SCAG Regional Travel Model Enhancement Program and 2008 Model Validation
Peer Review #4 Report

Appendices

Appendix A: Peer Review Meeting Attendees

Appendix B: Peer Review Meeting Agenda

Appendix C: Presentation – SCAG Travel Model Improvement Program

Appendix D: Presentation – SCAG Travel Model Networks and Zone System

Appendix E: Presentation – Socioeconomic Variables for SCAG Validation Peer Review

Appendix F: Presentation – 2012 Trip-Based Model: Overview of Model Components and Enhancements

Appendix G: Presentation – 2012 Trip-Based Model: Model Validation

Appendix H: Presentation – Model Integration and Software Implementation

Appendix I: Presentation – Computational Challenges and Advances in Transportation Computing

Appendix J: Presentation – Congestion Pricing Models for Express Travel Choices Study

Appendix K: Presentation – SCAG Heavy-Duty Truck Model Development

Appendix L: Presentation – SimAGENT: A Report on the Development of an Activity-Based Travel Demand Model for SCAG

Appendix M: Presentation – Land Use Forecasting Model: PECAS Progress Report

Appendix A: Peer Review Meeting Attendees

No.	Name	Organization
1.	Mike Ainsworth	SCAG
2.	Everett Bacon	LSA Associates, Inc.
3.	Mark Bradley	Mark Bradley and Associates
4.	Ken Cervenka (remote)	Federal Transit Administration
5.	Hao Cheng	SCAG
6.	Chaushie Chu	Los Angeles County Metropolitan Transportation Authority
7.	Viggen Davidian	Iteris, Inc.
8.	Michael Fischer	Cambridge Systematics
9.	Chris Forinash	US Environmental Protection Agency
10.	Guoxiong Huang	SCAG
11.	Nesamani Kalandiyur	California Air Resources Board
12.	Kara Kockelman (remote)	University of Texas (Austin)
13.	Arun Kuppam	Cambridge Systematics
14.	Jim Lam	Caliper
15.	David Levinson (remote)	University of Minnesota
16.	Sean McAtee	LSA Associates, Inc.
17.	Jonathan Nadler	SCAG
18.	Annie Nam	SCAG
19.	David Ory	Metropolitan Transportation Commission
20.	Kazem Oryani	Wilbur Smith Associates
21.	Ram Pendyala	Arizona State University
22.	Rosella Picado	Parsons Brinkerhoff
23.	Eric Pihl	Federal Highway Administration
24.	Ed Regan	Wilbur Smith Associates
25.	Guy Rousseau	Atlanta Regional Commission
26.	Sung Su Yoon	SCAG
27.	Tony Van Haagen	Caltrans District 7
28.	Teresa Wang	SCAG
29.	Warren Whiteaker	SCAG
30.	Seungju Yoon	California Air Resources Board
31.	Yongping Zhang	SCAG

Appendix B: Peer Review Meeting Agenda

Monday, June 27, 2011

Start Time (PST)	End Time (PST)	Activity	Presenters
10:30 AM	11:00 AM	arrive / refreshments	
11:00 AM	11:15 AM	**Welcome and Introductions**	Douglas Williford SCAG, Deputy Executive Director
11:15 AM	12:30 PM	**Presentation 1: Model Input and Assumptions** 1a: SCAG Travel Model Networks and Zone System 1b: Socio-Economic Variables for SCAG Validation Peer Review	**Presenter:** Simon Choi (SCAG)
12:30 PM	1:30 PM	lunch	
1:30 PM	2:00 PM	**Q&A 1: Model Input and Assumptions**	**Discussion Moderator:** Guy Rousseau, Chair **Notes:** Everett Bacon / Sean McAtee (LSA)
2:00 PM	2:30 PM	**Presentation 2: 2012 RTP Trip-based Model** Overview of Model Components and Enhancements	**Presenter:** Rosella Picado (PB)

