TMIP Webinar Series

Activity-Based Modeling

Session 12: Forecasting and Application

The Travel Model Improvement Program

Speakers: John Gliebe & Peter Vovsha

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- Presenters
  - John Gliebe & Peter Vovsha
- Moderator
  - Stephen Lawe
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  - Maren Outwater, Peter Vovsha, John Gliebe, Mark Bradley
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  - Bhargava Sana

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2012 Activity-Based Modeling Webinar Series

Executive and Management Sessions	
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Institutional Topics for Managers	February 23
Technical Issues for Managers	March 15
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Tour and Trip Mode, Intermediate Stop Location	August 9
Network Integration	August 30
Forecasting, Performance Measures and Software	September 20

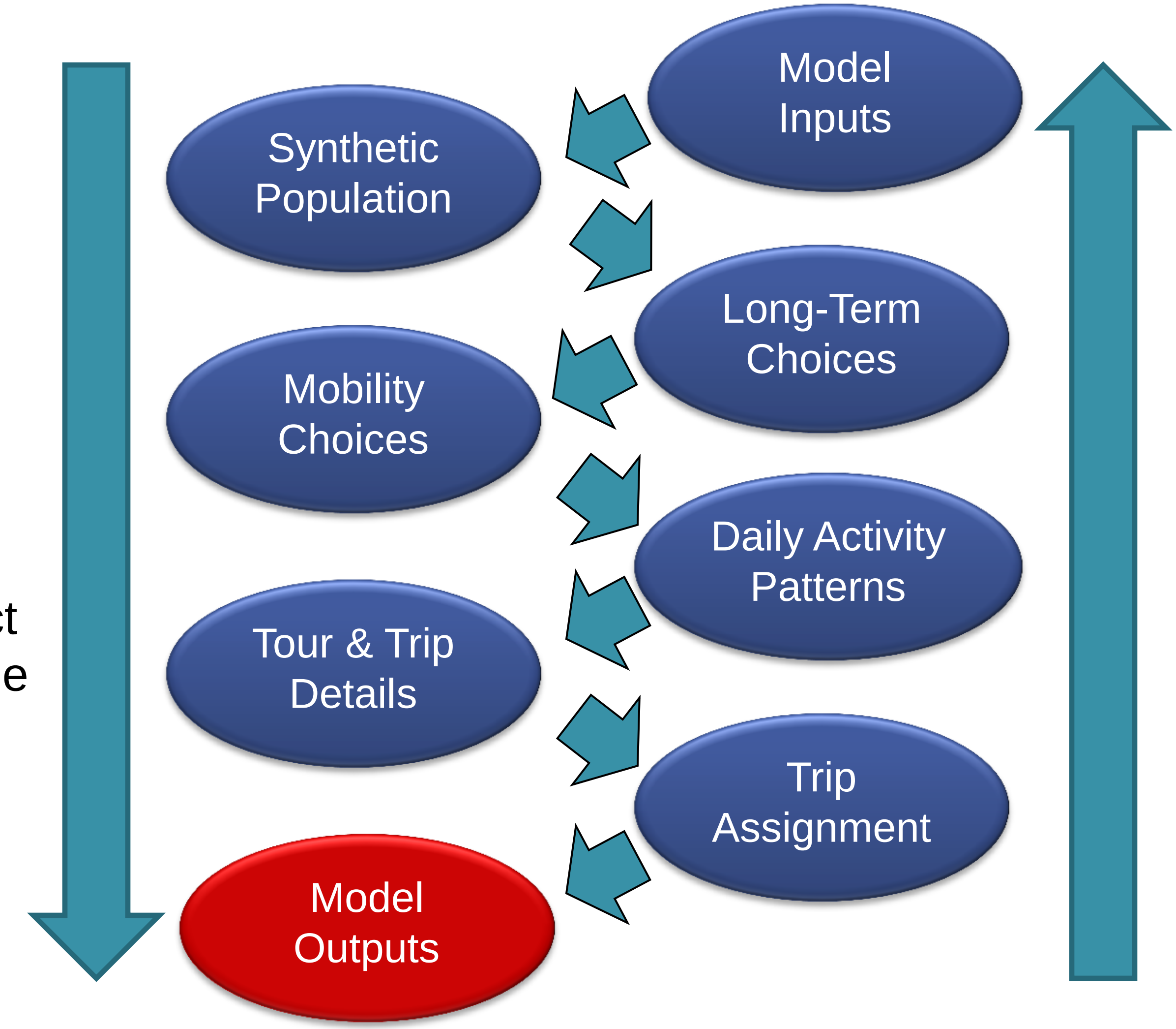
Learning Outcomes

- Steps involved in preparing an activity-based modeling system for forecasting
- Output measures produced with an activity-based modeling system
- Differences in alternatives analysis with an activity-based modeling system
- Hardware and software considerations for activity-based modeling applications

Activity Based Model System Components

Downward Integrity:

Choices made in higher models affect choices made in lower models



Upward Integrity:

Expected utility of making choices in lower models affect choices made in higher models

Outline

- Importance of forecasting methodology, performance measurement and software development
- Basic terminology
- Calibration with activity-based models
- Performance measures and sensitivity testing
- Random variation and alternatives analysis
- Example applications
- Implementation in hardware and software
- Areas of research

Important Differences in Activity-based Model Forecasting Practice

- A much richer array of output measures are possible
- Internal complexity requires new understanding of how to properly calibrate and validate activity-based models
- Are not just about trips–interpretation of daily patterns, tours, activity durations are important to comprehensible forecasts
- Use of simulation to produce forecasts–controlling and explaining random variation is important to producing consistent forecasts and communicating with decision makers
- Application software is needed to take advantage of more powerful analytical capabilities, but must be designed to handle greater computational loads

Terminology

Micro-simulation	• A travel demand model that simulates individual agents (person, households, vehicles)
Performance measures	• An output of the travel demand model that assesses the benefits of a strategy or alternative
Forecasting	• Representation of a future year with assumptions about growth, transportation and the economy
Data visualization	• Graphic, tabular or spatial presentation of model output or input
Multi-threading	• Processing across multiple cores within a computer
Distributed processing	• Processing across several computers in a network

Steps Involved

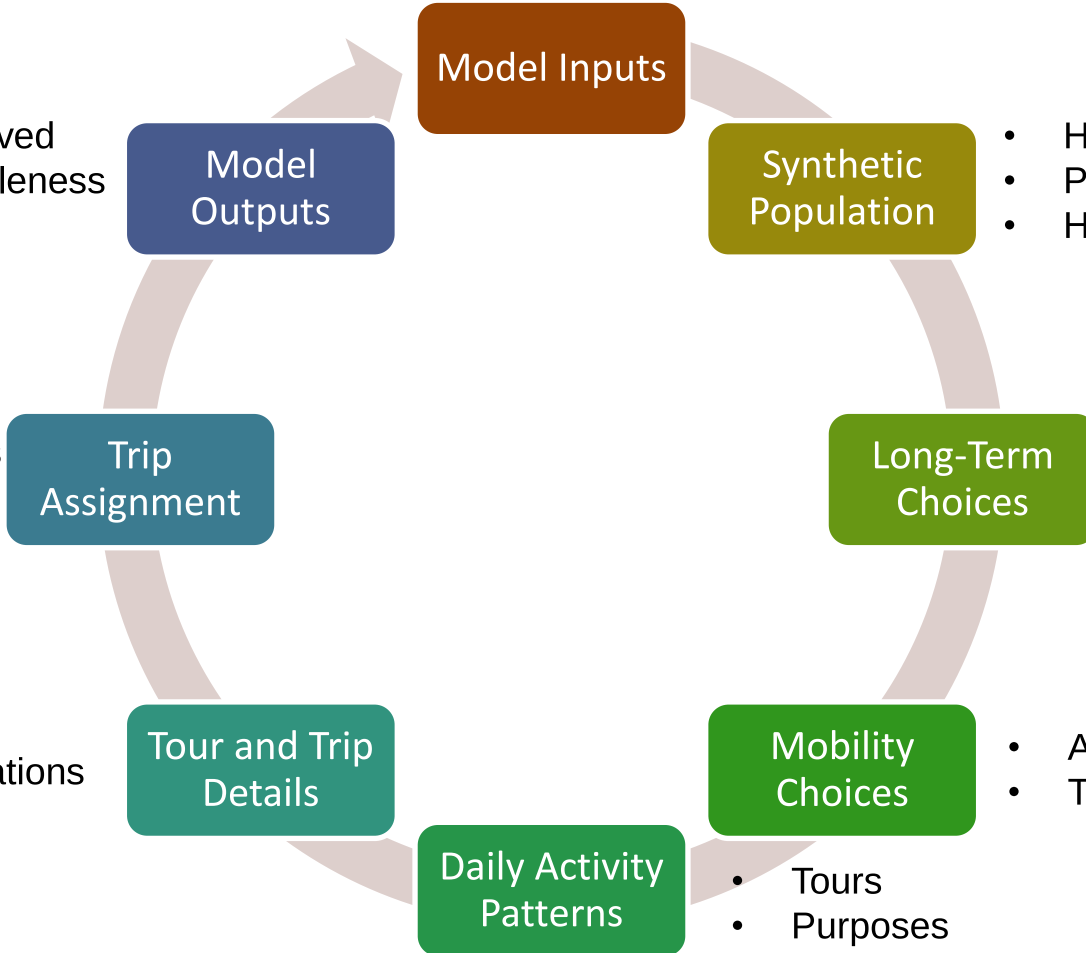
- Preparing forecasts involves steps very similar to those of trip-based model development
  - Base-year calibration and validation
  - Horizon-year baseline forecasts and sensitivity tests
  - Alternative forecasts
    - Network alternatives
    - Land use alternatives
    - Policy alternatives

Base-year Calibration and Validation

1. Calibrate individual model components—ensure expected behavior
   – Compare with expanded household survey, JTW data
   – More components produces more points of calibration and greater confidence in forecasts
2. Calibrate system-level with iterative feedback—make sure individual model components remain calibrated

- Validate to traffic counts and transit boardings
  – Expectation is that activity-based model will match the trip-based model (but not improve)

Iterative Calibration



- Households
- Persons
- Home location

- Work location
- School location

- Auto ownership
- Transit pass

- Tours
- Purposes
- Schedule

- Trips
- Destinations
- Modes

- Highway volumes
- Transit boardings

- Compare to observed
- Assess Reasonableness of Forecasts

Traditional Calibration Metrics

- Some calibration metrics are familiar to trip-based modelers and can be derived from activity-based model output
  – Vehicle availability by zone or district
  – Work commute flows by district
  – Activity/trip frequencies by type
  – Activity/trip frequencies by time of day
  – Trip length distributions
  – Trip mode shares

Additional Activity-based Model Metrics

- Others are specific to tour- and activity-based models
  - Activity duration by type
  - Number of tours by type
  - Number of work-based sub-tours
  - Number of stops per tour
  - Home-based tour duration
  - Tour mode shares
  - Auto tour lengths
  - Transit tour lengths

How much time to calibrate?

