TMIP Webinar Series

Activity-Based Modeling

Session 1: Executive Perspective

The Travel Model Improvement Program

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Acknowledgments

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Learning Outcomes

- How travel demand models are used
- Benefits and limitations of activity-based models
- Why current models can't answer certain policy questions
- Time and resources needed to implement an activity-based modeling system

Outline

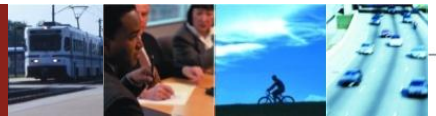
- Overview of activity-based models and their use
- Practical advantages of activity-based models
- Limitations of activity-based models
- Policy evaluations that benefit from activity-based models
- Staff and resource requirements

Terminology

Activity-based model	• A travel demand model that produces tours with activity stops
Tours	• A chain of trips that begin and end at home or work
Trip-based model	• A travel demand model that produces trips
Advanced models	• Applied at a disaggregate level, typically with greater spatial and temporal detail
Integrated modeling system	• Integration of economic, land use, travel, traffic and air quality models

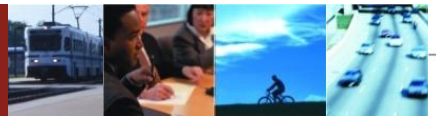
Key Concepts

- Activity-based models…
  - provide sensitivities to policies and more intuitive analysis than existing methods
  - produce many performance measures that are not possible with existing methods
  - do not necessarily take longer or cost more to develop and apply than existing methods
    - An all-new activity-based model is a similar level of effort and cost to developing an all-new trip-based model
    - An incremental change to an existing activity-based model is similar in effort and cost to an incremental change in a trip-based model



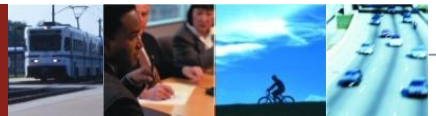
Why use models in planning?

- Objective assessments of transportation investments
- Demonstrate advantages and disadvantages of alternatives
- Forecasts depend on modeling assumptions, which should be systematic and transparent
- Assess a range of outcomes based on changes in assumptions
- Evaluate potential impacts of transportation policies

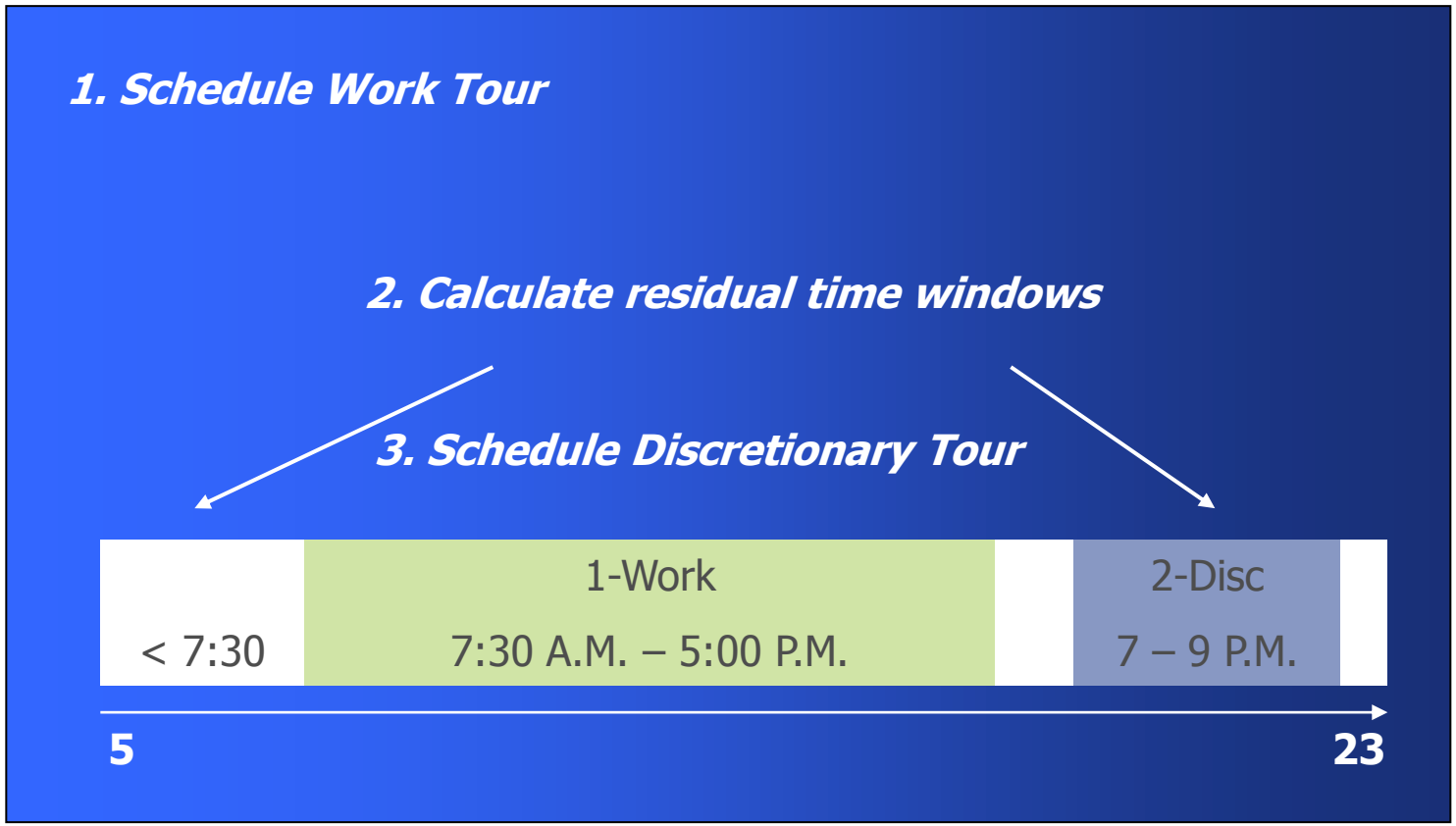


What is an activity-based travel model?

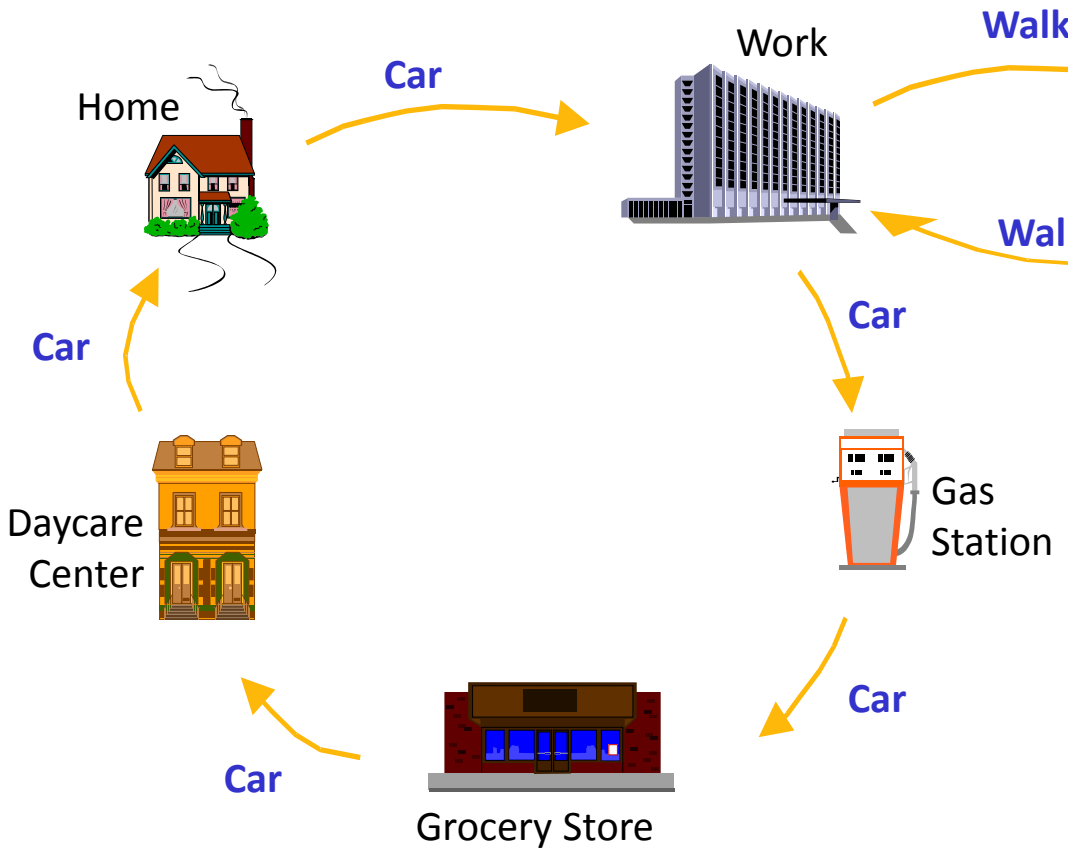
- Travel is a derived demand – it results from the need of people to engage in activities outside the home
- Activity-based travel models are based on behavioral decision-making theory
  - whether to travel
  - where to travel to
  - when to travel
  - how to travel
- This makes them better suited to address policies that affect how people make travel decisions than trip-based models



Modeling Daily Activity Schedules



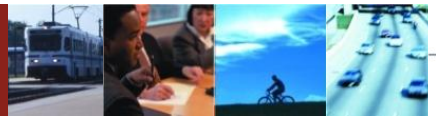
Modeling Trip Chains and Tours



- 7 trips
- 2 tours
  - 4 stops
  - 1 stop

Why use an activity-based model?