Start Time (PST)	End Time (PST)	Activity	Presenters
2:30 PM	3:00 PM	**Q&A 2: Trip-based Model**	**Discussion Moderator:** Guy Rousseau, Chair **Notes:** Everett Bacon / Sean McAtee (LSA)
3:00 PM	3:15 PM	**15-minute break**	
3:15 PM	4:00 PM	**Presentation 3: 2010 RTP Trip-based Model** Model Validation	**Presenter:** Rosella Picado (PB)
4:00 PM	4:30 PM	**Q&A 3: Trip-based Model**	**Discussion Moderator:** Guy Rousseau, Chair **Notes:** Everett Bacon / Sean McAtee (LSA)
4:30 PM	5:00 PM	**Presentation 4: Model Integration and Software Implementation** 4a: Model Integration and Software Implementation 4b: Computational Challenges and Advances in Transportation Computing **Q&A 4**	**Presenter:** Howard Slavin / Jim Lam (Caliper) **Discussion Moderator:** Guy Rousseau, Chair **Notes:** Everett Bacon / Sean McAtee (LSA)

TUESDAY, JUNE 28, 2011

Start Time (PST)	End Time (PST)	Activity	Presenters
8:30 AM	9:15 AM	**Presentation 5: Congestion Pricing Models for Express Travel Choices Study**	**Presenter:** Ed Reagan (WS) Kazem Oryani (WS)
9:15 AM	9:45 AM	**Q&A 5: Congestion Pricing Study / Time of Day**	**Discussion Moderator:** Guy Rousseau, Chair **Notes:** Everett Bacon / Sean McAtee (LSA)
9:45 AM	10:30 AM	**Presentation 6: SCAG Heavy-Duty Truck Model Development**	**Presenter:** Michael Fischer / Arun Kuppam (CS)
10:30 AM	10:45 AM	**15-minute break**	
10:45 AM	11:15 AM	**Q&A 6: Heavy-Duty Truck Model**	**Discussion Moderator:** Guy Rousseau, Chair **Notes:** Everett Bacon / Sean McAtee (LSA)
11:15 AM	11:45 AM	**Presentation 7: SimAGENT – A Report on the Development of an Activity-Based Travel Demand Model for SCAG**	**Presenter:** Ram Pendyala (ASU)
11:45 AM	12:00 PM	**Q&A 7: Regional Activity-based Modeling**	**Discussion Moderator:** Guy Rousseau, Chair **Notes:** Everett Bacon / Sean McAtee (LSA)

Start Time (PST)	End Time (PST)	Activity	Presenters
12:00 PM	1:00 PM	**lunch** **Discussion** - Organization of Afternoon Discussion Topics	**Discussion Moderator:** Guy Rousseau, Chair
1:00 PM	1:30 PM	**Presentation 8: Land Use Forecasting Model / PECAS Progress Report** **Q&A 8: Land Use Forecasting Model**	**Presenter:** Dr. John Abraham (HBA Specto) Dr. Doug Hunt (HBA Specto) **Discussion Moderator:** Guy Rousseau, Chair **Notes:** Everett Bacon / Sean McAtee (LSA)
1:30 PM	3:00 PM	**Peer Review Discussion and Report Writing**	**Discussion Moderator:** Guy Rousseau, Chair **Notes/Report writing:** Everett Bacon / Sean McAtee (LSA)
3:00 PM	3:15 PM	**15-minute break**	
3:15 PM	4:00 PM	**Peer Review Panel Presentation of Findings and Recommendations to Study Team** Staff and consultants should be on the teleconference during this period.	**Discussion Moderator:** Guy Rousseau, Chair **Notes/Report writing:** Everett Bacon / Sean McAtee (LSA)

Appendix C: Presentation - SCAG Travel Model Improvement Program

Introductory Teleconference - May 26, 2011

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ASSOCIATION of GOVERNMENTS

Fourth Peer Review Panel

SCAG Travel Model Improvement Program

Guoxiong Huang

5/26/2011

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Fourth Peer Review Panel

SCAG Travel Model Improvement Program

Guoxiong Huang

5/26/2011

Presentation Outline

- Overview of Model Development Program for Year 2008 Model Validation and 2012 RTP
- Review of Third Peer Review Panel Recommendations
- Review of Expert Panel Recommendations

Objectives

The purpose of year 2008 model validation program is to develop a base year model for the analysis of 2012 RTP and related programs, including conformity analysis (Title 40 CFR Part 93.122) and development of Sustainable Communities Strategy (SCS).

