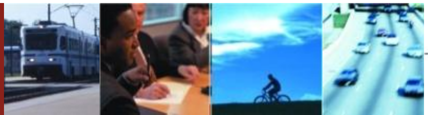
- It can be difficult for agencies to separate out the costs of activity-based model development from other activities
  - Range of consulting budgets and staff FTEs – separation of budgets (before/after)
  - In-kind contributions of MPO staff
  - Database development (GIS, surveys) serve multiple purposes
  - Maintenance costs blended into work programs
- The first activity-based models started from scratch, but newer development options have different cost structures



# Development Cost – Sacramento Example

- $849,000 in consulting fees over 11 years
  - Initial development costs $514,000 to get to calibrated model in 2008
  - 2011 Model enhancement costs $335,000
    - Enhanced temporal resolution
    - Tolling/pricing analysis capabilities
- SACOG staff prepared land use parcel database over 5 years, a significant effort shared with other agency staff





# Development Cost – San Diego Example

- $1.2 million in consulting fees over 4 years
  - Approximately $300k per year
  - Significant software development (micro-zones)
  - Phase I models (long-term models, tour\stop generation)
  - Phase 4 (last) includes a series of sub-models including
    - Airport passenger simulation
    - Cross-border travel simulation
    - Special Events
    - Visitor Model
    - External Travel Model
  - SANDAG staff provided support in development of a land use database

# Development Costs – Other Examples

- Lake Tahoe - $250k
  - Transferred Columbus model and calibrated to local data
  - Developed a special visitor simulation model
- Chicago Metropolitan Agency for Planning ($800k)
  - $300k for initial pricing demonstration model, based upon ARC model with pricing enhancements
  - $500k for advanced transit innovations

# Development Timeline Drivers

- What is the annual funding stream?
- How soon is the model needed?
- Is new data collection required?
- Build upon existing models, or develop your own?
- Include special market models?
- What will be the extent of agency staff involvement?

# Development Timelines – Sacramento (SACOG)

- Model Design 2001
- Develop Parcel Database 2002-2004
- Model Estimation 2005-2006
- Model Calibration 2006-2008
- Peer Review 2008
- Model Update 2011

# Development Timelines – San Diego Example

- Model Design, Long-Term Models, and Phase I Model
  2009
- Tour Scheduling, Destination, Mode Choice Models
  2010
- Trip Models, Calibration
  2011
- Model Validation, Submodel Development, System Integration
  2012

# Agency Staff Resources

- Staff participation in model development depends on interest, skills, availability
- Ability to use the model effectively once it is implemented hinges on being able to understand it and explain it. This means investing in building staff activity-based modeling skills.
- Direct involvement in model development helps reduce budget for consultant services, and increases familiarity with model system

# Agency Staff Resources

- San Diego Example
  - Approximately 2-3 FTEs on the development and maintenance of the activity-based model
  - This is 30% of their transport modeling staff time
  - Some support required from land-use modeling staff
- Sacramento Example
  - Approximately 3-4 FTEs on the development of the parcel database in 2004
  - 4 staff working ½ time and 3 staff working ¼ time on modeling activities (2 ¾ FTE total)

# Model Maintenance and Applications Support

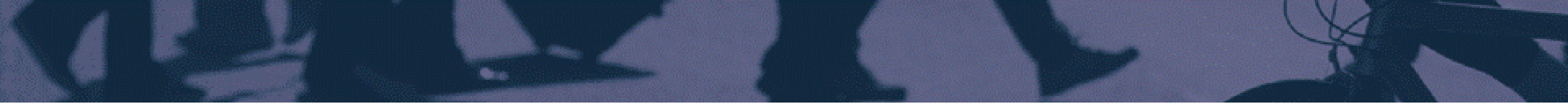
- Prepare input data, operate the model, analyze model results
- In-house GIS, database and SQL programming skills essential
- In-house programming skills highly desirable
- Consultant assistance for model extensions and upgrades

# Software

- All models rely on commercial transportation planning packages for skimming and assignment (TransCAD, Cube, EMME, VISUM)
- Models deployed or under development are written in object-oriented languages (C, C++,C#, Java); some are open source, public domain software
- Data management and data query software are required to maintain input and output datasets and create reports and visualizations (MS SQL, MySQL, etc.)
- Some models use distributed computing architecture (JPPF, Windows HPC)