- Activity-based models have many more components—and require more time to calibrate
  - Individual components
  - System-level calibration
- Activity-based models provide a better starting model
  - Fewer problems both in validation and in other types of scenario/sensitivity runs
  - Disaggregate population; linkages across persons, long-term and medium-term decision modules, activity generation and scheduling modules, tour-based linkages, daily pattern linkages, time of day consistency

Transferability of Model Systems

- Jury is still out on whether this is advisable… .
- MORPC → Tahoe was the first successful example
- ARC, MTC co-development of system structure--variable specifications, coefficients not so transferable
- DVRPC process
  - Transfer to get the AB model up and running
  - Estimate and calibrate with local data
- FHWA transferability research projects:
  - Comparing AB models developed in California and Florida under same model structure--DaySim

Disaggregated Model Forecasting vs. 4-Step

- Enhanced explanatory power
  - One-way toll in PM period—included in tour mode choice
  - Shorter work days—included in day pattern models
- Intuitive interpretations
  - Ability to trace back outcomes to their source of change
  - Improved communication with planners

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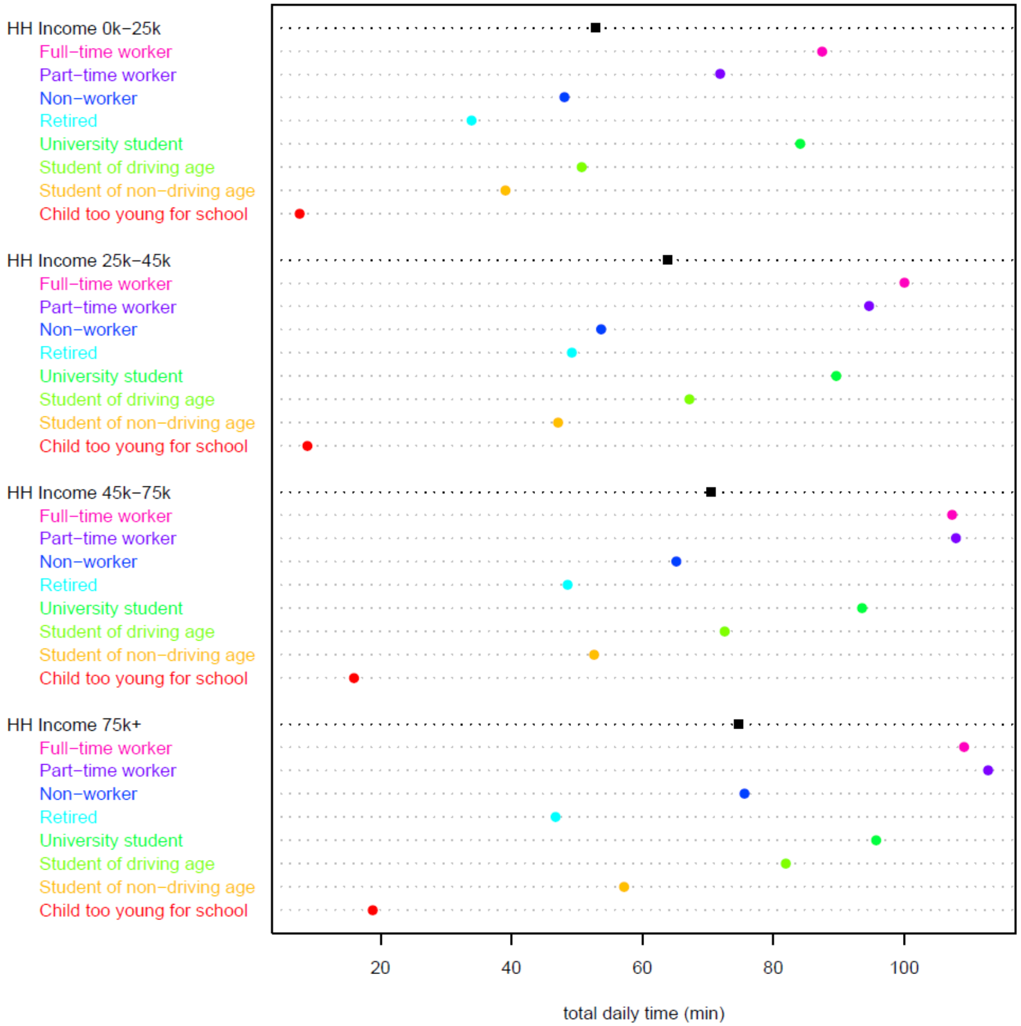
Mobility and Equity Performance Measures

- Mobility
  - Trip length distributions
  - Mode shares
  - Travel times and costs
- Equity
  - ABM output looks like a full population household survey and can be expanded in any way to understand equity

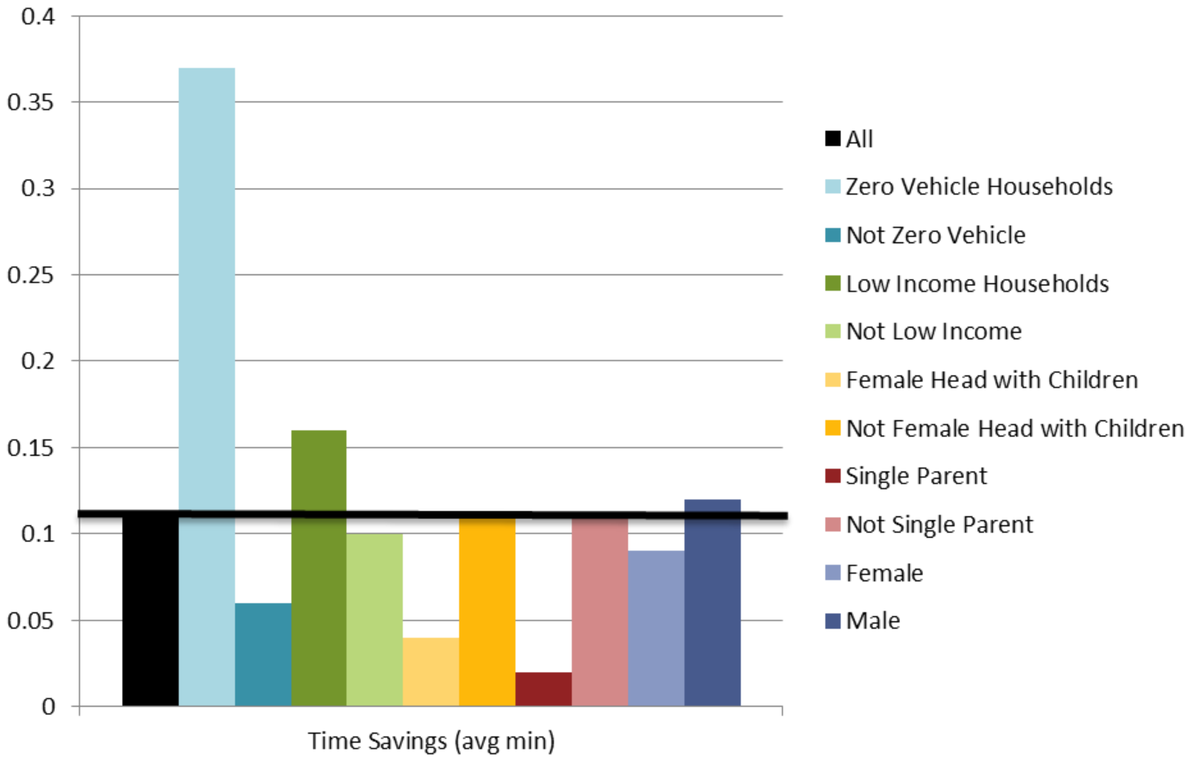
Travel Time Analysis in Chicago

- Total daily travel time by income group and person type



Equity Analysis in San Francisco

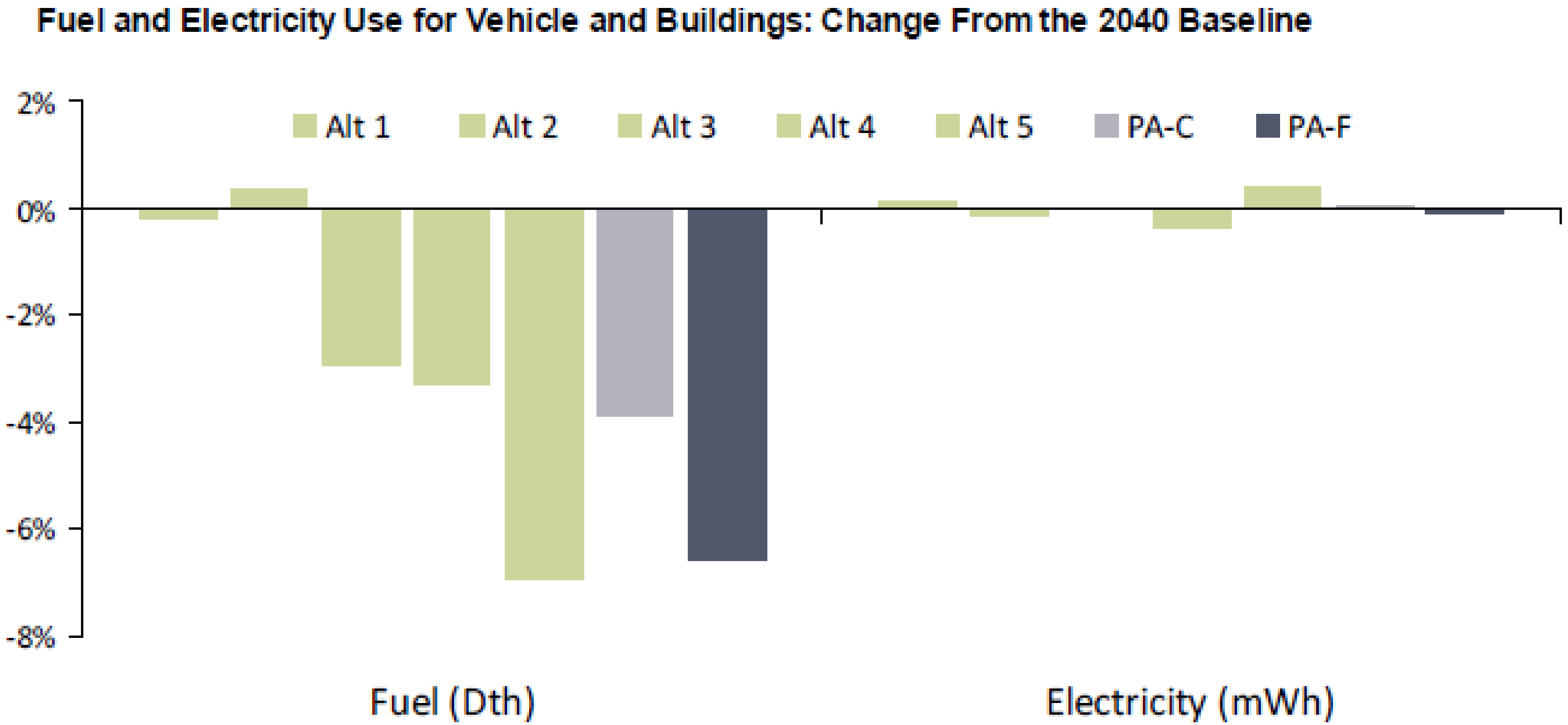
- Travel time savings for different population groups compared against the average



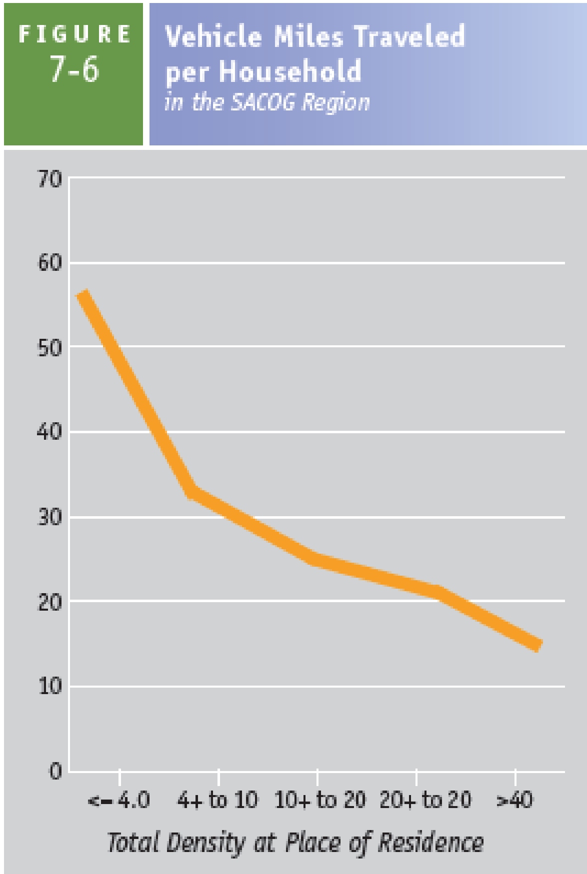
Environmental and Growth Performance Measures