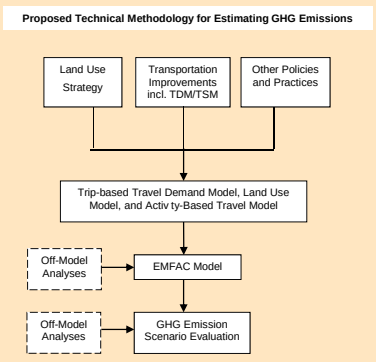
To highlight, the model will be

- validated against observed data (CFR 93.1 22(b)(1)(i))
- sensitive to changes in the time(s), cost(s), and other factors affecting travel choices (CFR 93.122(b)(1)(vi))
- able to measure the benefits of land use strategies aimed at reducing GHG emissions

Modeling SCS Scenarios

- SB 375 requires a Regional Transportation Plan to include a Sustainable Communities Strategy that demonstrates how the region will meet its greenhouse gas reduction target through integrated land use, housing and transportation planning.

- SCAG SCS scenarios comprise seven elements of strategies:
  - Land Use and Growth
  - Highways and Arterials
  - Transit
  - Travel Demand Management
  - Non-Motorized Transportation System
  - Transportation System Management
  - Pricing



Products and Schedules

Completed Projects:

- Development of a Tiered Zone System (July, 2010)
- Regional Highway Network Inventory (Jun, 2009)
- Base Year Highway Network (Sep, 2010)
- Transit LOS Data Collection (June, 2010)
- Base Year Transit Network (Sep, 2010)
- Arterial Speed Study (Feb, 2010)
- Screenline Traffic Count (Mar, 2010)
- Sustainability Tool (Jun, 2010)

Ongoing Projects:

- Trip-Based Model Update
- Heavy Duty Truck Model
- Congestion Pricing
- Activity-Based Model (Completed Phase I)
- Land Use Model (Completed Phase I)
- California Household Travel Survey

Schedule:

- Updated Interim Trip-based Model (Jan, 2011)
- Peer Review (May and June, 2011)
- Final Model Validation Report (July, 2011)
- RTP Alternatives Evaluation (Summer and Fall, 2011)

Tiered Zone System - Process

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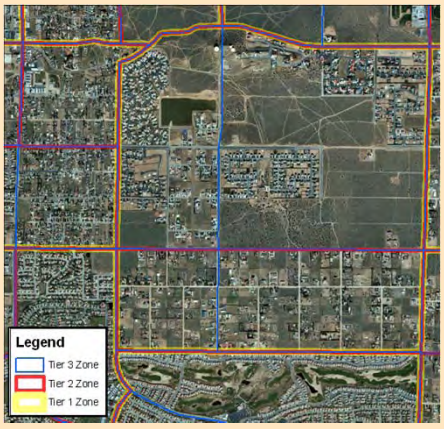
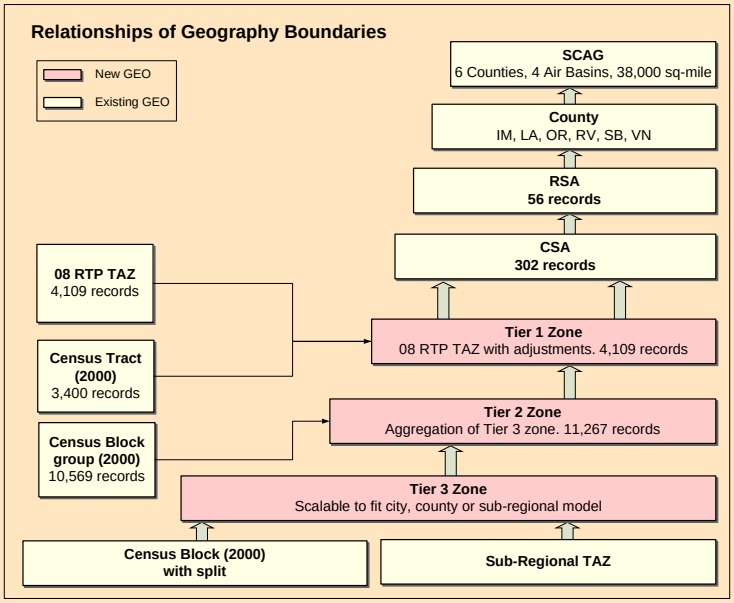
- To enhance the precision of micro-level land use and smart growth analysis for SCS
- Process
  - Collaboration with local jurisdictions
  - Initial TAZs from cities, counties, and subregions
  - Extensive local review and revisions
  - Tier 1 zones consistent with 08RTP zones (4109 internal zones)
  - Minor Tier 1 boundary adjustment based on local requests