# Hardware Specification and Cost

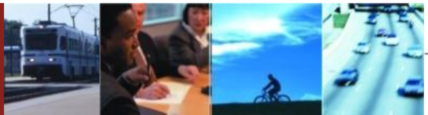
- Most important driver of run time is the size of the model population
- Number of network assignment periods and feedback loops is also important
- Tradeoff between run time and hardware cost – more and faster processors reduce run time, but increase server costs
- Some models use distributed processing, splitting the computation time among several computers
- Other hardware includes backup systems and model run archiving capacity



# Hardware Specification & Cost

- San Diego Example (CT-RAMP)
  - Trip-based model run time is 9-12 hours (with TransCAD) on a single desktop computer
  - Activity-based model run time is 12 hours with TransCAD on 24 processors (3 machines with 8 processors each - hardware cost $40,000)
- Sacramento Example (DaySim)
  - Trip-based model run time is 4-6 hours on a single desktop computer
  - Activity-based model run time is 16-20 hours with Cube on a single desktop computer, purchased in 2008.





# Hardware Specification and Cost

- Fresno, CA (DaySim):
  - 288,862 households
  - 820,890 persons
- Trip-Based Model System
  - Total run time: 12 hours with 3 feedback loop iterations
  - “3-step demand components”: 2 hours per iteration
  - Running on 2.8GHz 8 core machine, 16GB of fast RAM
- Activity-Based Model System
  - Total run time: 8 hours with 3 feedback loop iterations
  - DaySim demand components: 1.3 hours per iteration
  - Running on 2.93GHz 4 core machine, 16GB of standard RAM

  (Cube Voyager used in both cases)

# Data Requirements

- Data requirements are the same or similar to those of trip-based models
- Some optional model features call for additional data collection:
  - Parcel or micro-zone population and land use inventories
  - Parking availability, transponder ownership, transit pass ownership
  - Highway and transit operations data for multiple time periods

# Data Requirements

- Recent household survey required for model estimation and development of some calibration targets
  - Activity based modeling is less forgiving of incomplete person roster, trip diaries or missing information
    - Requires consistency across trip choice dimensions and across individuals
  - But it can make use of data that is typically asked for but not used by trip-based models
    - Age, gender, occupation, employment status, driver license, usual workplace and school locations, vehicle used, etc.

# Funding Approaches

- Build into model development work program
- External grants (SACOG, SANDAG)
- In-kind, cost-sharing arrangements
  - MPO staff develop land use database, networks, auxiliary demand (SANDAG)
  - MPO staff develop enterprise database, software (DRCOG)
- Cross-agency cost sharing
  - Two agencies share the cost of developing a common software component (ARC & MTC)

# User Experience Compared with Trip-based Model

- Calibration , validation, sensitivity testing
- Model applications
- External users
- Communicating results to stakeholders

# Calibration, Validation, Sensitivity Testing

- Calibration is similar to trip-based model.
- There are more models to calibrate, but they look better “off the box”.
- Validation to external sources (traffic counts, etc.) is nearly same as trip-based model
- Sensitivity testing is where activity-based models reveal their true advantages
  - Extremely important for staff comfort in adopting a new model
  - Comparison with legacy trip-based model is recommended

# Model Applications

- SFCTA Applications
  - Congestion Management Program
  - Countywide Transportation Plan
  - Geary Corridor and Van Ness Avenue BRT Studies
  - Multiple Neighborhood Transportation Plans
  - Transbay Terminal Development
  - Caltrain Electrification Study
  - San Francisco Mobility Access and Pricing Study
  - Third Street Light Rail Study
  - MTA Central Subway New Starts Application

# Model Applications

- NYMTC Example
  - Air Quality Conformity Reports
  - Regional Transportation Plan
  - Manhattan Area Pricing Study
  - Goethals Bridge Environmental Impact Study
  - Lincoln Tunnel Exclusive Bus Lane II
  - Evaluation of Tolls at the Henry Hudson Bridge and Rockaway Crossings
  - Highway development studies for the Tappan Zee Bridge, Gowanus Expressway, and Bruckner Sheridan Expressway
  - Long Island East Side Access Study (Commuter Rail)
  - Multiple subarea studies (highway & transit needs)