- Environmental
  - Vehicle emissions at the source
  - Stationary emissions
  - Energy use
- Growth
  - Jobs-Housing Balance
  - Growth in centers

Energy Use by Alternative and Source in Seattle



VMT per Household for Sacramento



Source: SACOG Household Travel Survey, 2000

- VMT can be tracked per household, incorporating all tours and trips
- VMT decreases with density at residence
- Growth in areas of higher density will have lower VMT per household

Economic and Life Performance Measures

- Economic Development
  - User benefits to low and high wage employment
  - User benefits to freight centers
- Quality of Life
  - Safety (crashes)
  - Health (active transportation)

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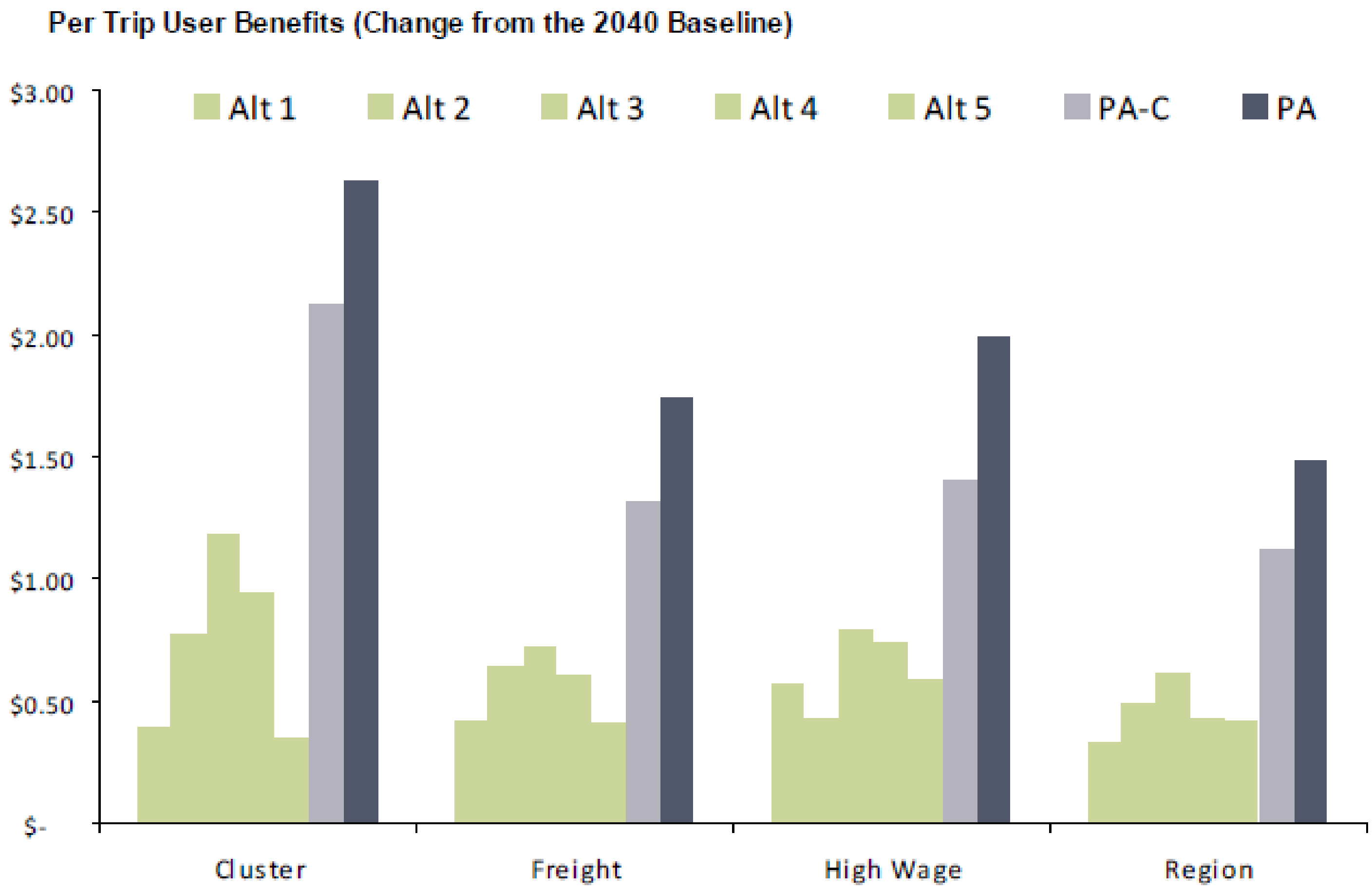
User Benefits for Economic Prosperity in Seattle



Bike and Walk Considerations

- Include location and types of bicycle facilities, the presence of sidewalks, crossing locations and other network elements in networks
- Separate bike access to transit
- Include bike and walk times in accessibility measures
- Use bike and walk networks to estimate parcel to parcel distance instead of straight-line distance
- Estimate bike route choice
- Use of distance-decay functions in creating buffer-based measures rather than a simple total within a ½ mile.

Scenario Testing

- Reasonableness tests -- sensitivity of outputs to changes in inputs
- Evaluation of specific policies and projects -- is the tool appropriately specified for the job for which it is needed?
- Fine tuning assumptions and specifications

Parking Pricing Scenarios in San Francisco

- $3 charge into/out of NE Cordon during weekday peak periods
- $3 parking charge in Focus Area

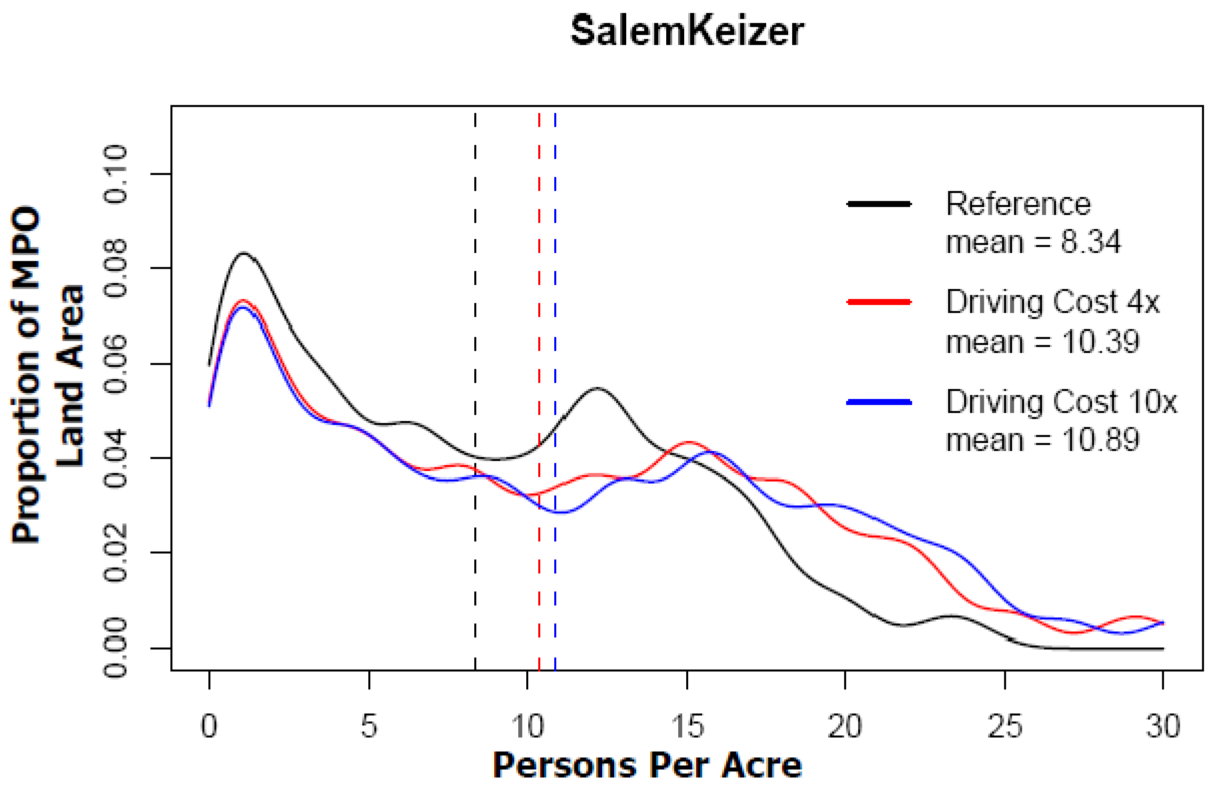
TABLE 1 Key results compared to a baseline scenario.

	Northeast Cordon Charge	Focus Area Parking Charge
Total Daily Charged Trips	250,000	145,000
Δ Total Daily Trips Citywide	~	-3%
Δ Peak Vehicle Trips to/from/within Focus Area	-14%	-22%
Δ Peak Vehicle Trips to/from/within NE Cordon	-12%	-12%
Δ Daily Non-Work Trips to/from/within Focus Area	~	-4%
Δ Daily VMT, Focus Area	-10%	-9%
Δ Daily VMT, Citywide	-5%	-3%
Δ Peak Period Transit Trips to/from Focus Area	+12,000	+15,500
Δ Peak Period Walk/Bike Trips to/from Focus Area	+6,000	-500

Sensitivity Testing

- Sensitivity of outputs to changes in inputs—baseline vs. alternative scenario
  - Reasonableness of "shifts" in
    - Routes, time of day, destinations, modes
    - Consider place-to-place geography, neighborhood impacts
    - Consider differences by value of time segmentation (activity purpose, income)
    - Consider differences by vehicle availability segmentation
  - Are there certain daily patterns that are under- or over-predicted (relative to survey)?

Oregon DOT SWIM Test to Increase Cost



- Regional Centers densities gain 20%+
- Other areas 0-10% density gains

Stability Across Scenarios

- Research indicates almost unequivocally that people maintain time budgets in daily life, which should remain stable across scenarios
  - Are average activity durations stable, reasonable?
  - Are the total amounts of time persons spend on out-of-home activities and travel stable, reasonable?
  - Is the ratio of travel time to activity-time stable, reasonable?
  - How does total household VHT change? Are there compensatory effects with household VMT?
  - Are the components of forecasted transit paths reasonable?
    - Walk access and egress distances?
    - Number of transfers?
    - In dynamic models, it is possible to miss connections?

Is tool appropriately specified for the job for which it is needed?