- Connects travel throughout the day, similar to how decisions are made
- Is sensitive to cost, time, demographics, and policies
- Allows for greater spatial and temporal detail
- Allows greater household/person attribute detail.
- Tracks individual's travel behavior (not averages)

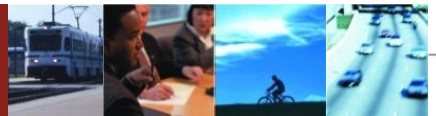


Modeling Individuals in Households

- **Household Attributes**
  - number of persons
  - housing tenure
  - residential building size/type
  - number of persons age 65+
  - number of persons under age 18
  - number of persons that are part of the family
  - number of children
  - household income
  - number of vehicles owned
    number of workers
  - number of students
- **Person Attributes**
  - relationship to householder
  - gender
  - age
  - grade in school
  - hours worked per week
  - worker status
  - student status

Derived Person Attributes

- Given a synthetic person's attributes and a travel context, it is possible to derive an individual value of time ($/hour)
  - May vary by person and trip context (purpose, time of day)
  - Useful for mode choice and assignment of trips for various pricing policies
- Possible to carry this through network modeling to account for multiple user types on roadways and transit systems



Activity Purposes

- Work
- School/College
- Personal Business (e.g., Medical)
- Shopping
- Meals
- Social/Recreational
- Escort Passenger(s)
- Joint Participation
- Home (any activity which takes place within the home)

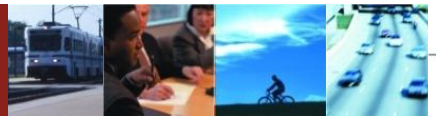
Contrasting Modeling Approaches

Trip-Based

- Trips are generated from zonal aggregations of households
- Each trip is independent of every other trip's generation, distribution, mode and timing
- Timing/direction of trips is not an explicit choice (fixed factors)
- Travel demand is not affected by accessibility or the built environment
- Market stratification limited by ability to maintain trip tables throughout model stream

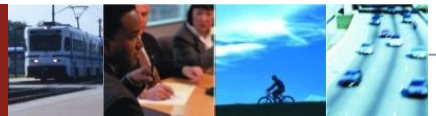
Activity-Based

- Simulation of individual households and persons
- Trips are chained—modeled as part of tours, sub-tours and larger daily activity patterns
- Starting and ending time of activities are modeled choices
- Built environment and accessibility variables affect travel demand
- Market stratification is a function of individual and household attributes



Practical Advantages: Behavioral

- Models behavior more intuitively and is therefore easier to explain results
- Travel is based on round trips, which is how people make decisions
- All relevant variables can affect decisions, rather than being limited to a few (because of disaggregate logit choice models)
- This also allows for incorporation of travel time and cost (weighted by mode and destination and time of day) to be included in higher level models (like auto ownership and trip generation)
- Travel behavior is modeled consistently throughout the process (e.g. trip chaining)



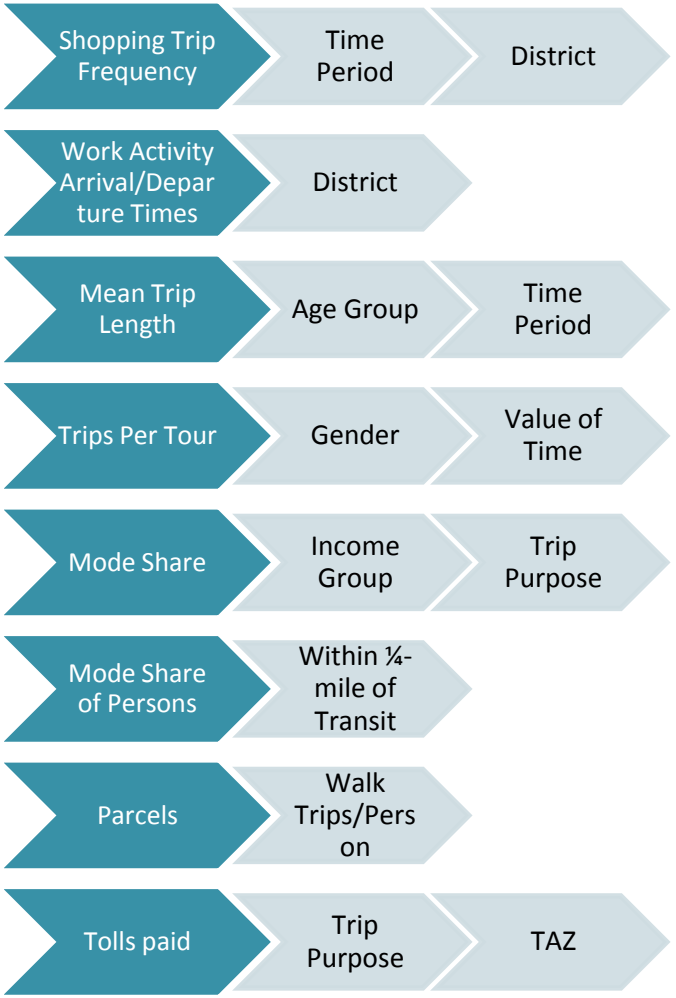
Practical Advantage: More Performance Measures

- Activity-based model raw outputs are disaggregate trip records, with important identifying attributes:
  - Activity/trip purpose, start/end times, travel mode, location IDs
  - Tour purpose, primary location, primary mode, start/end times
  - Household ID, Person ID, Tour ID, Trip/Activity ID
- This allows the user to summarize system performance data along a at least four potentially useful dimensions:
  - Household and person attributes
  - Time period of the day
  - Activity/trip/tour purposes
  - Geographic units and spatial clusters

Ability to Derive Performance Measures

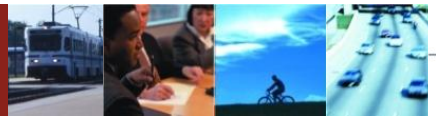
Can summarize travel behavior metrics by various combinations of the activity-based model dimensions

Some examples are→



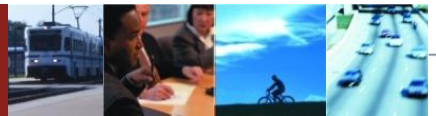
Practical Advantages: Spatial Detail

- Can be developed at a highly detailed level (parcels), Census block level (micro-zones) or an aggregate level (zones)
- Increased spatial detail (with parcels or micro-zones) provides more precision than is possible with 4-step models
- Used to create accessibility buffers for access to employment, population, transit stops, paid parking supply, and surrounding intersection connectivity
- Non-motorized and transit trips can be more accurately represented

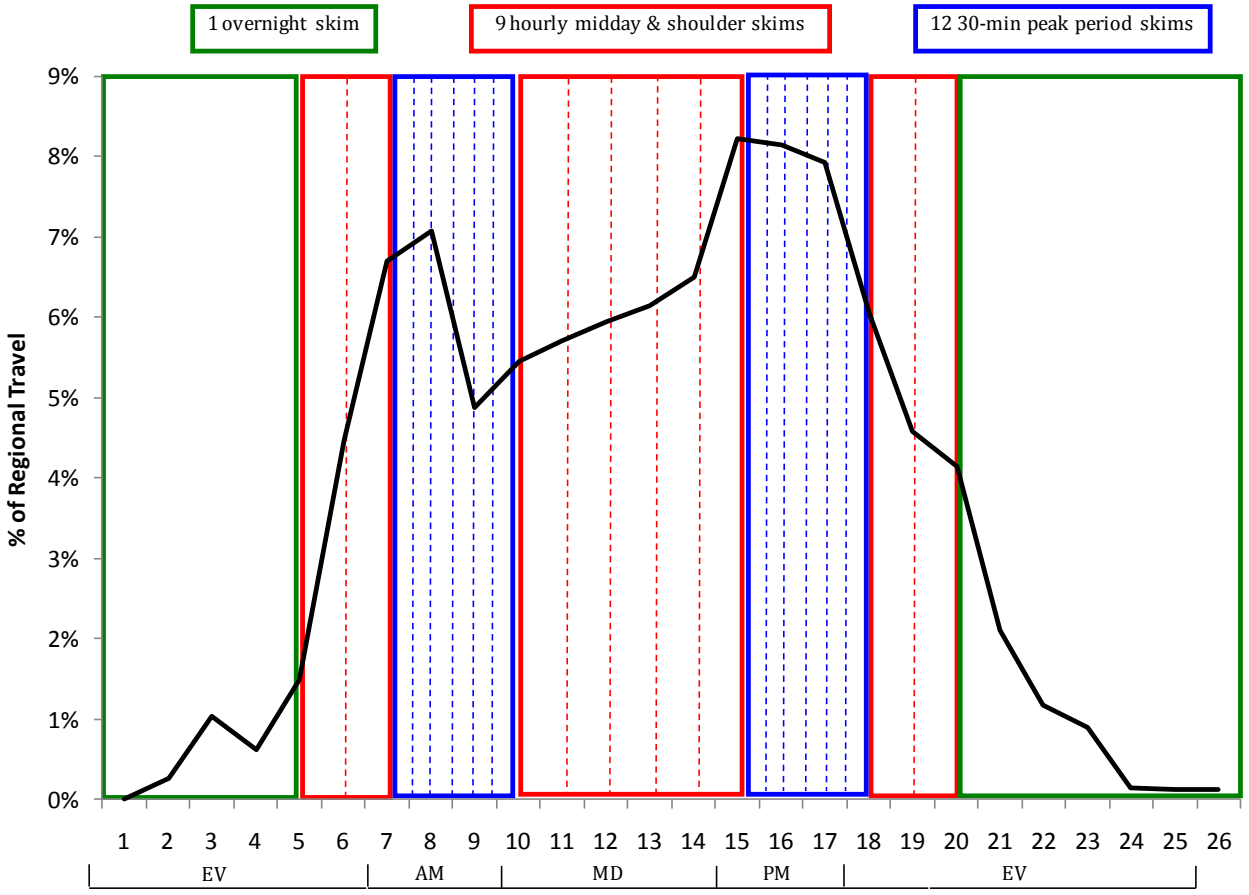


Practical Advantages: Temporal Detail

- Models are much more detailed (e.g. 30-min, 5-min, 1-min)
- Time chosen for travel is represented by the complex demands of household members, work and school schedules, etc.
- Trip timing is affected by congestion and tolls that change by the minute (dynamic) resulting in peak shifting