Tiered Zone System - Structure



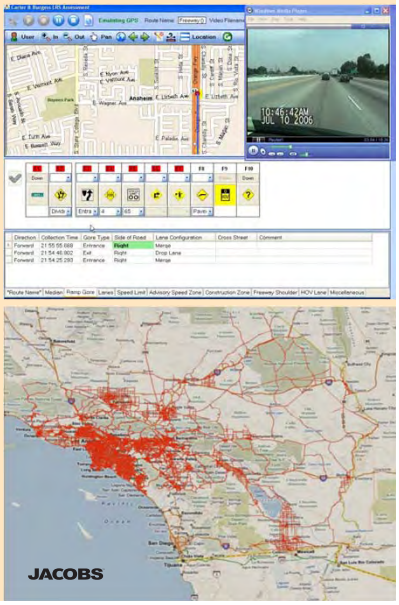
Tiered Zone System - Summary

SUMMARY OF TAZ STATISTICS

Modeling Area	2000 Census Tract	2000 Census Block Group	RSA	CSA	08 RTP TAZ (Internal)	Tier 1 Zone (Internal)	Tier 2 Zone (Internal)
Imperial County	29	105	1	15	110	110	239
Los Angeles County	2,052	6,345	21	155	2,243	2,243	5,697
Orange County	577	1,826	10	43	666	666	1,741
Riverside County	343	804	11	38	478	478	1,532
San Bernardino County	244	1,099	7	34	402	402	1,395
Ventura County	155	390	6	17	210	210	663
Total	**3,400**	**10,569**	**56**	**302**	**4,109**	**4,109**	**11,267**

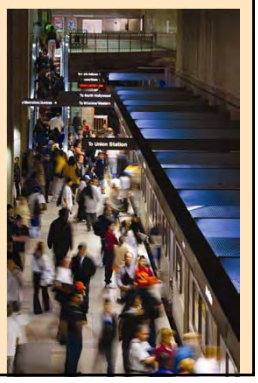
Regional Highway Network Inventory

- To gather regional highway network inventory and transfer attributes to SCAG's TransCAD Network
- Network included (over 16,000 centerline miles) all freeways, arterials, urban major collectors
- Primary Attributes:
  - Speed Limits
  - Lanes (by time period)
  - Intersection Control
  - Median Type
  - Directionality (one-way streets)
- Secondary attributes:
  - Shoulder type, parking, school zones, advisory speeds, HOV access, ramp gore points, bike lanes, other controlled intersections



Transit LOS Data Collection

- To prepare transit level of service database for year 2008 model validation
- To build a complete transit database that covers key attributes of NTD and TripMaster for SCAG region
- Received excellent support from transit operators in the region
- Data collected include:
  - Boarding
  - Service (freq., route miles, pass. miles, stops, schedules, fares, VRM, VRH)
  - Operation (cost/revenue, subsidy, vehicles by mode and service type)
  - Performance (accident/road call rates, on-time rate)
  - Contacts
  - Other (on-board surveys, transfers, PNR)
- Consultant:
  MECS



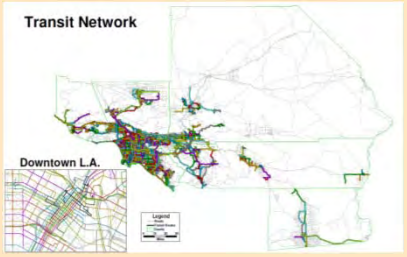
Regional Transit Network Development

- **Reviewed and revised methodology for non-transit links**
  - Used TeleAtlas to associate census block level data to develop walk access links
- **Updated transit network to reflect the following modes of services:**
  - Metrolink & Amtrak
  - Urban Rail
  - HSR
  - Transitway Bus
  - Express Bus
  - Rapid Bus
  - Local Bus

- **Developed a program to:**
  - Automate the process of separating out shortlines/interlines ba
  - Keep the correspondence for pattern/line conversion
  - Calculate more accurate headways and detailed service hours (
  - Developed a TripMaster to TransCAD transit network conversion tool
- **Fixed problematic routes and stops not addressed by automation**
- **Consultants:**
  Caliper Corporation
  MECS