- Depends on the analysis objectives
- Example: evaluating road pricing options
  - Should respond appropriately to price signals
  - Elasticity different for different decision levels
    - Route choice – most elastic
    - Time of day – fairly elastic
    - Intermediate stop insertion/location – somewhat elastic
    - Tour mode / HOV choice – less elastic
    - Work location choice – inelastic
  - Should differ by person and household type appropriately
    - Greater willingness to pay
      - Higher income, work/school/college purposes, own transponder
    - Lower willingness to pay
      - Lower income, discretionary purposes, transit pass holder

Fine Tuning Assumptions and Specifications

- Counter-intuitive results or model system non-response or over-response should lead to re-examination of model components
  - Start with evaluating quality of input data sources and data use for calibration benchmarks – correct obvious errors
  - May need to re-specify and re-estimate choice models to provide important missing variables, or to constrain relationships between variables
- Consideration of forecast variables
  - Variables that are forecast with confidence
  - Variables that are not forecast – included for policy testing
  - Scenario management
    - Experiment with alternative futures (technologies, cost structures)
    - Risk analysis—assign probabilities to distributions of inputs (Peter work-from-home example)

Alternative Analysis with Activity-Based Models

- Clear advantages in ability to summarize outputs by virtually any available household or person attribute, geographic stratification, or time of day
- Simulation of outcomes has theoretical advantages, but presents practical challenges in handling stochastic effects
- Doing away with trip-independence assumptions has clear theoretical advantages, but requires new ways of interpreting outcomes, taking into account intra-personal and inter-personal linkages; tour-level versus trip-level decisions

Stochastic Variation

- Advantage: ability to portray a distribution of outcomes – more realistic – ability to portray risk
- Challenges:
  - Need to demonstrate that random variation does not swamp meaningful changes in policy variables
  - Non-technical decision makers may prefer a single number
  - Some analyses require analysis of comparative statics

Number of Iterations

- Consider changes across multiple outcome variables
  - Link volumes
  - Mode shares
  - Tour lengths
  - Trip lengths
  - Work destinations
  - Other destinations
  - …etc.
- How many iterations are required until outcomes change by less than X%?
- Can also specify an error tolerance level (say 10% on link volumes)—the number of runs required to achieve this will depend on your coefficient of variation across runs

SFCTA Tests on Random Simulation Error

- Results are stable across 100 runs for all geographies
- More variation at TAZ level
  - 3% difference initially
  - <1% after 10 runs

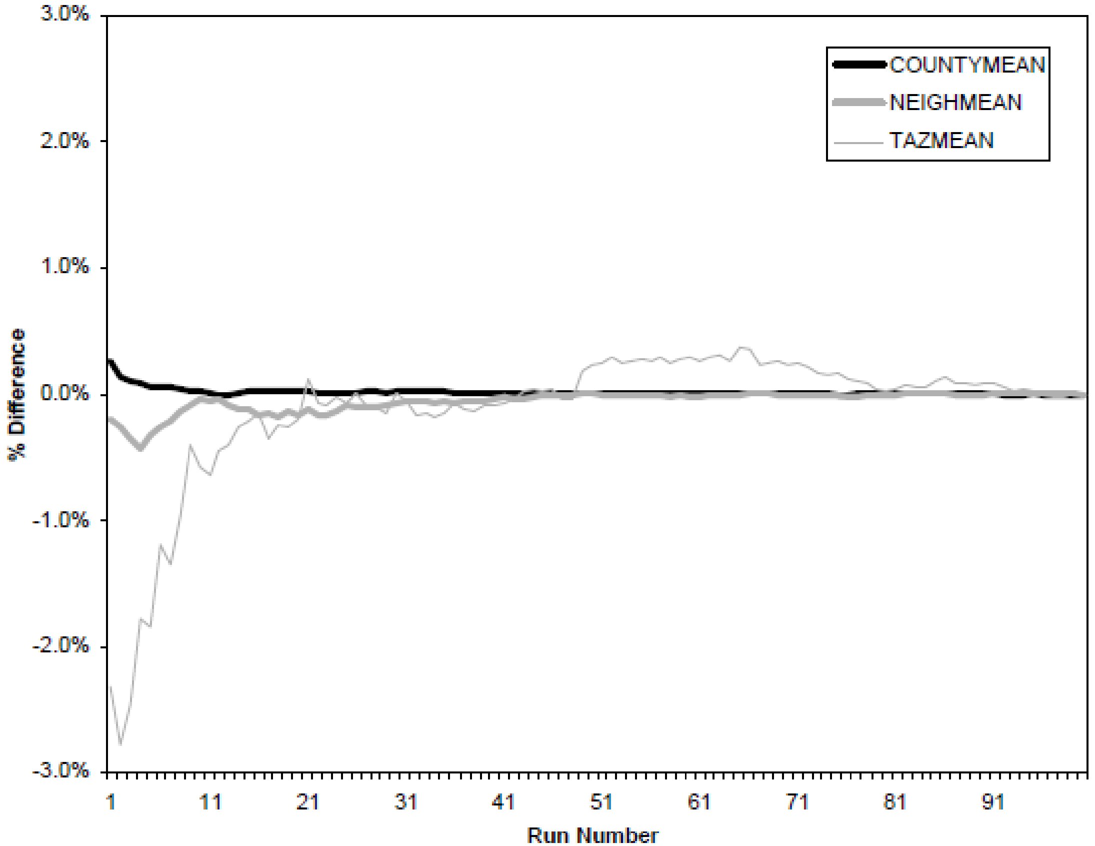


FIGURE 4 Trips per person (all levels), percent difference from final mean.

Strategies for Controlling Stochastic Variation

- Multiple demand system runs -- assignment performed on averaged trip tables
- Constraining random number sequences
  - Starting from same random number seed for same process
  - Saving random number sequences
- Freezing certain model components between runs
- Feedback and convergence through network integration (See Webinar #11)

Questions and Answers

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Types of Activity-Based Model Applications

- New Starts
- Pricing studies
- Conformity
- Regional Transportation Plans
- Environmental Impact Statements

Activity Based Models Adapted for New Starts Analysis

- SFCTA AB model:
  - Central Subway Project Study
- MORPC AB model:
  - COTA North Corridor LRT/BRT Study
- NYMTC AB model:
  - Tappan Zee Bridge Study

Major Issues

- FTA "fixed trip table" requirement & mode choice logsum as UB measure:
  - What to fix in tour-based structure?
  - Where to calculate UB in the model chain?
- Processing of microsimulation output:
  - Mode choice log-sum & probabilities along with "crisp" simulation
  - Aggregation of individual records

Trip-Based 4-Step Model

Trip generation

Trip distribution

Time of day

Fixed across all scenarios

Mode choice → UB

Assignment

Rerun for each scenario

Tour-Based AB Model (SFCTA)

Fixed

- Tour generation w/stops
- Time of day
- Tour primary destination

Rerun

- Entire-tour mode choice → UB
- Stop location
- Trip mode choice → UB
- Assignment

Transit User Benefits in San Francisco

- Tracking tour and trip benefits separately
- Retain sensitivity without a fixed distribution

Table 3. Tour and Trip User Benefits: IOS (baseline) to NCS (build)

	TOUR	TRIP	TOUR+TRIP
WORK TOUR TRIPS	388	2,098	2,486
SCHOOL TOUR TRIPS	187	483	670
OTHER TOUR TRIPS	132	1,528	1,660
WORKBASED TOUR TRIPS	-21	202	181
TOTAL	**686**	**4,311**	**4,997**

Important & Less Known

- Logsum UB cannot be directly totaled across conditional choices:
  - Upper-level choices constrain lower-level choices
  - Upper level choices already include UB from lower-level choices
- Drawbacks of trip-based 4-step models:
  - Independent NHB mode choice
  - UB for NHB trips are wrong and are better to be dropped

Tour-Based ABM (MORPC)

- Tour generation w/o stops
- Time of day
- Tour primary destination

Fixed

- Entire-tour mode choice → **UB**
- Stop frequency
- Stop location
- Trip mode choice
- Assignment

Rerun

Tour-Based ABM (NYMTC)

Tour generation w/o stops
↓
Pre-mode choice
↓
Tour primary destination
↓
Entire-tour mode choice → UB
↓
Stop frequency
↓
Stop location
↓
Trip mode & TOD
↓
Assignment

Fixed

Rerun

Aggregation

- Summit requirements
  - OD-pair structure
  - Mode utilities & probabilities
  - (?) Individual record version
- Microsimulation output
  - Individual tour records
  - Probability aggregation is trivial
  - (?) Utility aggregation is not trivial

Utility Aggregation Problem

- Given a set of individual choices with known utilities and probabilities
- Calculate aggregate representative utilities that exactly replicate:
  - Aggregate choice probabilities
  - UB measure (logsum)
- Simple naïve solutions like averaging utilities are wrong

Utility Aggregation Problem

Modes: $i = 1,2,\ldots, I$

Known individual:	Known aggregate:
$n = 1,2,\ldots, N$ $P_n(i)$	$P(i) = \dfrac{\sum_n P_n(i)}{N}$
	Unknown aggregate:
V_{in}	V_i

Sufficient Conditions (MNL)

1. Probability replication:

$$\frac{\exp\left(V_i\right)}{\sum_{j=1}^{I}\exp\left(V_j\right)} = P(i)$$

2. Logsum replication:

$$\ln\left[\sum_{j=1}^{I}\exp\left(V_j\right)\right] = \left\{\sum_{n=1}^{N}\ln\left[\sum_{j=1}^{I}\exp\left(V_{jn}\right)\right]\right\}\Big/ N$$

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Equivalent Transformation

1. Probability replication:

$$\exp\left(V_i\right) = P\left(i\right) \times C$$

where $C = \sum_{j} \exp\left(V_j\right)$

---

2. Logsum replication:

$$\sum_{j=1}^{I} \exp\left(V_j\right) = C = \prod_{n=1}^{N} \left[\sum_{j=1}^{I} \exp\left(V_{jn}\right) \right]^{\frac{1}{N}}$$

Unique Solution

Substituting 2 to 1:

$$\exp\left(V_i\right) = P(i) \times \prod_{n=1}^{N} \left[\sum_{j=1}^{I} \exp\left(V_{jn}\right) \right]^{\frac{1}{N}}$$

or equivalently:

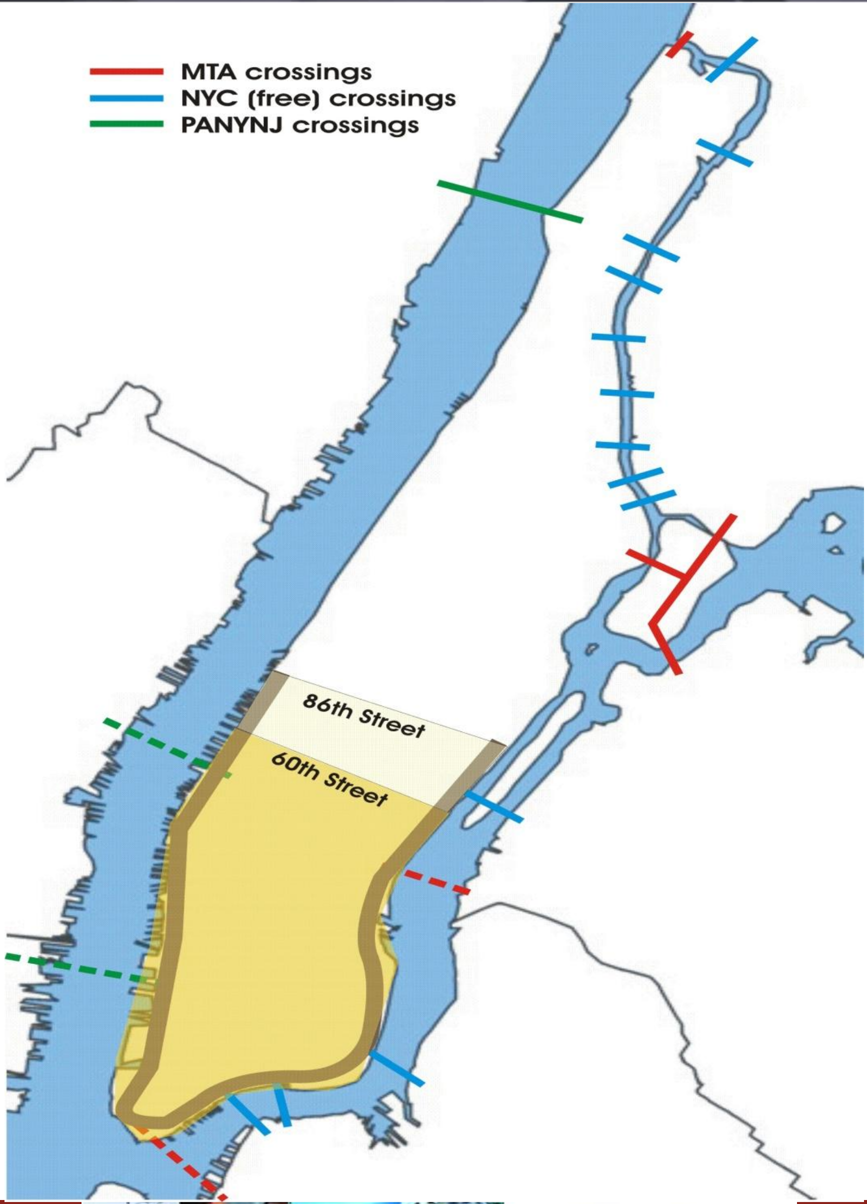
$$V_i = \ln P(i) + \frac{1}{N} \sum_{n} \ln \left[\sum_{j=1}^{I} \exp\left(V_{jn}\right) \right]$$