Example: Jacksonville Temporal Resolution



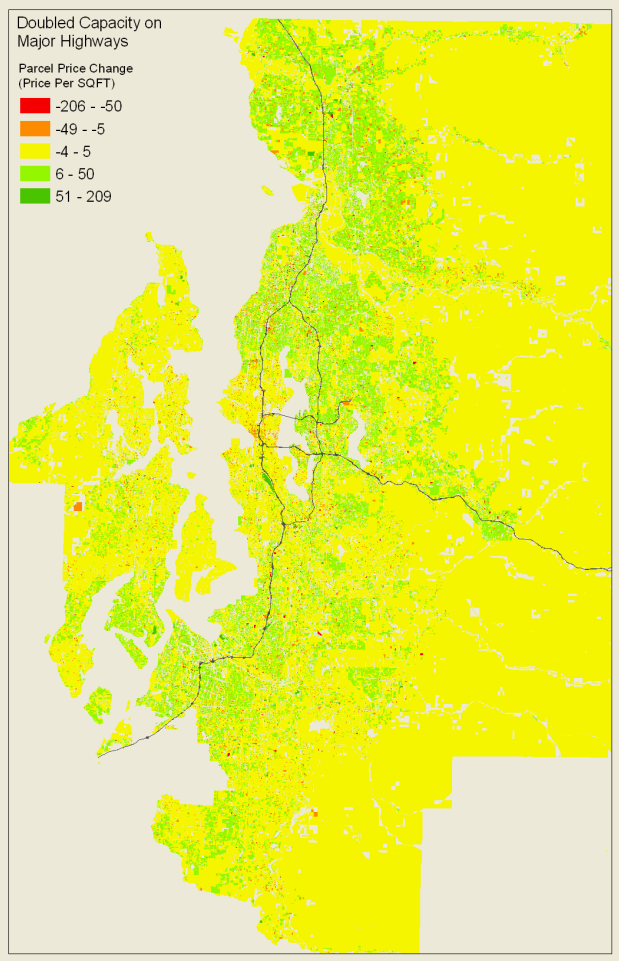
Practical Advantages: Micro-simulating Demand

- Results are disaggregate and can be combined along many dimensions for analysis
- Monte Carlo simulation approach can be used with large samples
- Results show a range of possible outcomes or random variation can be fixed to produce a single outcome

Monte Carlo simulation is a computerized mathematical technique that allows people to account for risk in quantitative analysis and decision making.

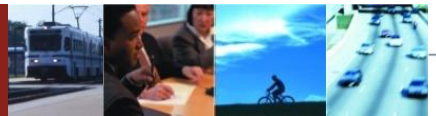
Practical Advantage: Visualization of Results

- There are many new types of measures that can be reported
- Detailed spatial or temporal data can be visualized quickly
- Aggregated results can be reported across many different dimensions



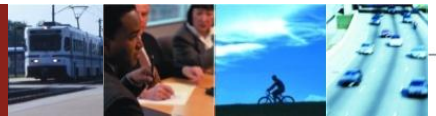
Limitations: Computational Challenges

- Tradeoffs between
  - Model features
  - Optimized software
  - Hardware
  - Run time
- New, unconventional software platforms



Limitations: Behavioral and Spatial Realism

- Some activity-based models have intra-household interactions to show how travel is coordinated among household members, which adds complexity to the calibration effort
- Some activity-based models have parcel-level or micro-zone data inputs to show how travel is affected by nearby land uses and accessibility to transit; some do not because of poor data quality
- Inclusion of travel times and costs at different parts of the process adds realism, but also adds complexity and time
- Some activity-based models model have increased temporal resolution—model more time periods—this adds realism and aids accuracy, but also results in more computational time and disk storage



Advantage and Limitation: Data

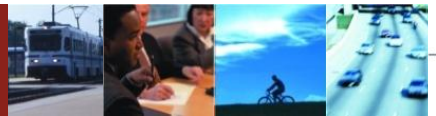
Traditional data that is generally applicable:

- Household travel survey data
- Highway and transit networks and zone systems
- On-board surveys

Other data desired includes:

- Parking supply and cost
- Built environment
- Pedestrian/bike

Data can be limited to existing sources, but advantages of the activity-based models will be dependent on level of detail, quality and completeness of the data

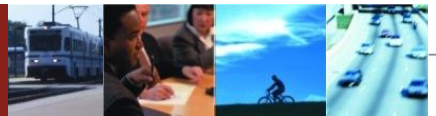


Questions and Answers

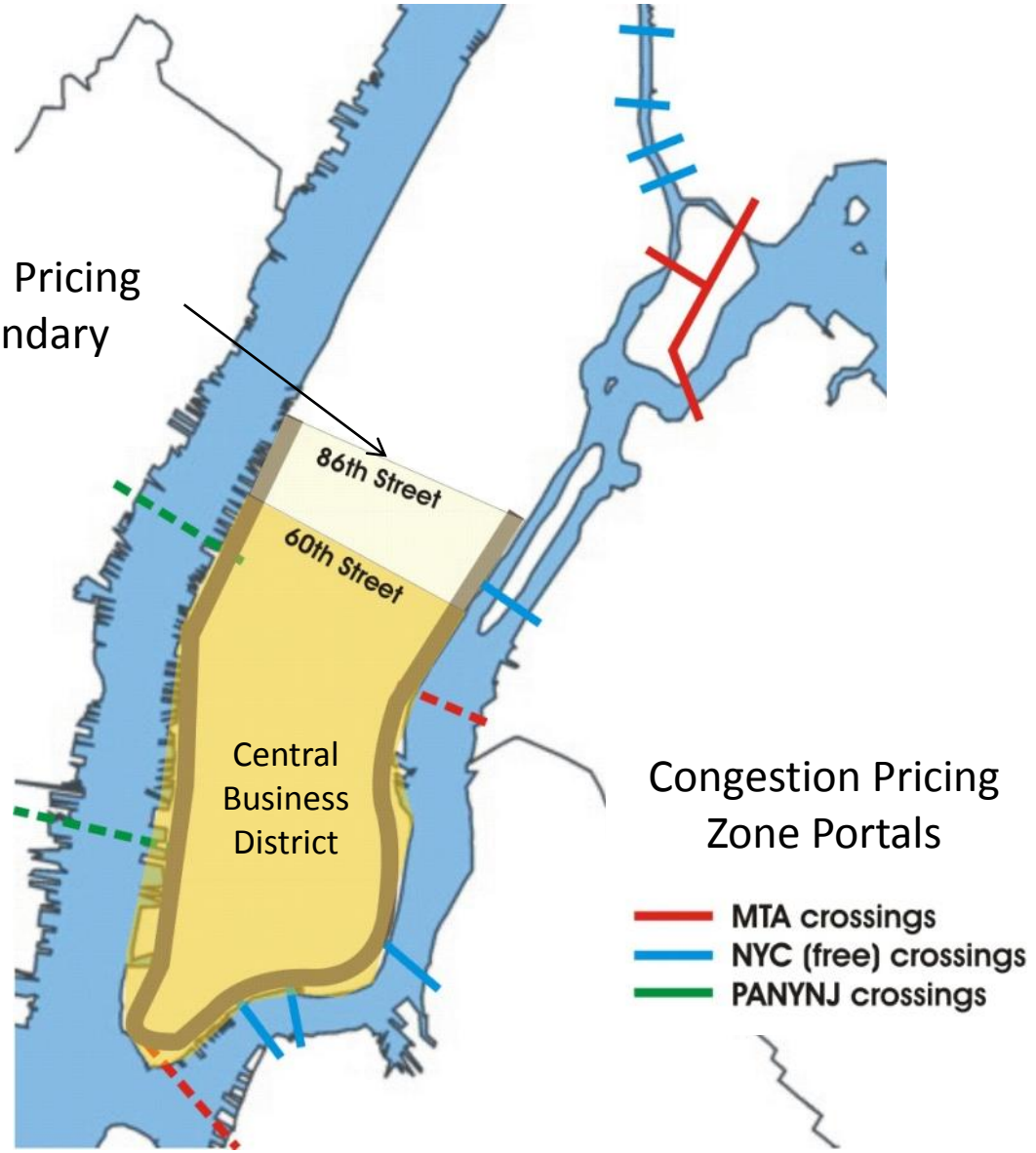
The Travel Model Improvement Program

Policy Evaluation: Pricing

- Ability to represent time-cost tradeoffs on multiple, relevant travel choices:
  - Daily/trip choices: route, time of day, mode, location, vehicle occupancy, pay toll/avoid toll, parking
  - Long-term choices: work and school location, vehicle ownership, transit pass holding
- Affected by income, household structure and mobility resources



Example: Manhattan Congestion Pricing Study



Analyzing "Who pays?" and "How much?"