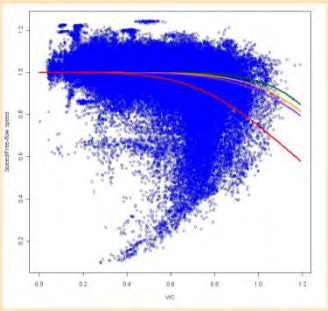
Regional Transit Network - Summary

- Created a year 2008 transit network with over 3,400 routes and 160,000 stops
- Separated shortlines to calculate correct headways
- Added transit routes not covered by TripMaster
- 15 transit networks developed to reflect transit operations by time of day (AM, MD, PM, EV, NT) and day of week (Mon-Fri, Sat, Sun)
- Data collected through Transit LOS project were used to update transit service attributes (headways, base fares, base fare factors, transfer fare factors)



Arterial Speed Study

- Conducted floating car surveys of 31 locations to collect flow and speed data on weekday PM peak periods
- Developed new VDFs for arterials based on data collected
- Researched PeMS database to develop VDFs for freeways
- Updated free flow speed and capacity look-up tables



Screenline Traffic Count

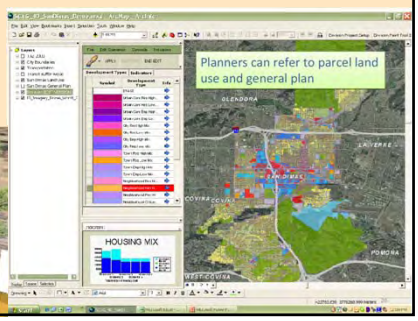
- To establish the validation traffic count dataset
- Obtained and reviewed existing traffic counts taken by member governments and stakeholder agencies
- Developed a regional traffic count database
- Conducted an analysis of count data to apply annual, seasonal, and other factors.
- The final database includes traffic counts by time-of-day, vehicle classification, and in some cases, occupancy for freeways and HOV lanes in SCAG region.
- The final data includes adjusted 2008 average annual April/May/June traffic for all screenline locations by vehicle type and time period.
- Focus was to establish validation counts for roadways that cross screenlines, although counts for non-screenline locations are included as well where data was available and resources provided.
- 34 screenlines with 535 arterial, 182 freeway, and 53 HOV links

Sustainability Tool

- Developed an ArcGIS-based sketch planning tool for local jurisdictions to analyze the impact of different land use scenarios on vehicle ownership, VMT, mode use, and associated effects on GHG emissions

- In response to SB 375
  - Primary emphasis on reducing vehicle travel through compact, transit-oriented land use
  - MPOs must develop Sustainable Communities Strategy (SCS)
  - Regional GHG reduction targets for 2020 and 2035 to be set by CARB in 2010

- Consultants:
  - Rich Kuzmyak
  - Fregonese Associates
  - Fehr & Peers

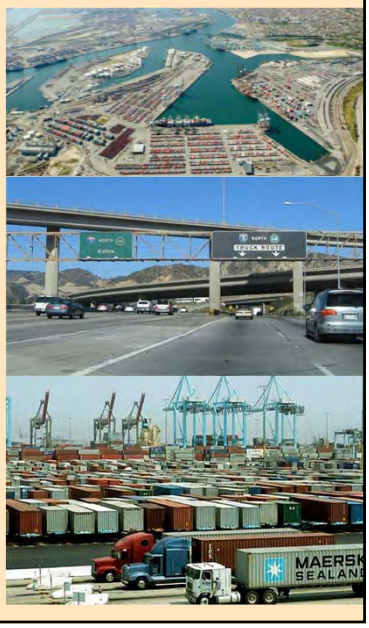


Heavy Duty Truck Model

To Support Policy and Project Planning in Areas of:
- Port Competitiveness
- Clean Technology Truck Lanes
- Operational Strategies
- Freight Facility Development
- Air Quality/Conformity Analysis
- Economic Impact Analysis

Major Improvements and Data Sources:
- External trip generation/distribution – TRANSEARCH commodity flow
- Internal trip generation – establishment survey, Trimble and ATRI GPS data
- Port/special generator – supply chain survey and port terminal survey