Technical Implementation

- Re-start version of ABM model:
  - Freeze all tour records with fixed destinations and time-of-day for baseline
  - Re-run mode choice and subsequent chain of models only
- Aggregation post-processor that creates SUMMIT input files
- Conventional SUMMIT run

Manhattan Area Pricing

- CBD - South of 60th
- Initial CPZ – South of 86th
- Manhattan CPZ Portals
  - Tolled – MTA
  - Tolled – PANYNJ
  - Free – NYC / East River
- Other Manhattan Crossings (Harlem River)



Benefits and Adaptations for Pricing Analysis

- Tour-level evaluation of daily fee on mode and destination choice
  - Transit – added demand / service requirements
  - Highway – reduced congestion measures
  - Destination (and Stop) Choice – reduced total travel
- Disaggregate reporting of record-based results
  - Who benefits / Who pays – residency retained
  - Logical and tractable at-work sub-tours/stops within CPZ
- An example:
  - Realistic modeling of Rationing by License Plate Option

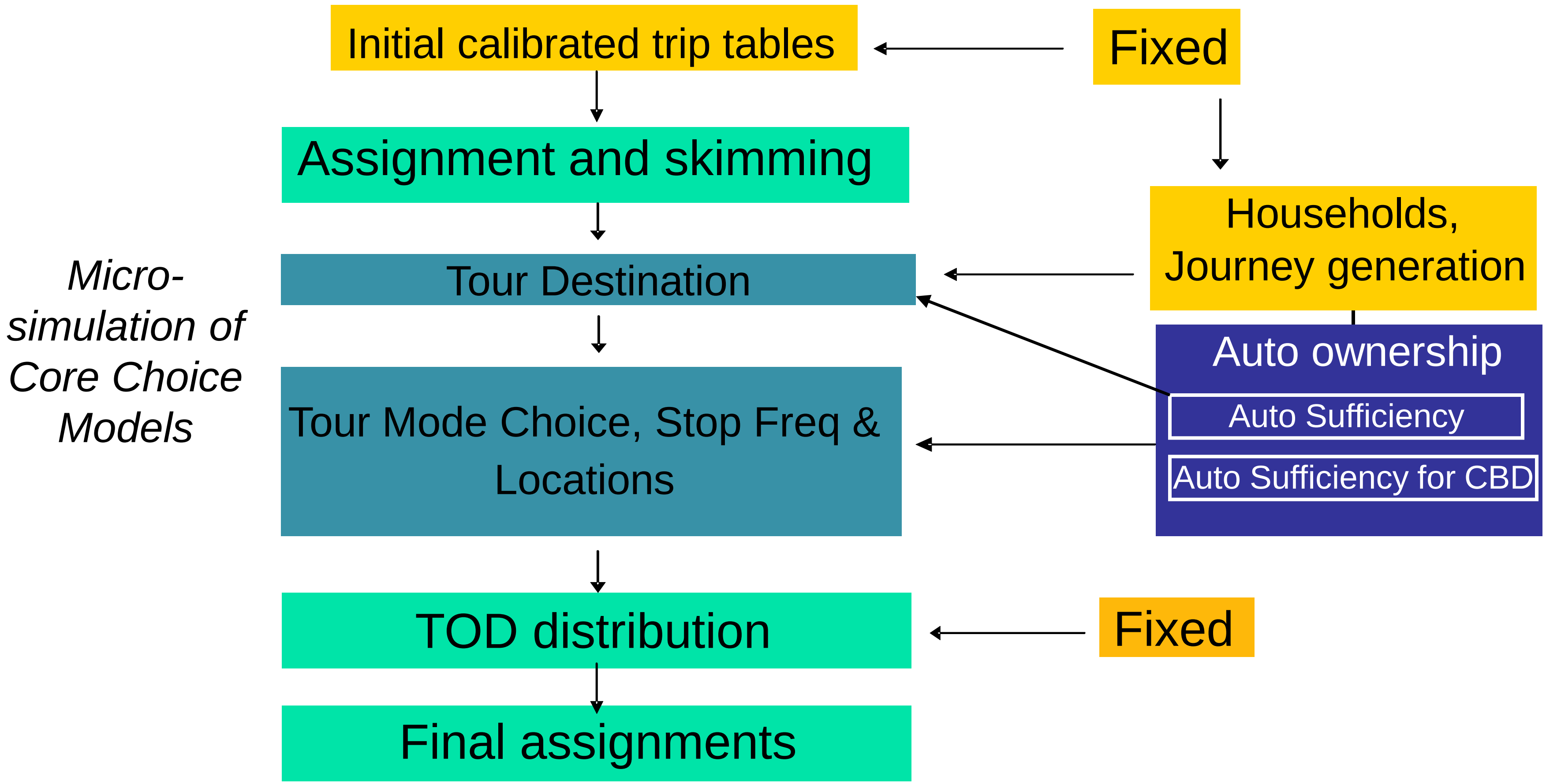
What is License Plate Rationing ?

Mon	Tues	Wed	Thur	Fri
✗	✓	✓	✓	✓
✓	✗	✓	✓	✓
✓	✓	✗	✓	✓
✓	✓	✓	✗	✓
✓	✓	✓	✓	✗

Impact of License Plate Rationing

- Policy: 20% (or 10%) No-drive to CBD vehicle ban based on last digit of license
- Impact on Travel Choices
  - Destination Choice – No
  - Mode Choice and Stop Location – Yes
- Account for opportunities to reduce impact of ban:
  - Changing the Day of Trip
  - Vehicle availability within Household
- Household Auto availability model is the key model component:
  - Vehicle available for Destinations to CPZ
  - Car Sufficiency revised - # of Autos minus of Workers

Applied Approach



License Plate Rationing – 20%
Auto Availability Model

Random #'s for tagging

HH#	Wkrs	Autos	Car Suff	a1	a2	a3	a4
1	2	3	1				
2	1	1	0				
3	1	2	1				
4	1	1	0				
5	2	4	2				
6	2	2	0				

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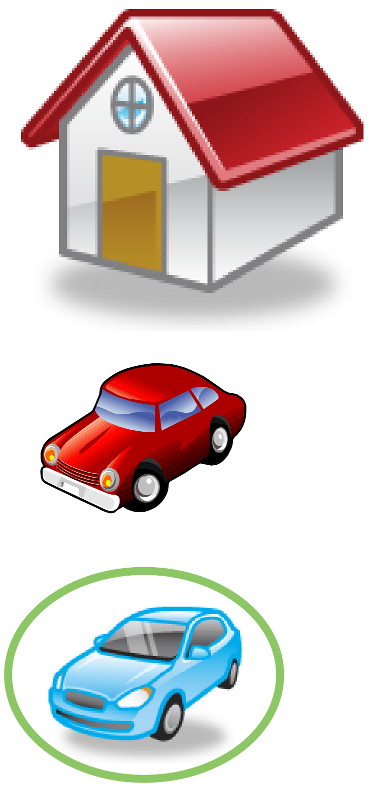
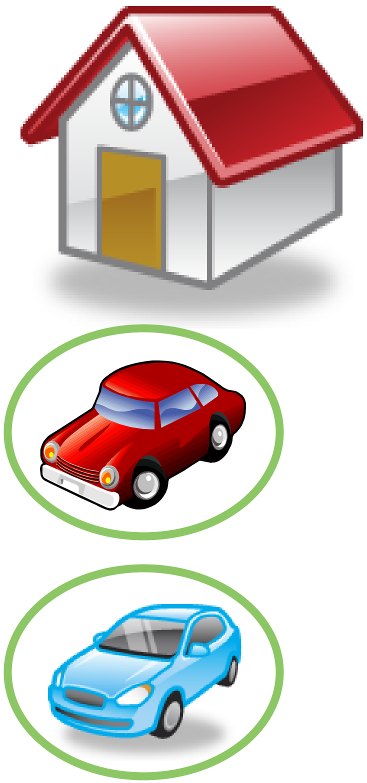
Impact on Mode Choice