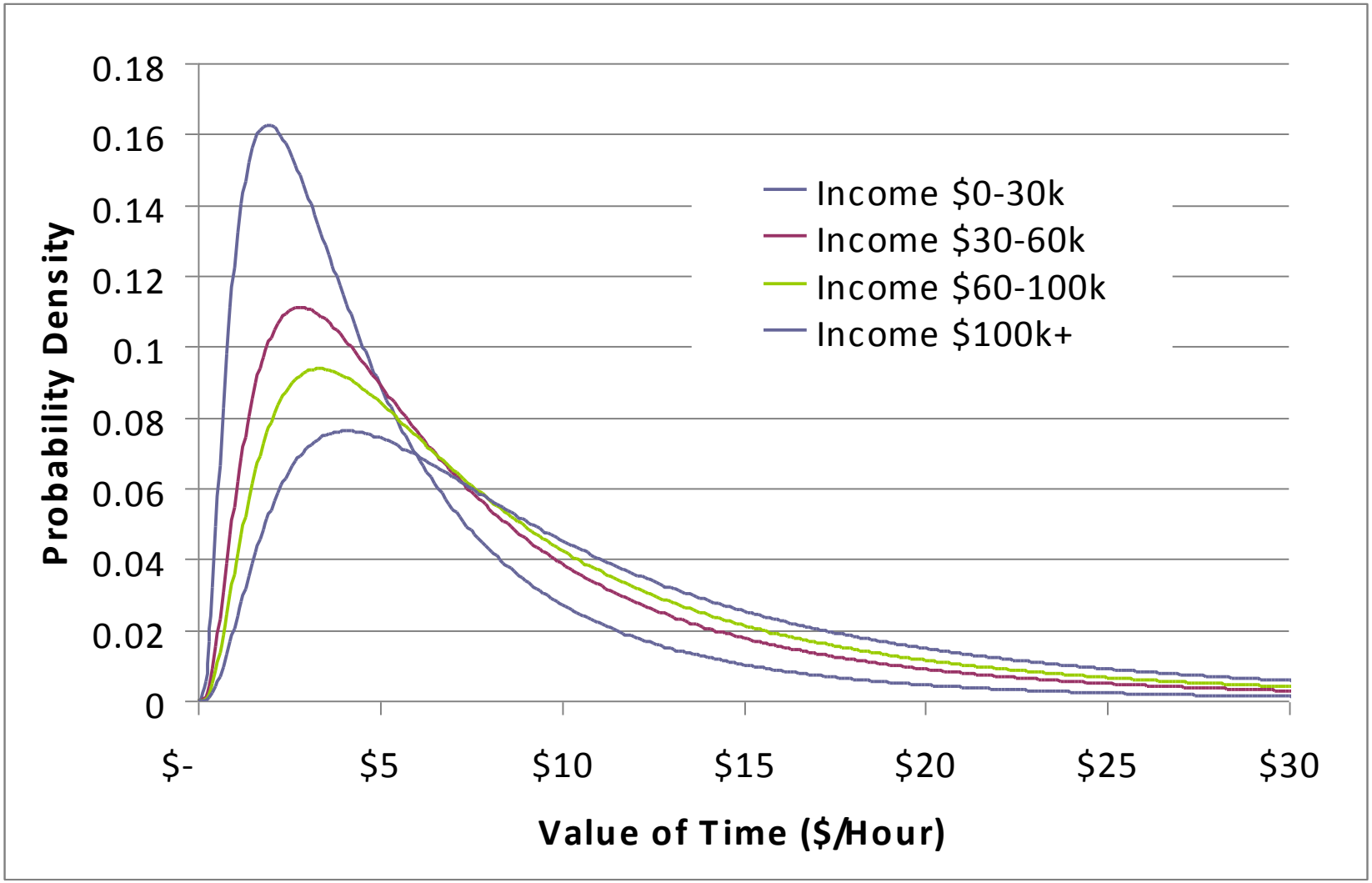
Type of Driver/ Group	Level of Discount
Taxi, Transit	FREE
Commercial Vehicles, Shuttles	FLEET
Rental Cars & Car Sharing	FLEET
Toll-payer 'Fee'-bate	$1 off
Low-Income (Lifeline Value)	50% off
Disabled Drivers	50% off
Zone Residents	50% off
Low-Emission Vehicles	-
HOV/Carpool	-

Helps minimize administrative impacts for businesses, and keeps industry moving

Would require documentation of inability to take transit

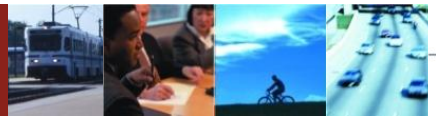
May be accompanied by investment in Means-Based Fare Assistance Program

Estimated San Francisco Resident Values of Time



Travel Demand Management

- Strategies to change travel behavior in order to reduce congestion and improve mobility
  - Telecommuting\Work-at-home
  - Flexible work schedules (off-peak)
  - Rideshare programs
- Scenario-based approaches necessary
  - Model system captures the effects of TDM policy outcomes
  - Cannot identify which policies will affect flexible work schedules
  - But can estimate the impact on transportation system performance of shift from a 5-day 8-hour work week to a 4-day 9+ hour work week

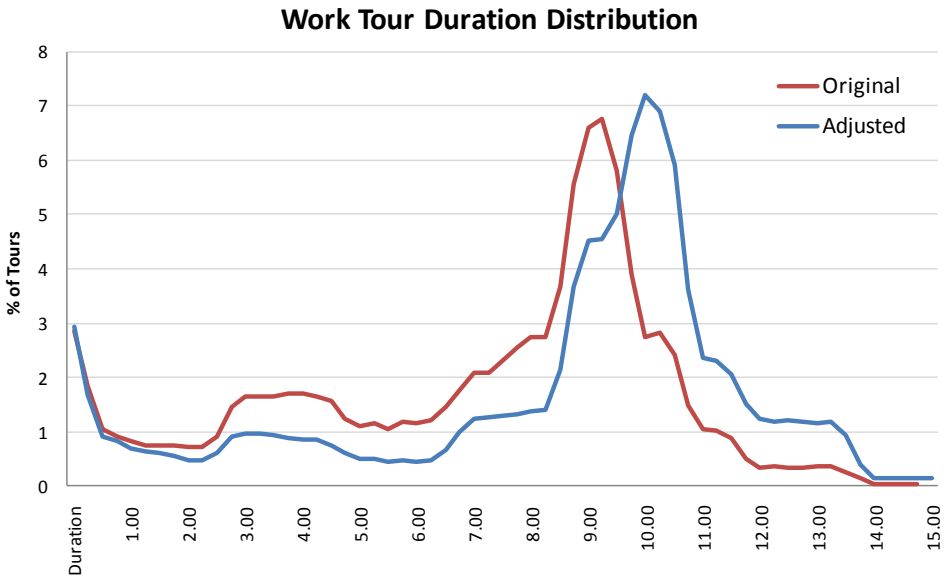


TDM Analysis: Burlington, VT

- "Flexible Schedule" scenario
- Asserted assumptions about:
  - Fewer individual work activities
  - Longer individual work durations
  - Aggregate work durations constant
- Target: Fulltime Workers

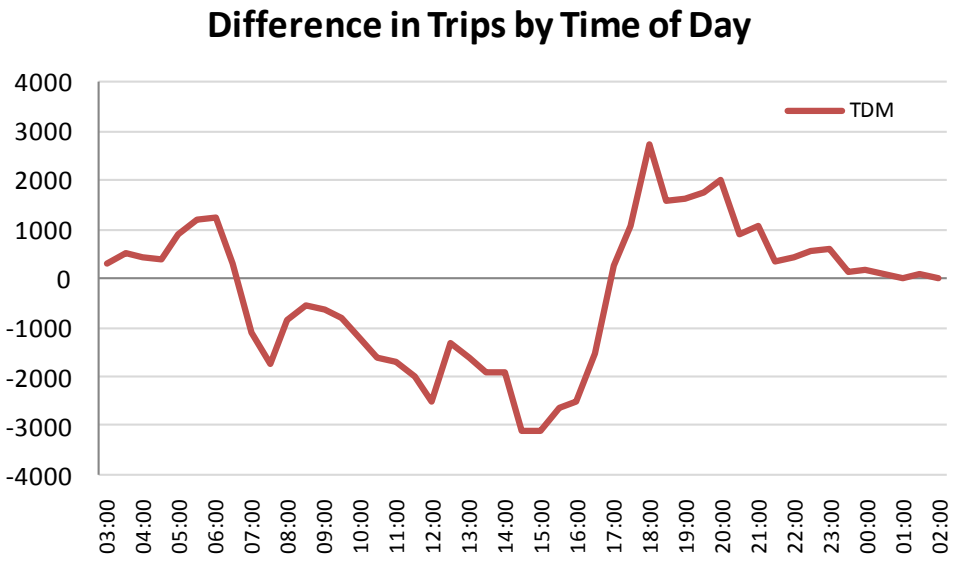
Tours by Purpose (Fulltime Workers)