Consultant:
- Cambridge Systematics



Congestion Pricing

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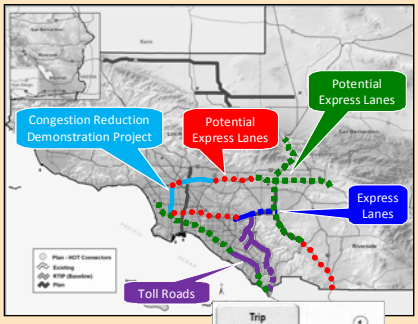
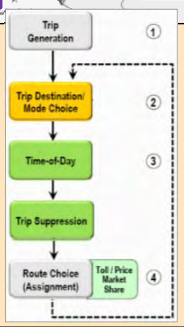
Data:
- Stated Preference Surveys in LA Region – 3,590 completed responses from six SCAG counties
- Analysis of 2005 PSRC "Travel Choices" Data Base – Revealed Preference
- Analysis of 2001 SCAG Household Travel Survey Data
- Analysis of Observed Behavioral Responses (e.g. SR 91 Express Lanes)

Pricing Alternatives Being Evaluated:
- Express Lanes/High Occupancy Toll (HOT Lanes)
- Cordon/Area Pricing (e.g. downtown LA)
- Facility Pricing (e g., pricing new highway facilities)
- Regional VMT/Emission Fees

Consultants:
- HNTB
- Wilbur Smith and Associates
- Resources Systems Group





Activity-Based Model

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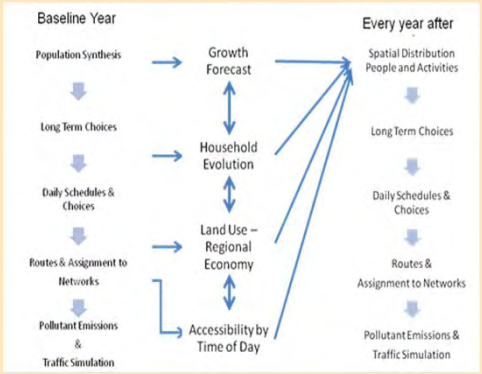
Phase 1 Adapt DFW Model

Phase 2 Develop SCAG Model

Phase 3 Complete ABM w/DTA



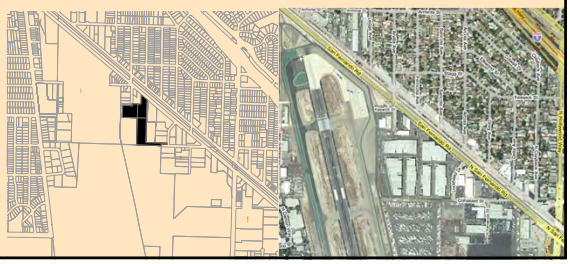
Kostas Goulias
University of California
Santa Barbara

Ram Pendyala
Arizona State University
Tempe

Chandra Bhat
The University of Texas
Austin

SCAG Land Use Model

- Support demand for comprehensive impact analysis from land use and transportation system scenarios, a tool for land use scenario development
- Collected and processed parcel level data
  - 5.8 million Households by household characteristics
  - 684,000 businesses, 7.8 million Jobs by industry
  - On 4.8 million parcels with land use / floor space characteristics
- PECAS Modeling System
  - Activity Allocation (AA) Model
    - demand for land and price
  - Space Development (SD) Model
    - supply of land
  - Transport Model
    - network skims to AA model
- Consultants:
  - ULTRANS, UC Davis
  - HBA Specto