	Destination	*Mode Choice Probability*	
	CBD	**SOV**	**HOV**
	Other	No Change	

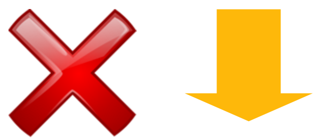
Impact on Mode Choice

Destination *Mode Choice Probability*



CBD

SOV **HOV**



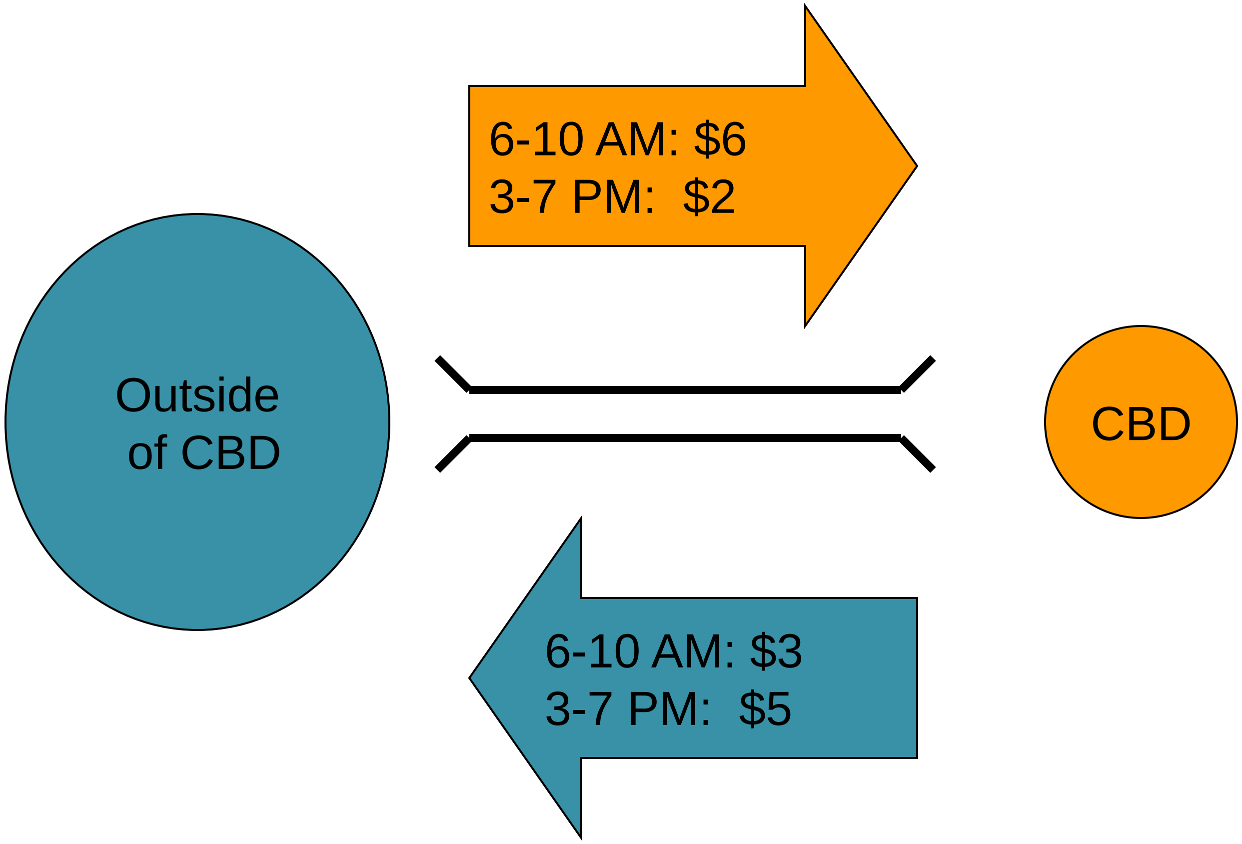
Other

No Change

Accounting for Tolls in both Directions by TOD

- Scenarios to model:
  - TOD-specific tolls differentiated by directions
- Required model sensitivities:
  - Travelers have to see both tolls that affect:
    - Route choice (independent by directions)
    - Mode choice
    - TOD choice
    - Destination choice

Realistic Example



True Tolls Paid by Commuters

Outbound time	Inbound time	Toll, $
Earlier than 6AM	Earlier than 6AM	
Earlier than 6AM	6-10AM ($3)	3
Earlier than 6AM	10AM-3PM	
Earlier than 6AM	3-7PM ($5)	5
Earlier than 6AM	Later then 7PM	
6-10AM ($6)	6-10AM ($3)	9
6-10AM ($6)	10AM-3PM	6
6-10AM ($6)	3-7PM ($5)	11
6-10AM ($6)	Later then 7PM	6
10AM-3PM	10AM-3PM	
10AM-3PM	3-7PM ($5)	5
10AM-3PM	Later then 7PM	
3-7PM ($2)	3-7PM ($5)	7
3-7PM ($2)	Later then 7PM	2
Later then 7PM	Later then 7PM	

Modeling True Tolls & LOS

- With 4-step model:
  - Impossible to ensure any reasonable level of consistency across trip distribution, mode choice, and time of day choice
- With tour-based ABM:
  - It is still difficult to ensure a full consistency, but a much better job can be done

Conformity Analysis Temporal Resolution

- Improved temporal resolution allows for shifts in demand patterns by time of day that may better support certain mitigation strategies and policies
  - Potentially more accurate inputs to traffic simulations aimed at quantifying impacts of capacity enhancement projects
    - Signal synchronization
    - Information provision
    - Incident response
    - Ramp metering

Conformity Analysis Emissions Tracking

- While the first-order effects on emissions are due to VMT/VHT, activity-based models provide the ability to trace these changes to individual behavior
  - Sensitivity to different traveler types, values of time, and tolling
  - Improved spatial resolution enhances ability to quantify emissions reductions benefits due to pedestrian and bicycle project improvements

Regional Transportation Plan Strategies

- Improved resolution and methods allow for improved analysis of transportation alternatives
  - Pricing strategies
  - Non-motorized/active transportation modes
  - Travel demand management strategies
  - Travel system management strategies (with dynamic traffic assignment models)

Regional Transportation Plan Metrics

- Activity-based models allow for additional performance metrics in transportation planning
  - Equity measures
  - Emissions at the household level
  - Energy use for vehicles and industries
  - User benefits at employment centers for economic development
  - Induced travel

Model Performance

- Model design drives computational performance—user requirements for computational performance constrain model design
- Custom software is needed to implement demand components of activity-based models
  - General purpose commercially available travel demand modeling software is not designed to handle all of the special decision structures, data pathways and accessibility variable calculations, and not designed to forecast using simulation methods
- Hardware and software considerations are a tradeoff
  - Distributed processing across many computers; additional computers reduces run times
  - Optimized software can reduce run times as well

Custom Application Programs

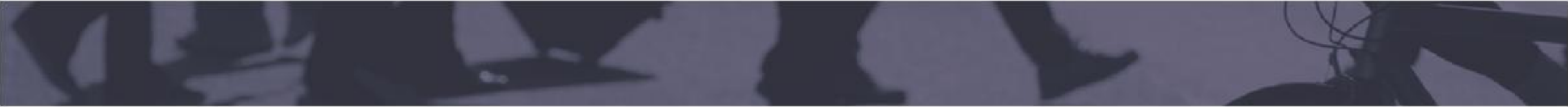
- Many different ABM developers have created custom application programs for specific projects
- Typically free, open-source licensing, but code availability may be restricted to clients of developers and/or difficult to implement without developer assistance
  - Users pay for developer expertise and assistance in the development of data, model structures, parameters and calibration
  - Users may benefit by upgrades in subsequent applications for other regions

Software Application Platforms

- **Daily Pattern Simulation– DaySim** (Bowman & Bradley and RSG)
  - SACOG (Sacramento)
  - NFTPO (Jacksonville)
  - FDOT7 (Tampa)
  - PSRC (Seattle)
  - Fresno COG
  - San Joaquin, Merced and Stanislaus
  - DVRPC (Philadelphia)
- **Coordinated Travel Activity Model Platform– CT-Ramp** (PB)
  - MORPC (Columbus)
  - TMPO (Lake Tahoe)
  - ARC (Atlanta)
  - SANDAG (San Diego)
  - MTC (San Francisco)
  - MAG/PAG (Phoenix, Tucson)
  - CMAP (Chicago)
  - SFRPC (Miami)

Software Application Platforms

- FOCUS (DRCOG, CS)
  - DRCOG (Denver) Custom software, based on the Bowman & Bradley approach
- SimAGENT (U. Texas-Austin, UC-Santa Barbara, Arizona State U.)
  - SCAG (Los Angeles)
- SimTravel (Arizona State U., U. California-Berkeley, U. of Arizona)
  - Case study in Phoenix
- MATSIM (ETH-Zurich and TU-Berlin)
  - Swiss National Model
- ILUTE (U. of Toronto)
  - Metrolinx (Toronto)
- ALBATROSS (Eindhoven University)
  - Applications in Netherlands
- DASH (RSG)
  - Metro (Portland, OR)



User Productivity

- Requires development of functionality similar to existing trip-based model software
  - User-friendly GUI
  - Scenario management
  - Efficient storage and organization of input and output files
  - Customizable outputs
  - Links to GIS
  - Links to commercially available trip-based packages for network assignment
  - Data visualization
  - Acceptable run times
  - Comprehensibility and documentation
  - Error checking
  - User support

Data Structures & Computational Requirements

- Greater complexity and resolutions leads to greater computational requirements
- Theoretical justification of system features is tempered with computational realities
- Model developers have experimented with and developed methods for getting as much out of an activity-based model system design as possible, while respecting computing budgets
  - System design compromises, simplifications necessary
  - Adding computational power—distributed processing

Run Times with Different Configurations

	ARC	MORPC	SACOG	SACOG
Households	1,760,000	610,774	1,250,000	700,000
Number of Global Iterations	3	3	10	10
Intra-household Interactions	Yes	Yes	No	No
Spatial Resolution	Zones	Zones	Parcels	Parcels
Run Times (hours)				
Without distribution/threading	146		33	
Households per hour per iteration	36,164		384,615	
Households per hour per iteration per processor	4,521		96,154	
With distribution/threading	16	36		16
Households per hour per iteration	330,000	50,898		437,500
Households per hour per iteration per processor	41,250			109,375
Specifications				
Hardware without distribution	8 processors, 16GB RAM, 1 computer		4 processors, 12 GB RAM, 1 computer	
Hardware with distribution	24 processors, 48GB RAM, 3 computers	3 computers		4 processors, 3.2 GB RAM, 1 computer
Software	CT-RAMP	CT-RAMP	DaySim	DaySim

Example of Model Design Tradeoffs: Fine-grained Spatial Resolution

- Includes micro-zones and parcels
- Potential explosion in point-to-point routing, memory utilization and access, and disk storage requirements
- Compromise through hybrid, hierarchical spatial unit processing schemes
  - TAZ routing of highway and transit vehicles
  - Micro-zone/parcel routing of walk and bike paths (SACOG example with run times)

Research Areas

- Quantifying and controlling effects of stochastic variation and uncertainty on model results
- Data visualization
- High-performance computing

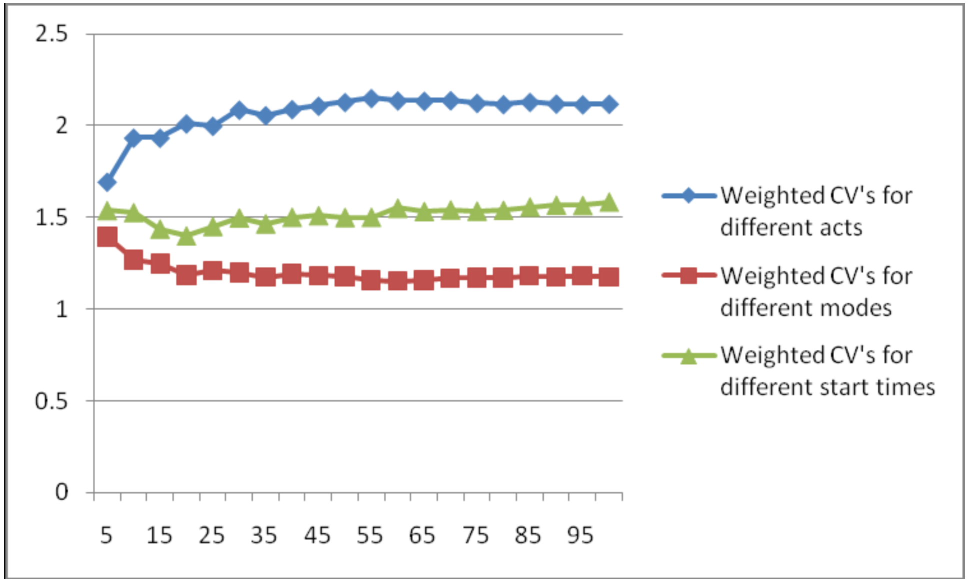
Stochastic Variation on Model Results

- Developing confidence intervals for outcome variables
- Quantifying stochastic effects of input variables
- Communicating stochastic effects to decision makers, other stakeholders

Uncertainty using Albatross (Rotterdam)