	Original	Adjusted	Adj/Orig
Work	94,408	78,472	0.83
School	115	140	1.22
Escort	8,070	9,023	1.12
Pers Bus	13,519	16,848	1.25
Shop	10,531	12,938	1.23
Meal	3,817	3,842	1.01
Soc/Rec	13,076	14,360	1.10
Workbased	27,949	23,211	0.83
Total	171,485	158,834	0.93

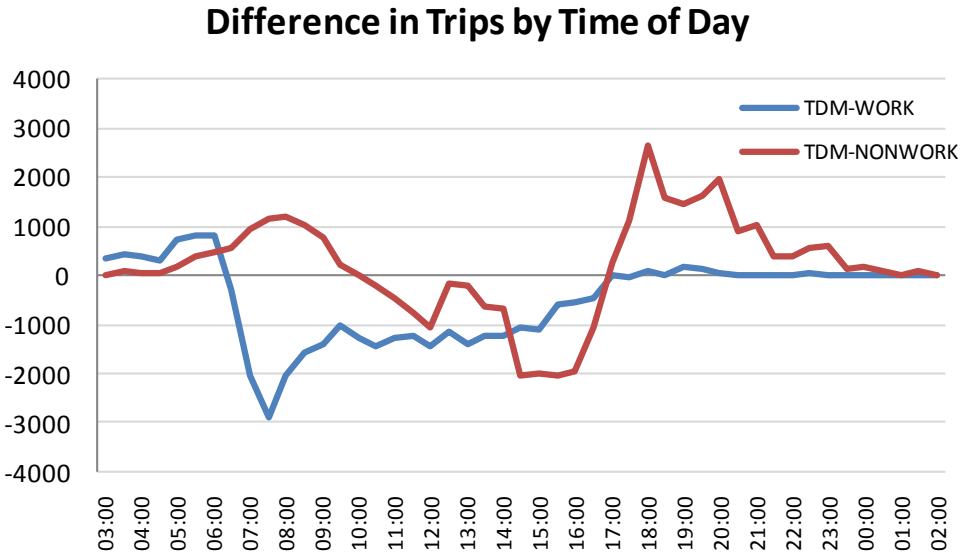


TDM: Demand Impacts

- ~4% Reduction in overall trips
- Reduced peak period and midday travel
- More early AM travel and evening travel

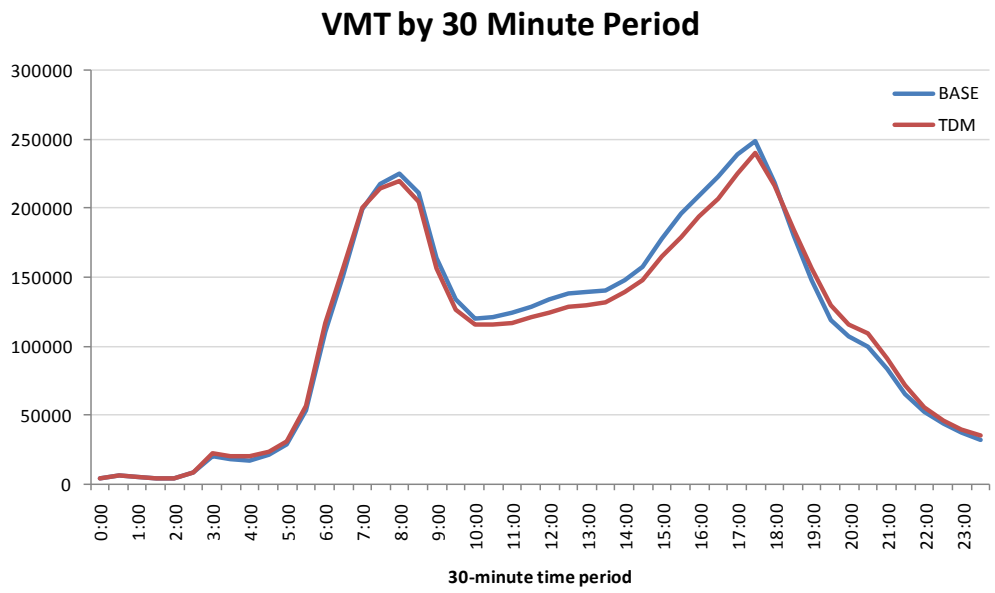


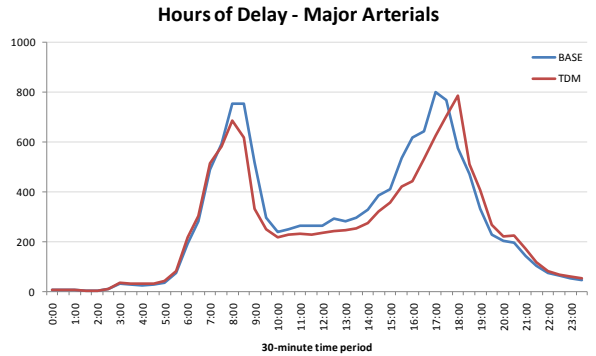
- Fewer, and earlier, work trips
- More nonwork trips in morning and evening with fewer in midday

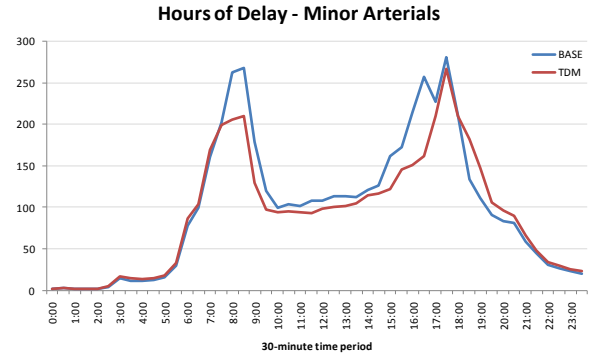


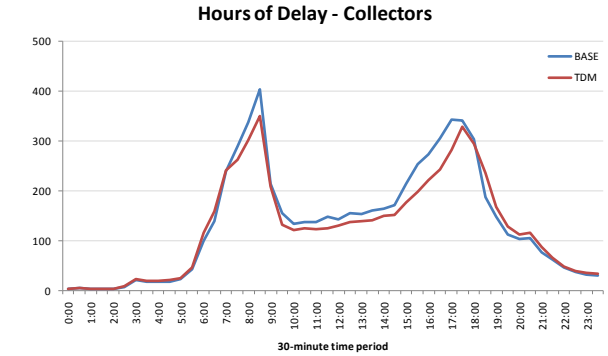
TDM: Supply Impacts

- Total VMT declines slightly
- Reduced peak period and midday VMT, increased VMT in evening
- Reduced peak period and midday delay across all facility types, additional delay in the evening





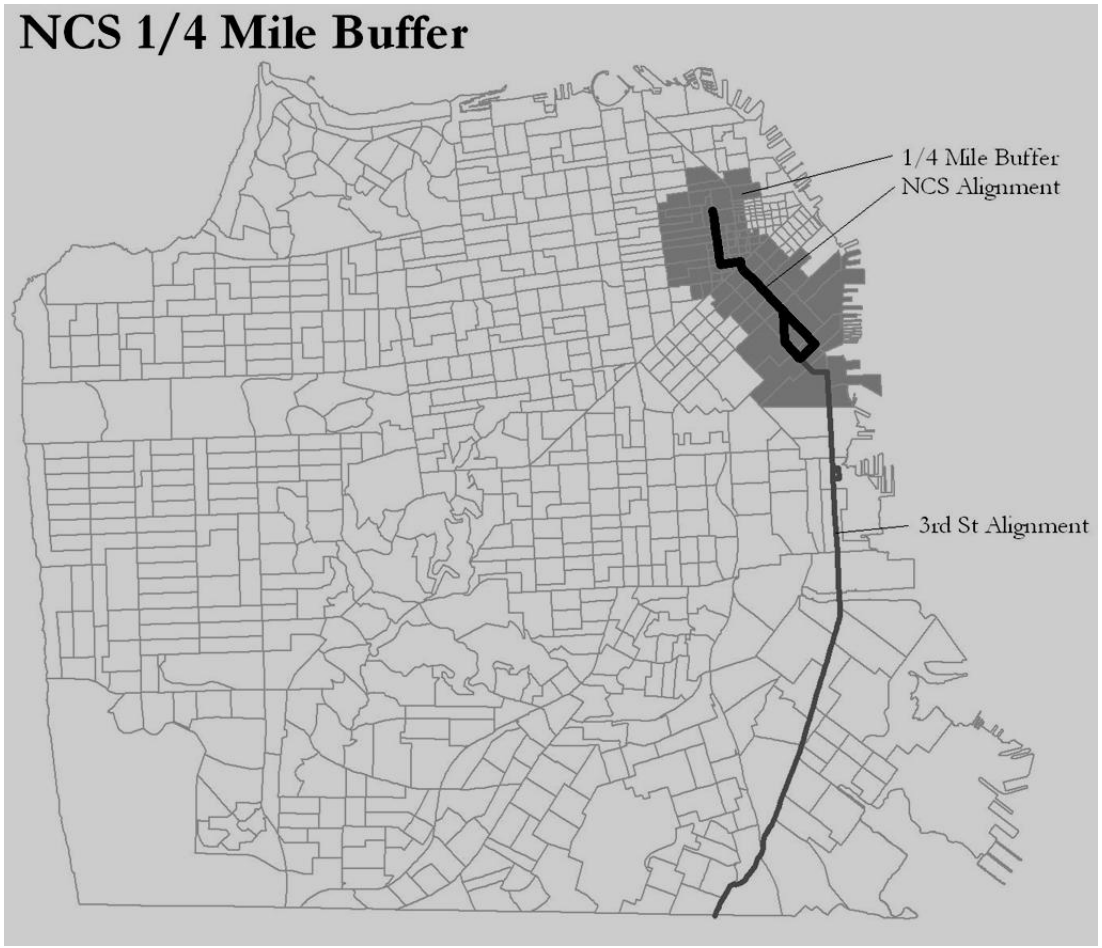




Policies: Transit

- Destination and mode choices for round trips (tours) affect destination and mode choices for individual trips
- Tour-level destination and mode choices consider both outbound and return availability, travel times and costs
- Added detail from home to the transit stop and from the stop to the destination and for local walk and bike travel has improved accuracy
- Transit fare passes and driver's licenses can be explicitly represented
- Built environments affect station area ridership