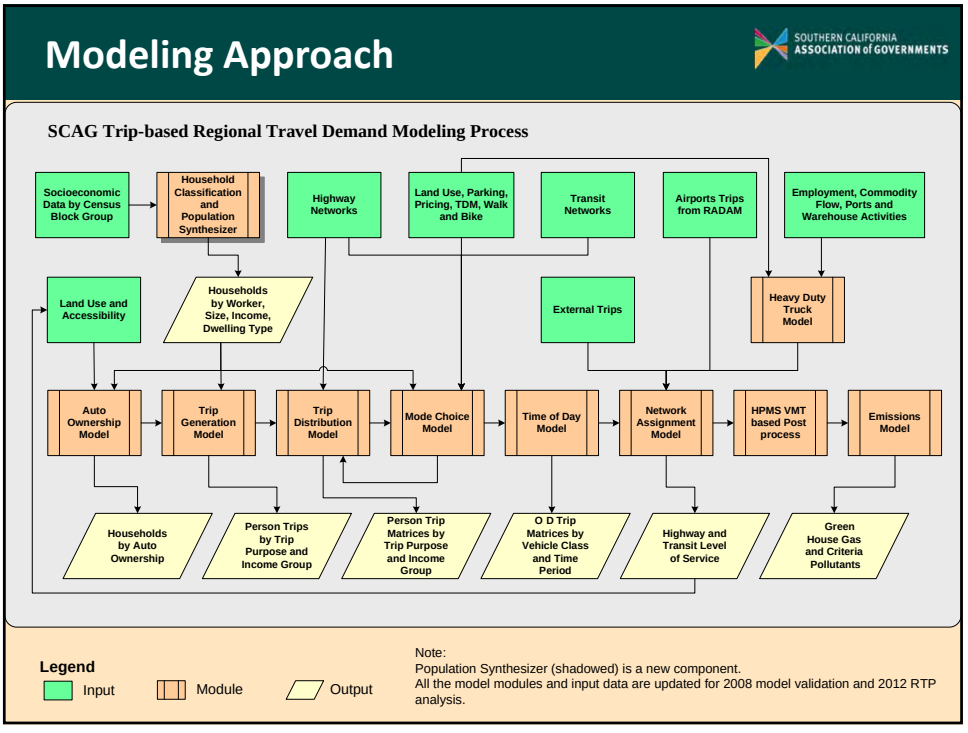
California Household Travel Survey

- Collaboration between Caltrans & MPOs to address both statewide and regional needs
- Support development of RTP, statewide travel model, next-generation models
- Status:
  - Pre-Survey Design (Goulias) Completed
  - NuStats – Contract Executed, 7/15/2010
  - CHTS Project Kick-off Meeting 9/22/2010
- Funding:
  - Prop 84 - $2,028,000, FY 2009/10
  - Caltrans - $4,302,000, FY 2009/10
  - MPOs - $4,000,000
  - Total - $10,330,000
- Samples: 60,000 Households (5,000 GPS Samples)
- Schedule:
  - 10/10 - 06/11 … Finalize Survey Design
  - 06/11 - 09/11 … Conduct Pre-Test Survey
  - 10/11 - 11/11 … Evaluate/Refine Survey
  - 11/11 - 12/12 … Conduct Main Survey
  - 12/11 - 2/13 … Analysis & Final Report

Trip-based Model Update Objectives

Improve Sensitivity to Smart Growth	• Implement Tier 2 zone demand model • Incorporate D-Variable effects in demand model • Improve intra-zonal trip forecasting • Perform Smart Growth sensitivity tests
Improve Sensitivity to Road Pricing	• Represent all first-order pricing effects: mode choice, time-of-day choice, route choice • Implement destination choice models linked to mode choice logsums
Improve Transit Forecasting	• Incorporate newly updated highway geography and transit networks • Update path-building procedures • Overhaul mode choice model
Improve Traffic Assignment	• Implement additional time periods • Implement toll trip and HOV assignment method • Perform detailed regional traffic validation
Improve High Speed Rail Forecasting	• Add HSR choice to mode choice model • Link to CAHSRA inter-regional trip tables
Improve Representation of Travel Markets	• Use PopSyn in lieu of household allocation models • Review and update model assumptions and trip market segmentation

Modeling Approach



Note:
Population Synthesizer (shadowed) is a new component.
All the model modules and input data are updated for 2008 model validation and 2012 RTP analysis.

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Review of Third Peer Review Panel Recommendations

Panelists:
Frank Spielberg (Chair), BMI-SG, a VHB Company
Mark Bradley, Mark Bradley Research Corporation
Chandra Bhat, University of Texas at Austin
Chuck Purvis, Metropolitan Transportation Commission
Jim Ryan, Federal Transit Administration
Erik Sabina, Denver Regional Council of Governments
Bruce Spear, Federal Highway Administration