- Stochastic variability is small (less than 5%)
- 25-30 runs are sufficient

- Confidence intervals are higher (around 28%)
- More than 100 runs are needed

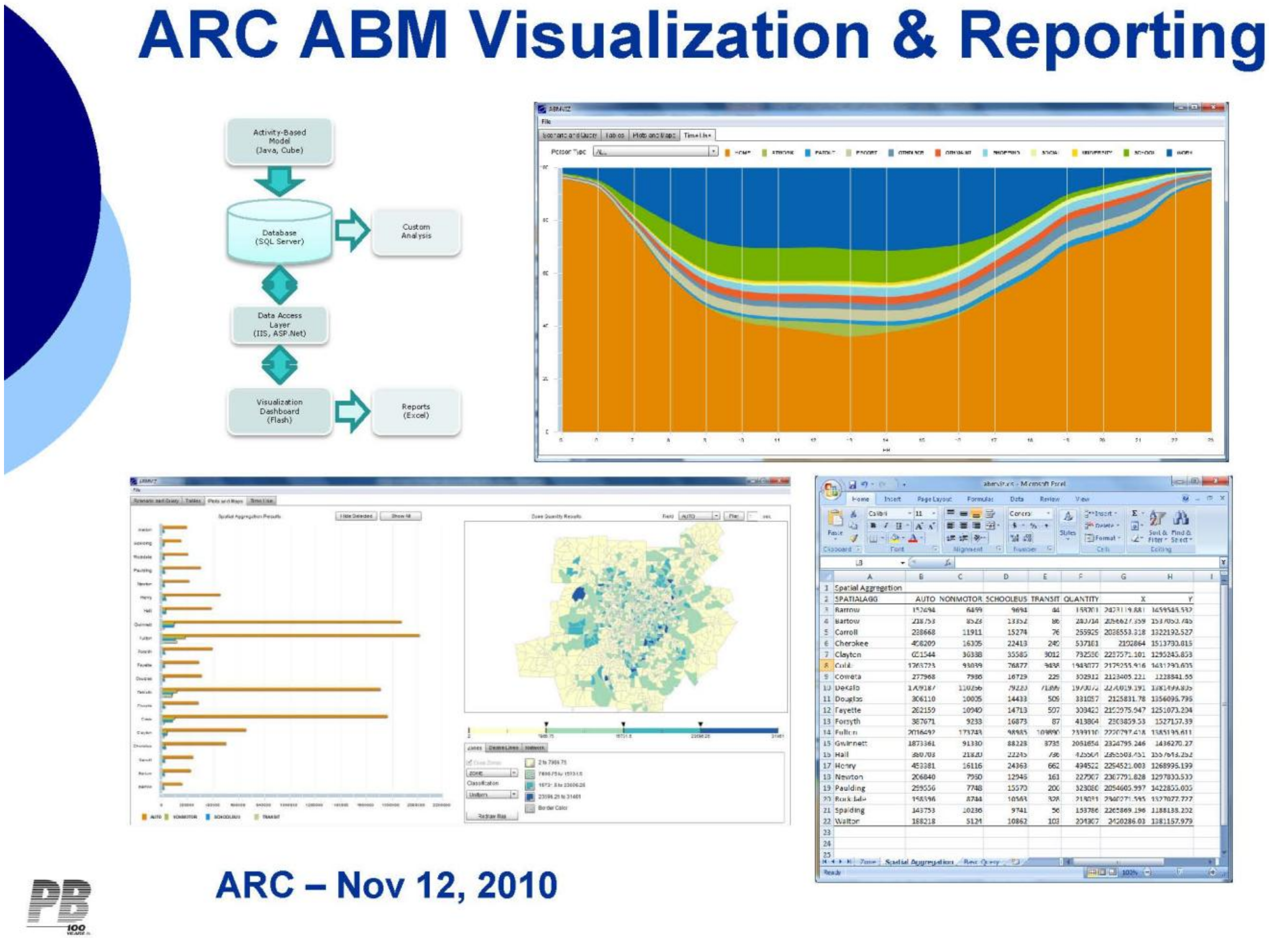


	No of runs	Lower boundary	Upper boundary	diff lower from mean(%)	diff upper from mean(%)
Work	100	0.0135	0.0179	14.0967	13.7153
	50	0.0127	0.0189	19.9935	19.6144
	5	0.0059	0.0328	69.3383	69.2352
CarD	100	0.0090	0.0120	14.0818	14.0818
	50	0.0085	0.0125	17.8593	21.7428
	5	0.0048	0.0266	69.3135	69.3135
3am-10am	100	0.0119	0.0158	13.9691	13.8824
	50	0.0101	0.0151	19.8021	19.8021
	5	0.0035	0.0192	69.3054	69.3054

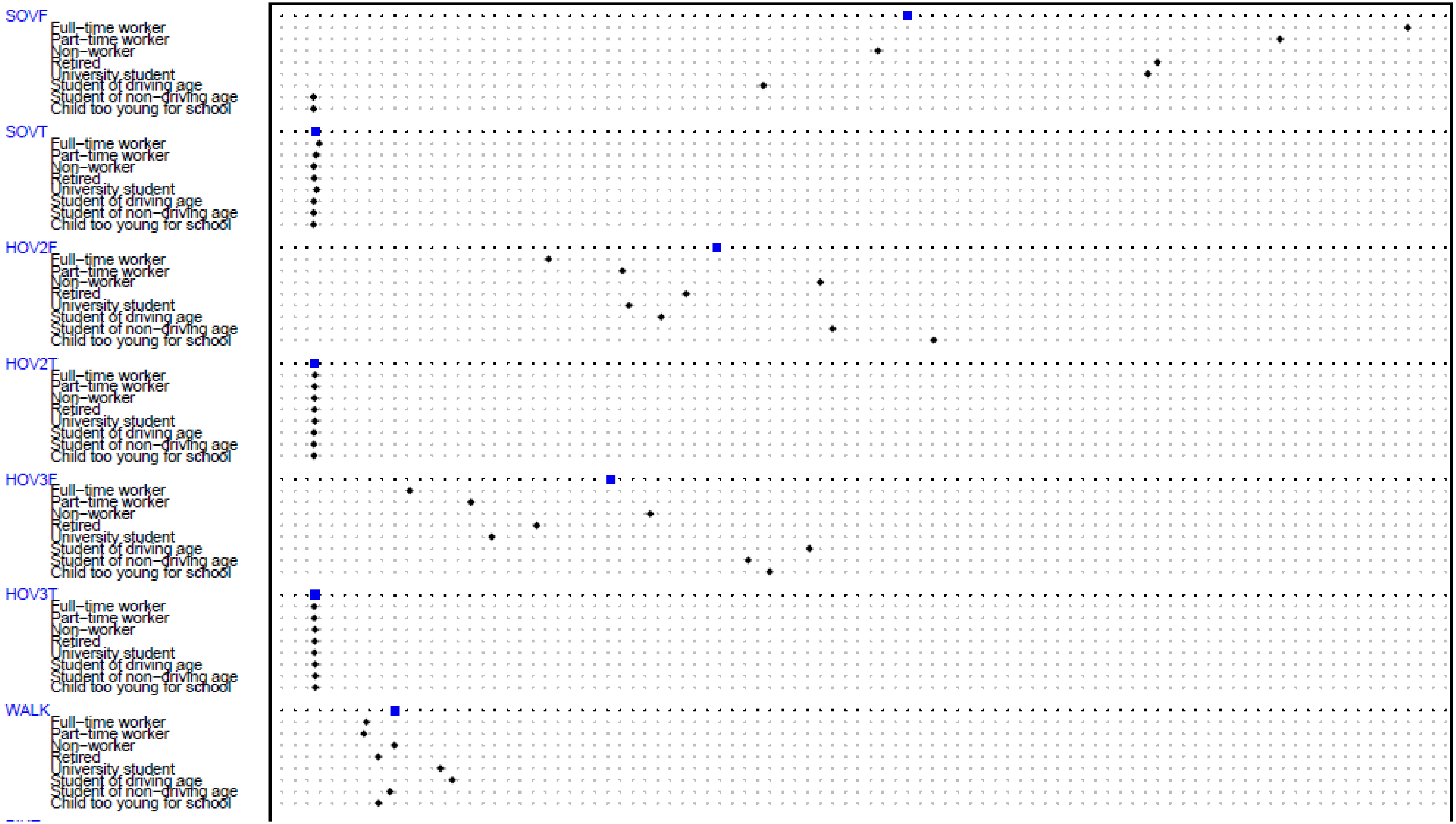
Data Visualization

- "Dashboards" for scenario analysis
  - Example from Atlanta Regional Commission (ARC)
- Dynamic processes using flash technology, sliding through scenario results
- Making results available to stakeholders via internet, with varying levels of access privileges
  - Cloud computing test in Atlanta