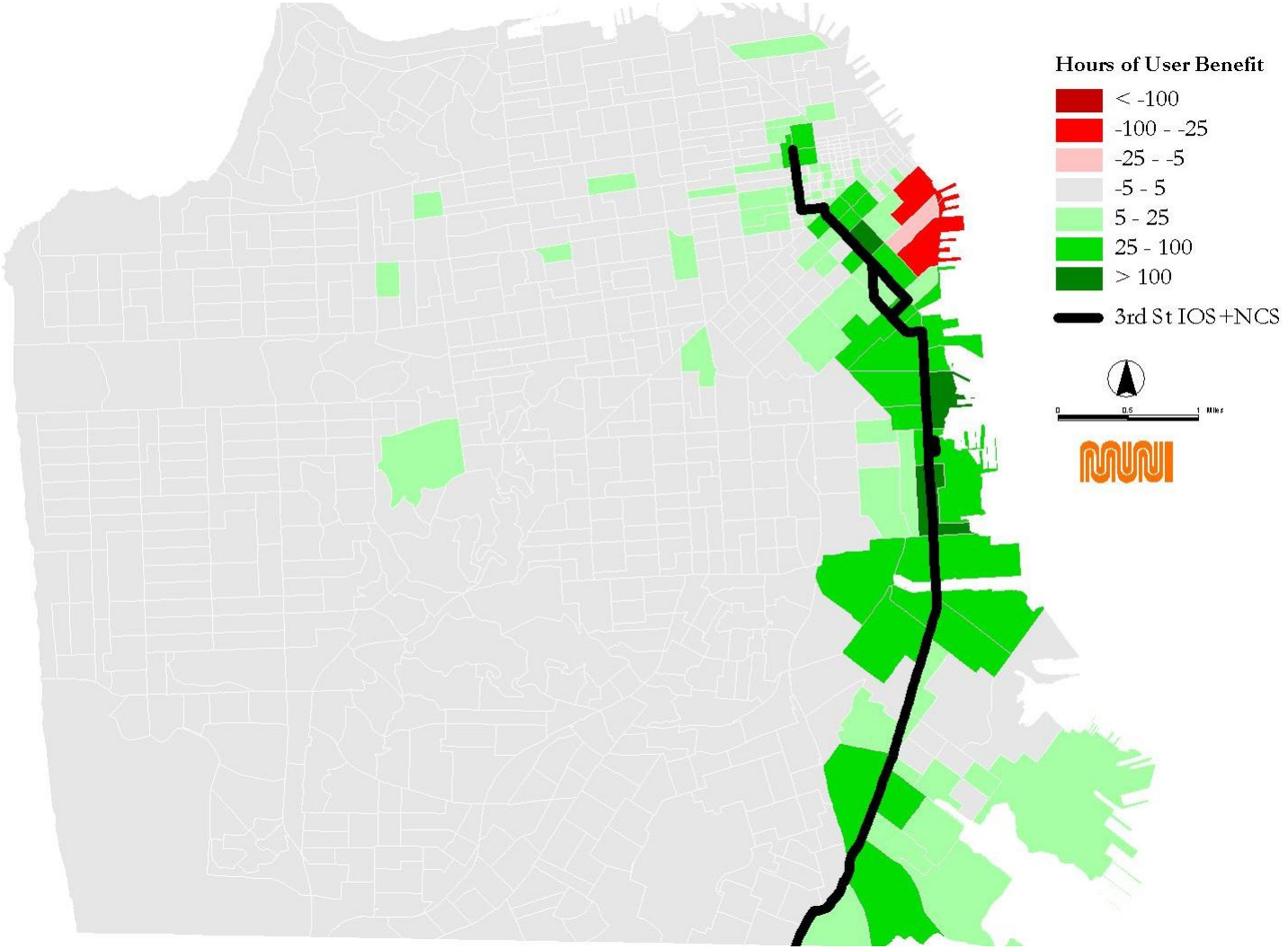
Transit New Starts Application: Muni Central Subway



San Francisco Municipal Railway

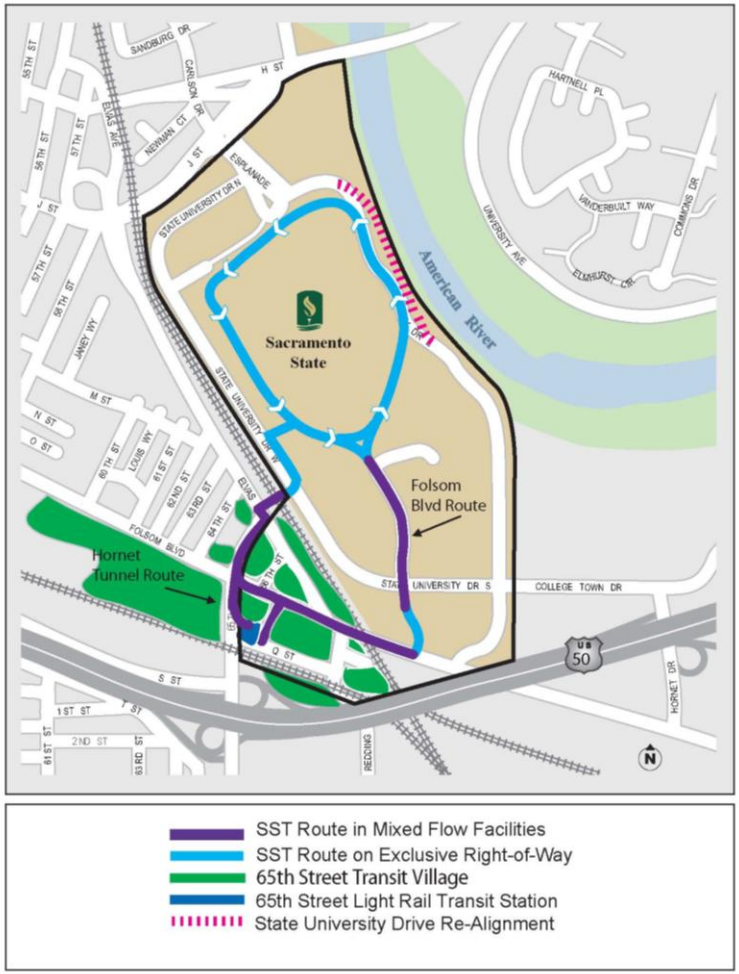
- 1.4 miles connecting South of Market to Chinatown
- Third Street LRT 7.1 mile surface line (IOS = Baseline)