# Model Applications

- SACOG Example
  - 2 Air Quality Conformity Reports since 2008
  - 2010 SB375 greenhouse gas (GHG) emissions analysis
  - 2008 head-to-head comparison with SACMET (trip-based model) in developing the 2035 Metropolitan Transportation Plan
  - Placer Vineyards transit-oriented development scenario analysis
  - Curtis Park Village infill development project scenario analysis

# Model Applications

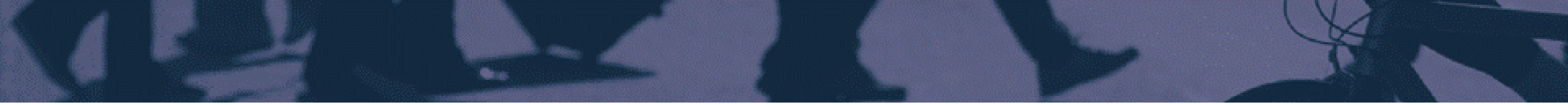
- Oregon Statewide Model
  - Oregon Bridge Study
  - Oregon Statewide Freight Plan
  - Willamette Valley Land Use and Transportation Visioning Study
- Ohio Statewide Model
  - Ohio Turnpike 2005 and 2010 toll changes.
  - US 22/36 Economic Impact Study.
  - Brent Spence Bridge Commodity Flow Study.
  - Go Ohio Transportation Futures.
  - TRAC program project evaluation.

# External User Experience

- Municipalities, local consultants, transit agencies
- May be initial resistance to adopting a new tool
  - Lack of familiarity, skepticism
  - Concerns: hardware/software costs, productivity, staff abilities/training
- Keys to success are same as for internal staff
  - Training and documentation
  - User-friendly interface

# External User Experience

- NYMTC
  - More than 30 external users among partner agencies and consultants
- SANDAG
  - Provides remote access to its servers
- ARC
  - Cloud computing implementation for external users