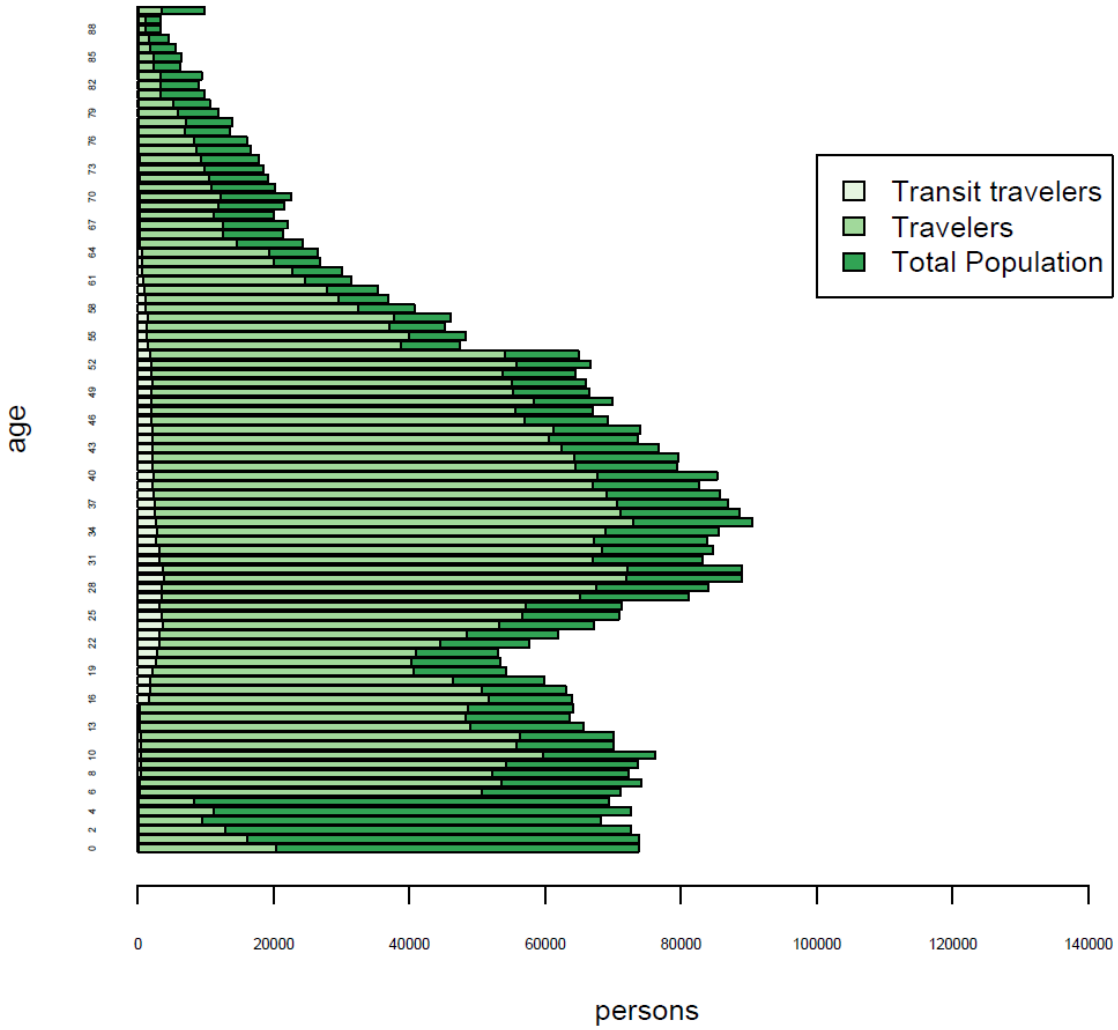
Atlanta Data Visualization Dashboard



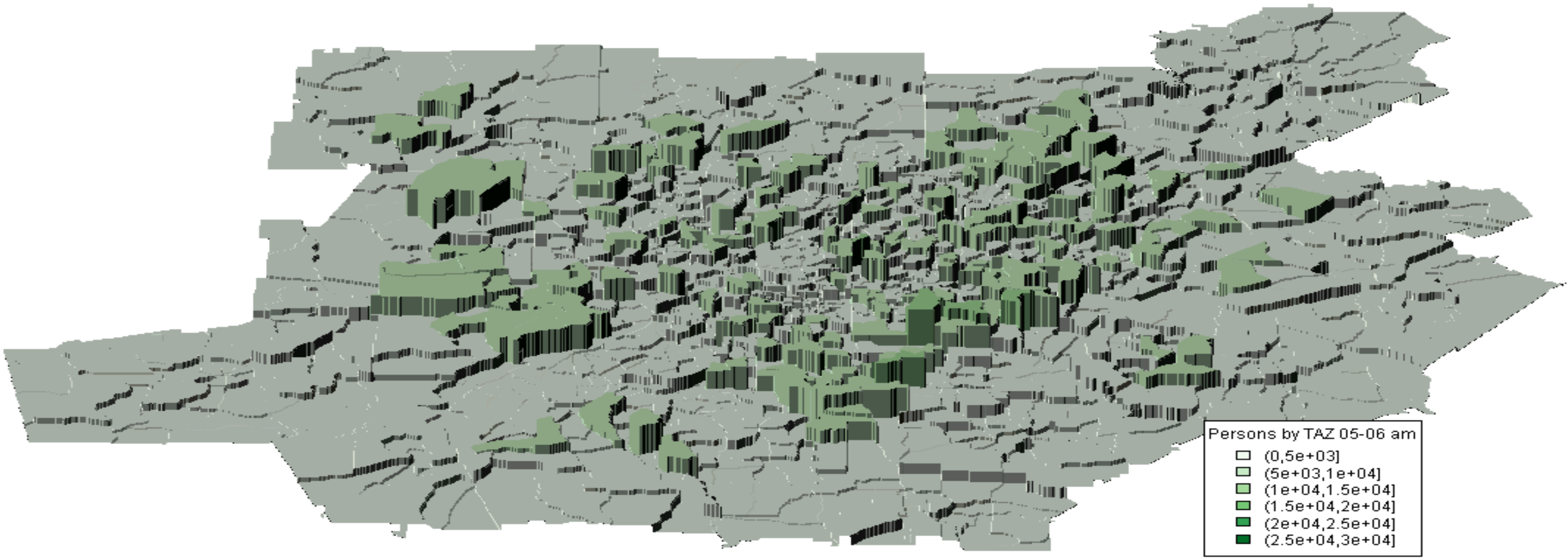
Mode Share by Person Type



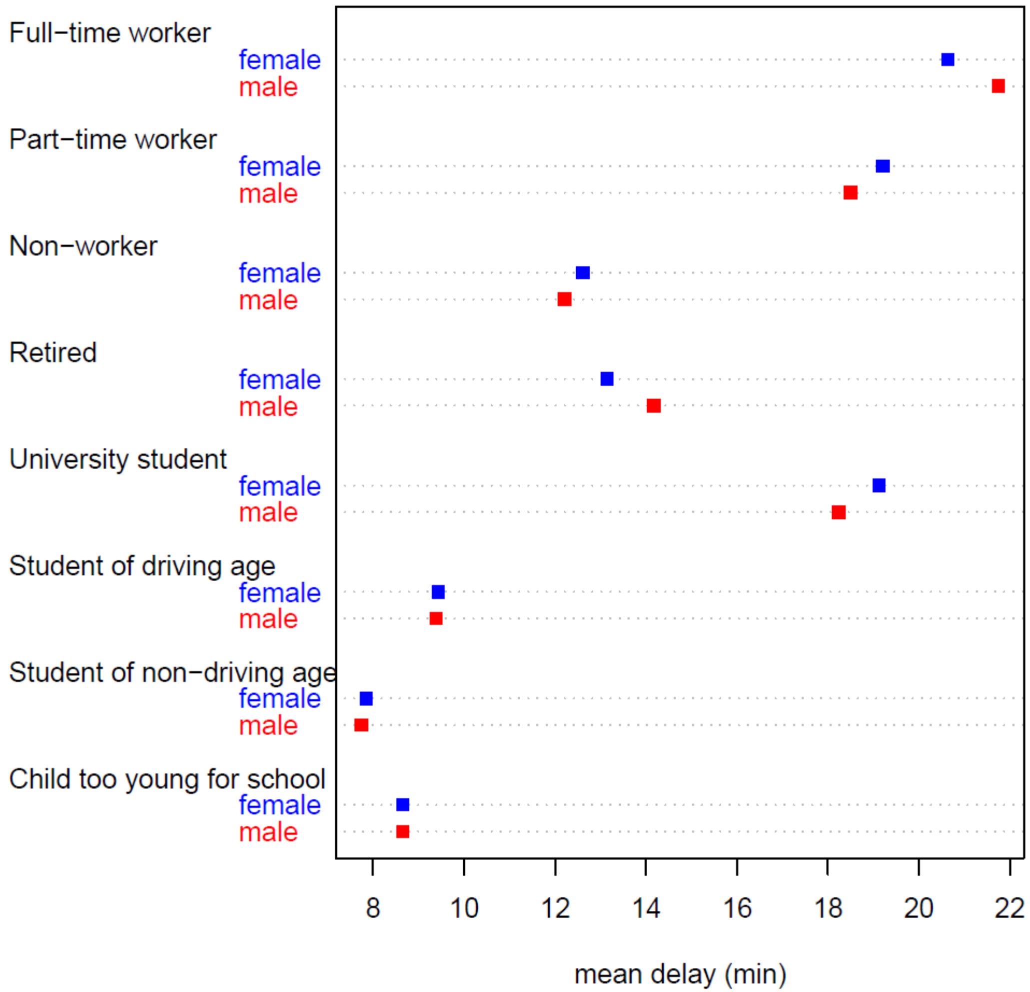
Travelers by Age



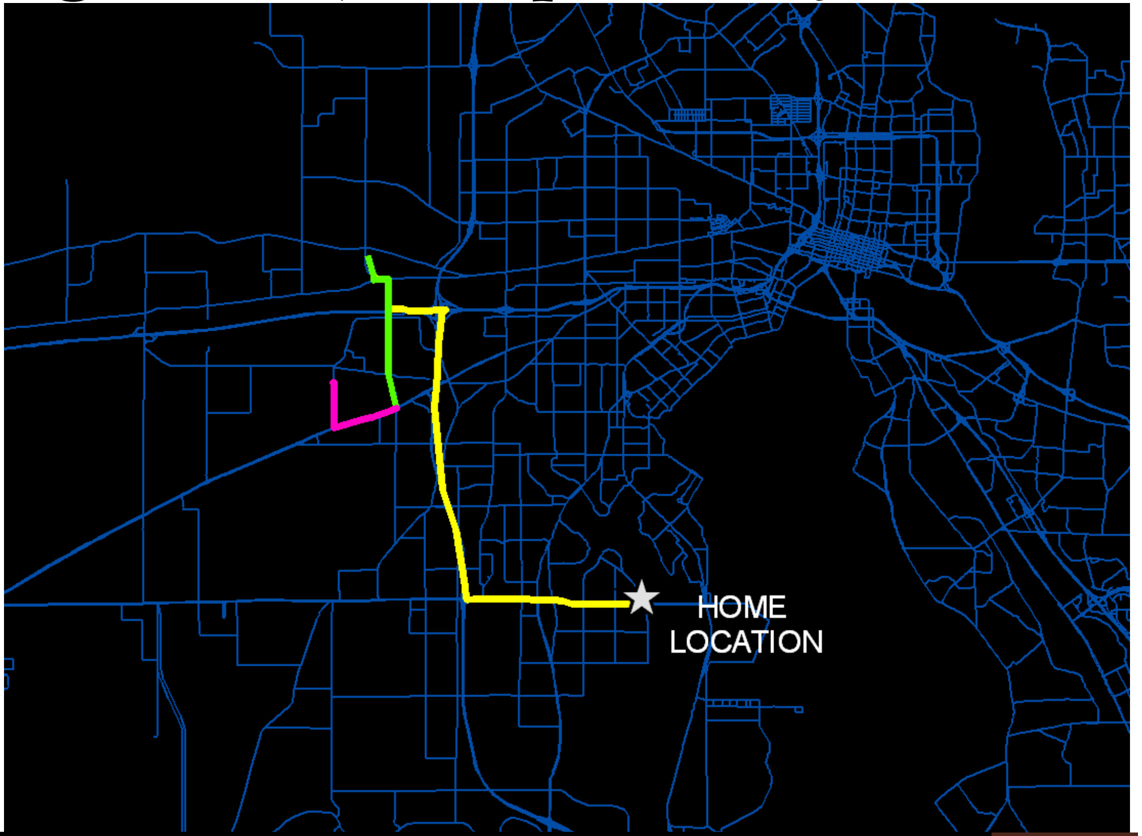
Persons By TAZ and Hour



Mean Delay for Peak Period Travel



DaySim/Transims Tracks Individuals Through Assignment (Example from Jacksonville)



Household 21
Person 1
Tour 1

HHOLD	PERSON	ACTIVITY	PURPOSE	PRIORITY	START	END	DURATION	MODE	VEHICLE	LOCATION	PASSENGER		
21	1	2114110	0	9	0	2:49	2:48	1	0	8679	0	***Start at home***	***Travel Time***
21	1	211411	3	9	3:08	7:37	4:28	2	1	4024	2	**TRIP 1**	**0:19**
21	1	211412	6	9	7:45	10:20	2:35	2	1	4175	1	**TRIP 2**	**0:08**
21	1	211421	3	9	10:25	10:29	0:04	2	1	3740	1	**TRIP 3**	**0:05**
21	1	211422	0	9	10:48	12:23	1:35	2	1	8679	0	**TRIP 4**	**0:19**

High-performance Computing

- Advances in efficient data structures and algorithms (software engineering)
- Multi-threading
- Options for distributed processing
  - In-house LAN servers—large hardware investment, but local control
  - Leased time on remotely hosted networks (Argonne Labs)—more processors, no sunk cost in extra hardware; lack control over processing availability, software maintenance
  - Cloud computing—farming out processing tasks while software resides locally; may be public (enterprise-wide) or private (Google, Amazon) —more processors, no sunk cost in extra hardware

Summary

- Disaggregate representation of individuals provides summarization by any available attributes, enabling more sophisticated, higher-resolution analyses of transportation policy and investment alternatives
- Application of ABMs to alternatives analysis presents some challenges in how to present and interpret results vis-à-vis the expectations of policy makers and other agencies used to seeing trip-based model results

Summary

- Enhanced data visualization methods are being developed to take advantage of this richer information
- Some standardization has begun to emerge across projects that follow the same design approach
- Research into distributed computing environments offers promise of greater performance for lower cost

Questions and Answers

The Travel Model Improvement Program