Work Tour Destination-Based User Benefit

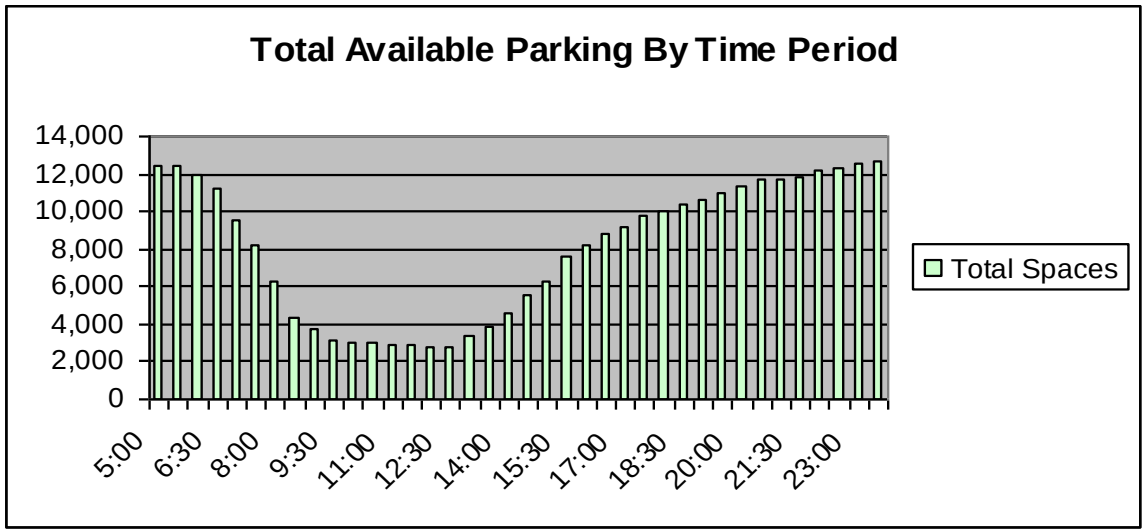


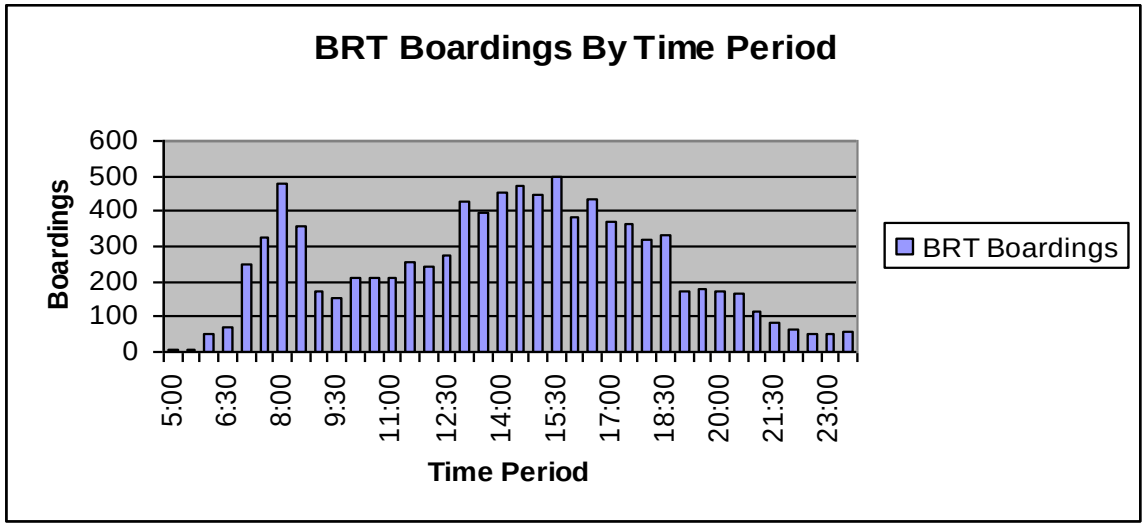
Another (non-New Starts) Transit Application: Sacramento State BRT Project

- Activity-based model used to simulate campus arrivals and departures by ½ hour time periods
- Parking lots fill up -> park further from destination
- Choice of BRT or walk from lot to destination



Temporal Analysis of BRT Parking and Boardings



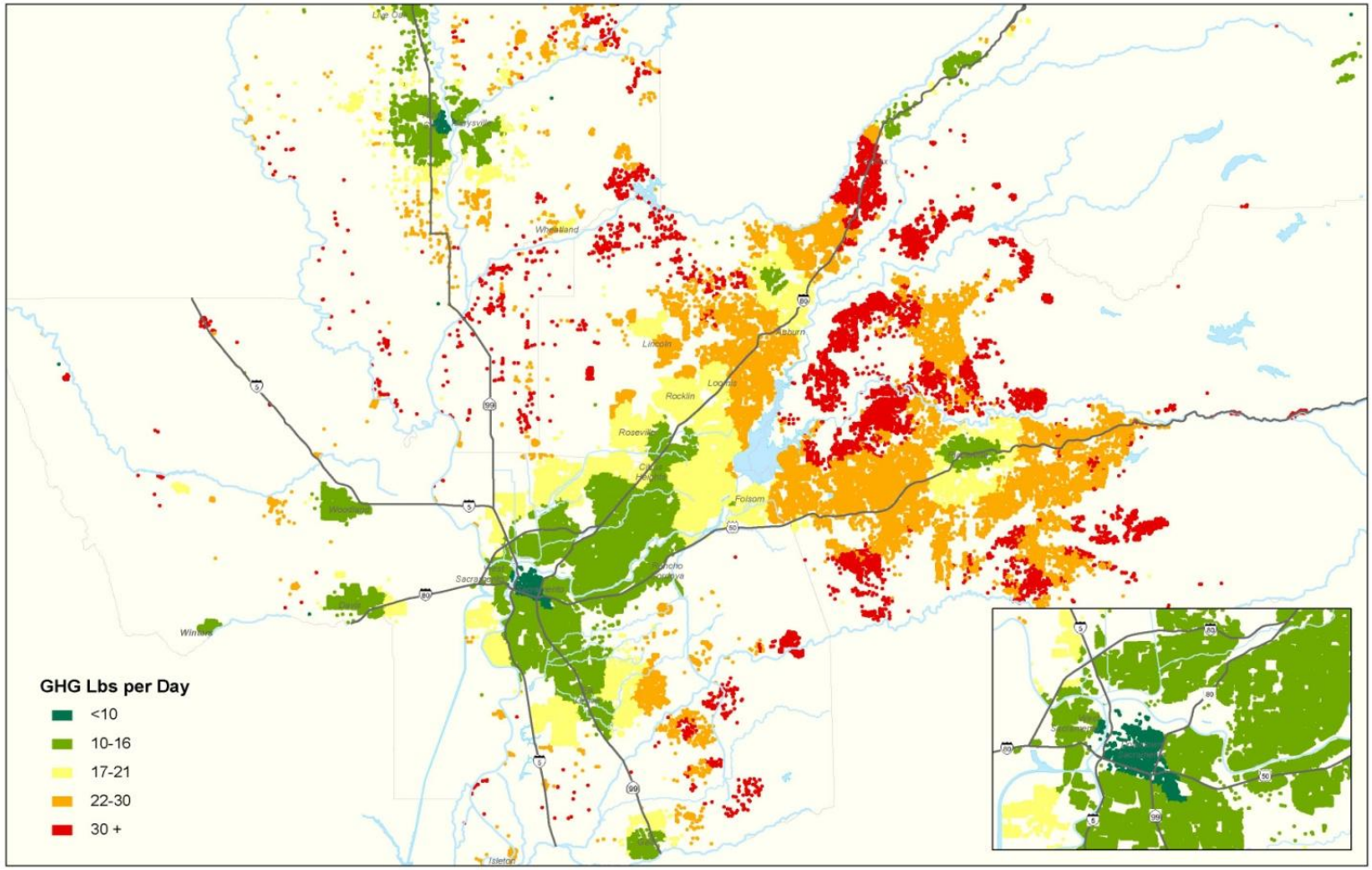


- The tour-based model tracks time in ½ hour periods
- Conventional models do not have this level of detail
- Parking constraints and policies affect transit ridership

Policies: Environment and Climate Change

- Disaggregate data on travel provides more accurate estimates of emissions
- Trip chaining provides better data on starts/stops
- Compact Urban Form and Transit Oriented Development represented more completely through greater level of detail
- Pricing and TDM are important policies for GHG reduction
- Vehicle ownership (type, age) affects emissions

Combined with Emissions Modeling



GHG estimates by residence parcel -- Sacramento Area Council of Governments

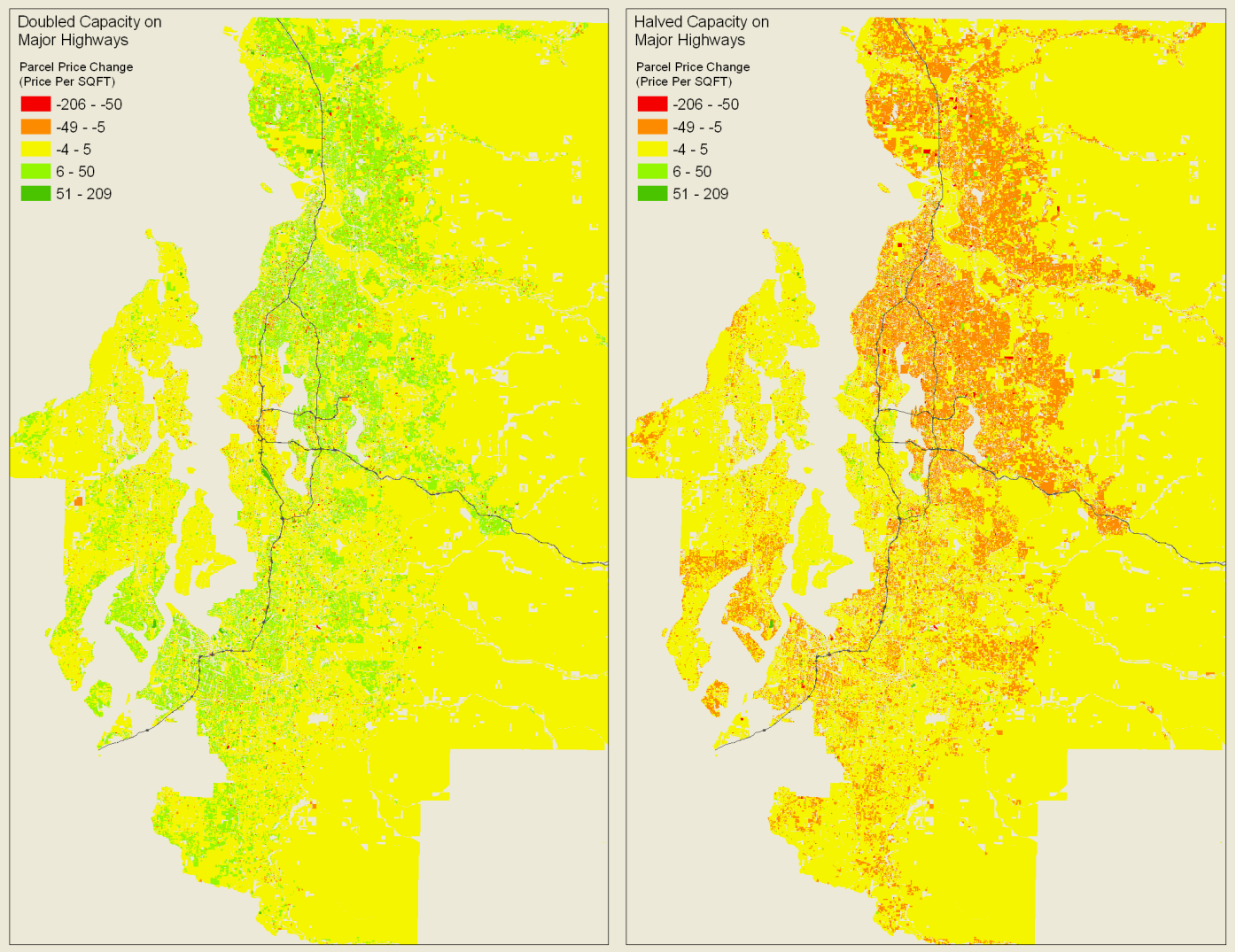
Evacuation Modeling:
Persons "Not at Home" by TAZ and Hour