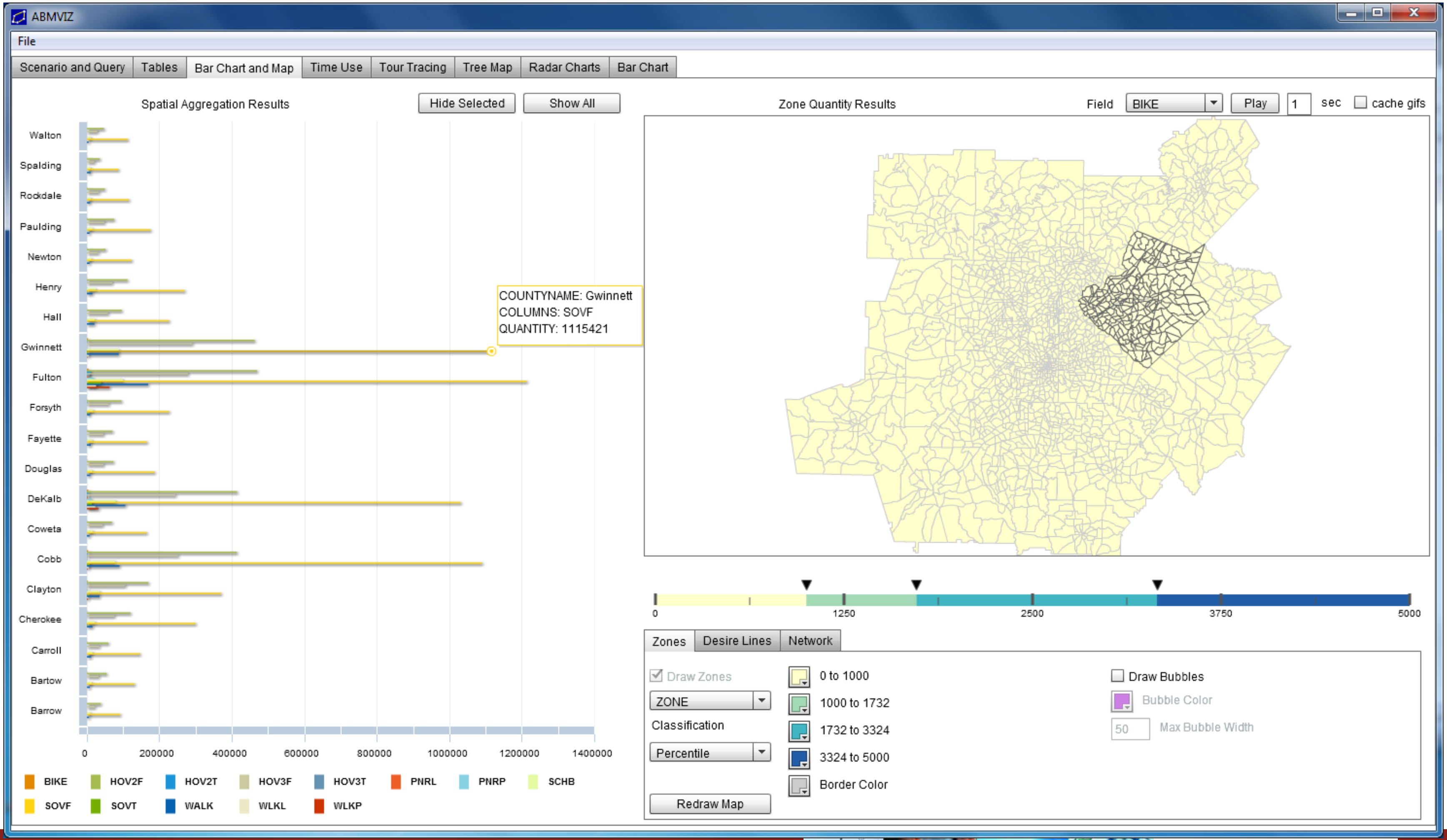
# Stakeholder Acceptance and Use

- Disaggregate nature of activity-based models provides unprecedented opportunities for data exploration and derivation of performance measures
- Theoretical design of activity-based models (tours, scheduling, etc.) is closer to reality than trip-based abstractions
- Experience in communicating with stakeholders
  - Anecdotal evidence (SACOG) suggests that stakeholders generally find the results easy to understand and intuitive