Atlanta Regional Commission

Policies: Land Use

- More direct representation of different land uses (dwelling unit type, industry categories, parks, etc.) with types of travel (recreation, eating out, shopping, etc.) and the households that occupy those units
- Use of worker occupation better connects workers with their right jobs
- Parcel-based and micro-area systems allow for more detail at businesses/destinations and to aggregate at different level for households

Effects of Transportation Capacity on Parcel Prices



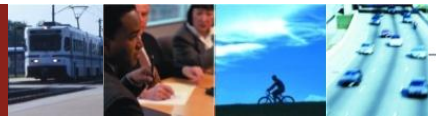
Effects of Transportation Improvements on Land Use

Population and Employment Growth in Regional Centers
(2040 Baseline and Change from Baseline)

Alternative	2000	Baseline	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	PA-C	PA
Population in Regional Growth Centers	122,800	293,400	-6,600	-4,500	8,600	7,300	-200	5,000	10,100
Employment in Regional Growth Centers	573,600	1,049,900	12,600	-1,600	-16,900	-37,400	6,900	-34,600	3,900
Employment in Man/Ind Centers	172,900	195,700	700	700	3,700	4,700	700	2,200	-4,400

Policies: Induced (Latent) Demand

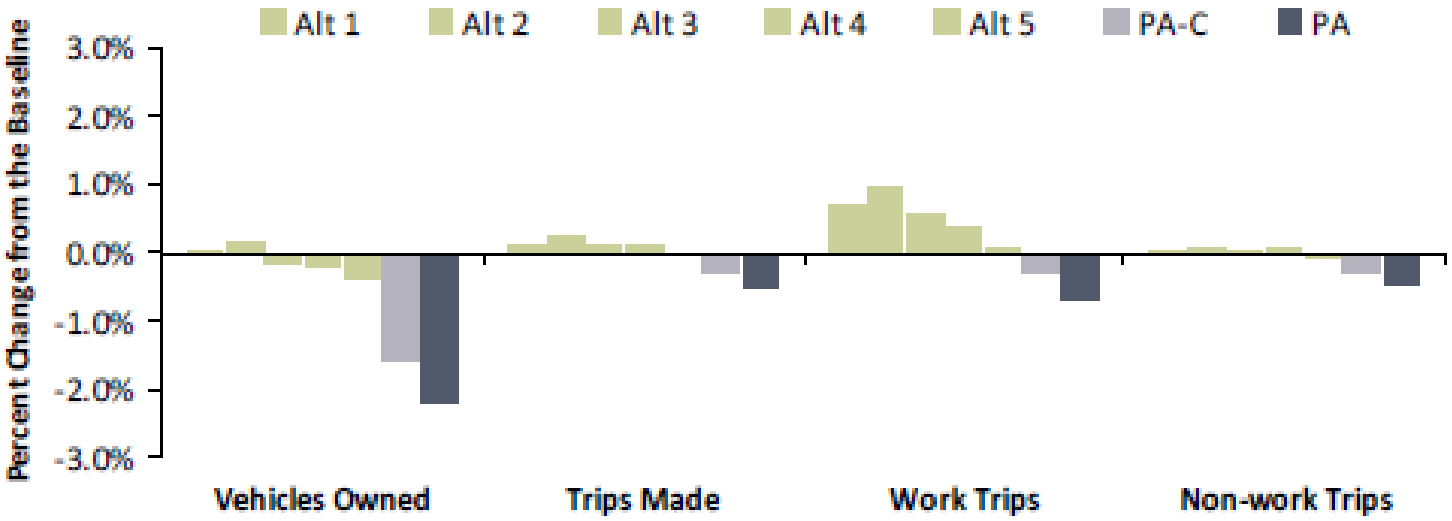
- Additional travel demand resulting from a transportation investment is directly represented
- Additional travel demand resulting from a change in growth patterns due to a new transportation investment can be represented if the model is integrated with a land use forecasting model
- Induced demand may be tempered by changes in performance after the investment is in place (improved speeds on a facility induces more travel in that corridor, which lowers the speed) – these interrelationships are important to capture induced demand



Effects of Transportation Investments on Demand

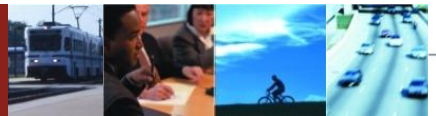
Total Daily Travel (Vehicles Owned and Daily Person Trips Made by Households)

Scenario	2006 Base Year	2040 Baseline	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	PA-C	PA
Vehicles Owned	2,587,000	3,841,000	3,842,000	3,847,000	3,836,000	3,833,000	3,826,000	3,759,000	3,759,000
Change from 2006		48%	49%	49%	48%	48%	48%	45%	45%
Work Trips Made	2,169,000	3,161,000	3,183,000	3,191,000	3,178,000	3,174,000	3,162,000	3,130,000	3,130,000
Change from 2006		46%	47%	47%	47%	46%	46%	44%	44%
Non-Work Trips Made	11,563,000	15,990,000	15,993,000	16,000,000	15,993,000	15,996,000	15,984,000	15,919,000	15,919,000
Change from 2006		38%	38%	38%	38%	38%	38%	38%	38%



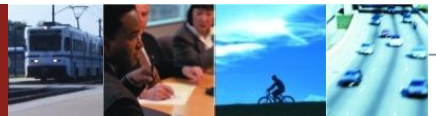
Requirements: Staff Resources

- Need to understand discrete choice models
- Need to learn activity-based models modeling process
- May require more custom scripting and light programming
- Helpful to understand database or statistical queries (in addition to working with matrices)
- Will require time to maintain and prepare scenario databases, if parcels or micro-zones represent land use
- Network coding – potentially more time-of-day networks to code (PM in addition to AM)



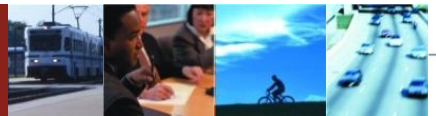
Requirements: Consultant Resources

- Often desired for activity-based model development, but not application
- Most recent development contracts the same cost range as 4-step model development contracts (although initial contracts were higher due to learning curves)
- Most recent contracts the same schedule as 4-step models (schedule largely driven by data availability and funding resources at agency)
- May need to retain consultants for making major model changes and code maintenance



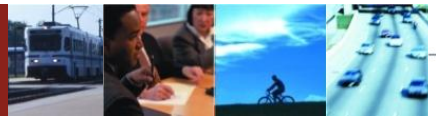
Requirements: Hardware and Software

- Some activity-based models run on single, multi-core processor machines, others run on clustered solutions
- Hardware and runtime is a function of
  - Size of region\population
  - Number of alternatives in models
  - Number of feedback iterations and constraints
- Several software platforms available, none through traditional vendors of 4-step models; these are all open source and freely available



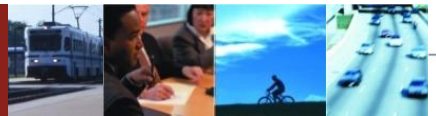
Extensions: Travel Markets

- At their core, activity-based models cover daily person travel generated by households (similar to existing methods)
- May need separate models for other special markets
  - Visitors
  - Airports
  - Universities
  - Commercial travel
  - Internal\External and through-travel
  - Other long-distance travel
  - Special events
- An integrated land use model would be needed to model impacts of travel activity and accessibility on urban development and land values



Interpreting Activity-Based Model Forecasts

- Models are based on simulation, so there is random variation across forecasts
- A distribution of outcomes is more realistic, but may be uncomfortable for those looking for a single answer
- Fixing random numbers can limit result to a single, replicable answer (but only one point on a distribution)
- Multiple runs can be averaged
- Important to conduct "reasonableness checks" and "sensitivity tests" to gain confidence in model outputs

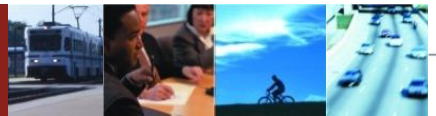


Some Lessons Learned

- Develop a data collection and model development plan
  - Need more, better data?
  - Develop all at once or phase over a few years?
  - Thorough calibration, validation, sensitivity testing, documentation required
- Know the risks
  - Transfer existing model, adapt and incrementally improve, or develop from scratch?
- Train staff
- Identify a champion

Further Research

- Advancements in modeling decisions across multiple dimensions (destination, mode, tours, trips, schedules)
- Testing models with information technology policy parameters
- Integration with dynamic traffic assignment models
- Transferability of activity-based models
- Visualizing and communicating model outputs for decision making



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	March 22
Population Synthesis and Household Evolution	April 5
Accessibility and Treatment of Space	April 26
Long-Term and Medium Term Mobility Models	May 17
Activity Pattern Generation	June 7
Scheduling and Time of Day Choice	June 28
Tour and Trip Mode, Intermediate Stop Location	July 19
Network Integration	August 9
Forecasting, Performance Measures and Software	August 30