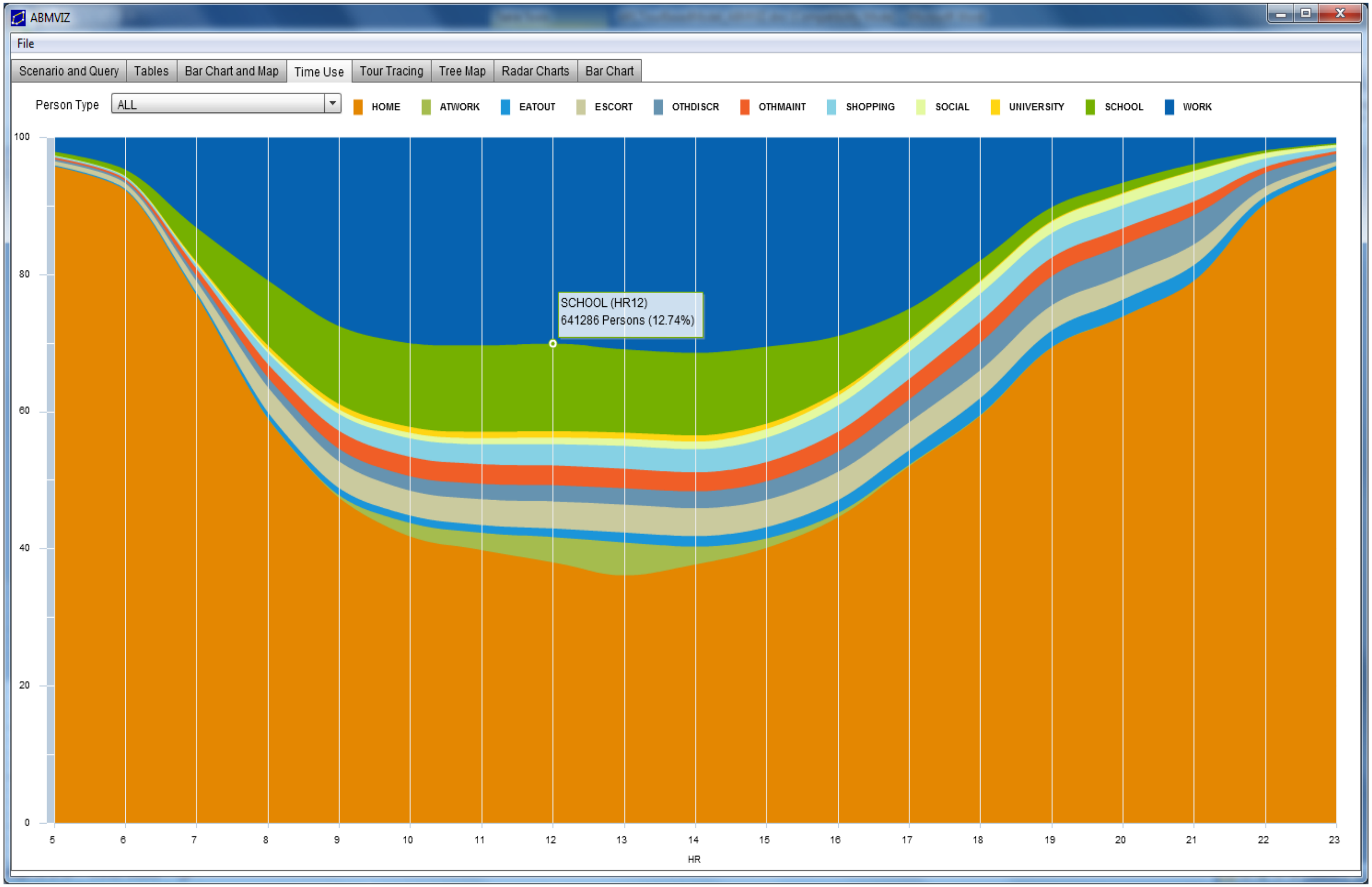


# Atlanta Dashboard – ABMVIZ

## Generates Tables, Reports, Charts, Maps and Animations

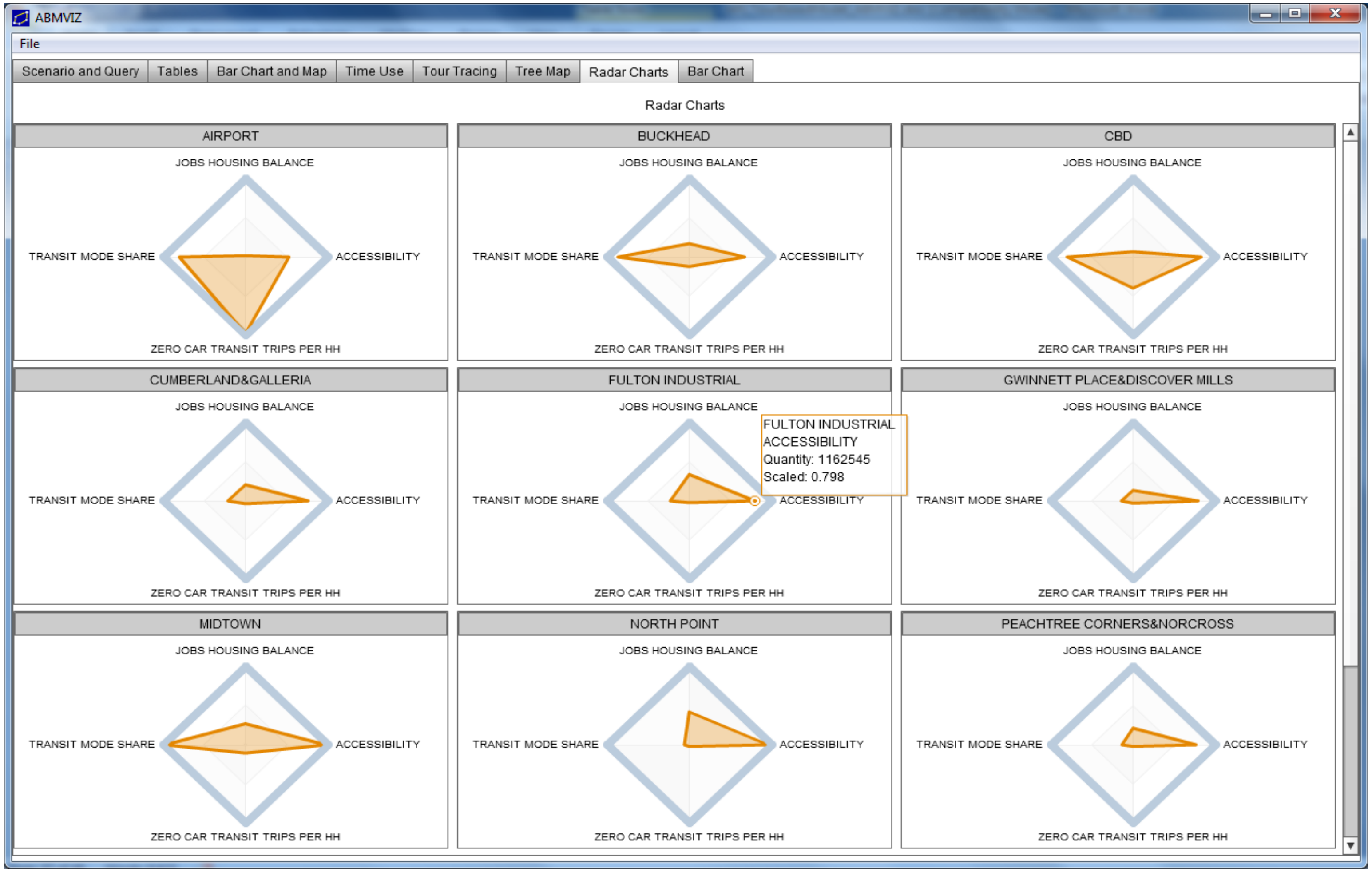


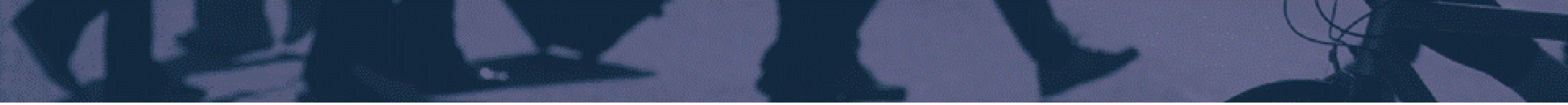
# Atlanta Example – Time Use Analysis



# Atlanta Example – Radar Chart

## Comparing Difference Entities Across Multiple Measures

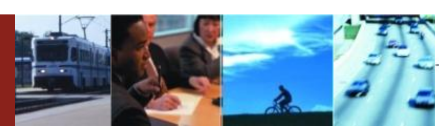




# Ongoing Developments

- Multiple instances of model transfers, with adaptations
- Continuous improvement of existing designs
- Better processing technology improves run times
- Scenario management and visualization of outputs continue to improve
- Integration with dynamic traffic assignment under development
- Integration with urban land use models underway (already achieved with 2 statewide models)





# Review:  Learning Outcomes

- Typical motivations and concerns of agencies considering an activity-based model
- How activity-based models have evolved in the U.S.
- Development options for migrating from 4-step to activity-based models
- Resources needed to implement an activity-based model program
- Experience with stakeholder acceptance and use

# Questions and Answers

The Travel Model *Improvement* Program

# 2012 Activity-Based Modeling Webinar Series

| | |
|---|---|
| **Executive and Management Sessions** | |
| Executive Perspective | February 2 |
| Institutional Topics for Managers | February 23 |
| Technical Issues for Managers | March 15 |
| **Technical Sessions** | |
| Activity-Based Model Framework | April 5 |
| Population Synthesis and Household Evolution | April 26 |
| Accessibility and Treatment of Space | May 17 |
| Long-Term and Medium Term Mobility Models | June 7 |
| Activity Pattern Generation | June 28 |
| Scheduling and Time of Day Choice | July 19 |
| Tour and Trip Mode, Intermediate Stop Location | August 9 |
| Network Integration | August 30 |
| Forecasting, Performance Measures and Software | September 20 |

# Continue the discussion online…

The new TMIP Online Community of Practice includes a Discussion Forum where members can post messages, create forums and communicate directly with other members. Simply sign-up as a new member, navigate to http://tmiponline.org/Community/Discussion-Forums.aspx?g=posts&t=523 and begin interacting with other participants from today's webinar session on Activity-Based Modeling.