Date: January 9-10, 2006

Panel Recommendations and Action

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Recommendation	Model improvement actions
1. Vehicle Availability Model Examine the sensitivity of the auto availability model to density	Re-estimated and re-validated the auto availability model. Explanatory variables: • household size, number of workers, household income • type of housing unit (single family detached, multi-family) • mixed residential and employment density • walk accessibility to employment • transit accessibility to employment Validated to CTPP 2000 and ACS 2005-2009 data.
2. Mode Choice Model Review the nesting structure of the mode choice model. Re-estimate the mode choice model. Explore additional market segmentation. Use CTPP data for model validation.	Adopted the mode choice model developed by the Los Angeles Metropolitan Transportation Authority for the Southern California region. The LACMTA model has been reviewed by FTA and is currently being used to support multiple transit corridor studies. Features: • Fully stratified by trip purpose, time period and household income • Model parameters and constants within expected range of values • Detailed transit choice set • Binary toll choice and binary HOV lane choice nests Calibrated to 2008 conditions using extensive array of on-board surveys and available CTPP and ACS data

Panel Recommendations and Action

Recommendation	Model improvement actions
3. Trip Distribution Model Develop destination choice models	Estimated and calibrated destination choice models for all purposes except school trips. Model estimation was based on 2000 household travel behavior survey. Model calibration has been performed in stages – initially to 2000 conditions, based on the Tier 1 zones, and ending with 2008 conditions, based on Tier 2 zones. Sensitive to mode choice logsums, mixed residential and employment density, household income, and regional employment. The model has been validated to ACS worker flows and 2008 NHTS data.
4. Other Possible Model Improvements a) Develop a methodology for including HOT lanes b) Incorporate peak spreading	a) Developed highway assignment methods to model HOT lanes, as part of the Congestion Pricing Study. The mode choice model has the ability to model HOT lanes within its binary toll choice nest. b) Developed a time of day choice model that operates at 30-minute resolution. This model is stratified by trip purpose.

Panel Recommendations and Action

Recommendation	Model improvement actions
5. Validation Dedicate significant time to model validation	Model components have been validated individually as part of the model improvement program. Full model validation is on-going.
6. Assigning On-board Survey Data Assign on-board survey data	The development of the LACMTA mode choice model included an extensive validation of the on-board survey trip table assignment. Lessons learned from this effort are reflected in the specification of the model and in the way in which the transit skims are built.
7. Model Run Time SCAG should to install hardware that is fast enough to permit efficient use of the models.	An extensive effort has been done to reduce model run time, including the development of custom Caliper software, source code optimization, model flow optimization, and purchase of top-of-the-line hardware.
8. Survey Data Sharing SCAG has an impressive set of survey datasets. The panel felt that SCAG should make these survey datasets available to other agencies.	SCAG modeling group received nearly 200 modeling and data requests each year, many of them are survey data related requests. SCAG has been able to process the data and to provide the survey data absent of the sensitive individual identifications.

Review of Expert Panel Recommendations

Expert Panel Review – Pricing Model

Panelists :

Kara Kockelman – *University of Texas, Austin (Co-Chair)*

Robert Donnelly – *Parsons Brinckerhoff, New York (Co-Chair)*

Mark Bradley – *Bradley Research and Consulting*

Matthew Kitchen – *PSRC*

Ram M. Pendyala – *Arizona State University*

Eric Pihl – *FHWA, Denver*

Date: August 28, 2009

Expert Panel Review – Pricing Model

Important Issues

- **Need to be very transparent in all modeling decisions, with clearly and comprehensively documented methods so that anyone could replicate the process.**
  - *Response: The Team has provided the following documents which specify model enhancement steps during the model development period:*
    - *Model enhancement plan, November 20, 1999*
    - *Time-of-day model with pricing impacts, development and methodology for application, October 7, 2010*
    - *Trip suppression for pricing impacts, development and methodology for application, October 7, 2010*
    - *Time-of-day and time-of day shift prototype test results, March 22, 2011*
- **Sample Size – Sample is a concern. Need to conduct enough surveys in order to adequately fill-in all of the cells.**
  - *Response: The sample size was increased from about 1,200 to 3,600 to fill all major quota cells.*

Expert Panel Review – Pricing Model

- **Time-of-Day - The evaluation of tolls and pricing schemes should account for time-variation of traffic demand and during peak and off-peak periods.**
  - *Response: Time-of-Day model estimates traffic demand for 30 half-hour period from 6:00 AM 21:00 PM. Night period is from 21:00 to 6:00 for total of 31 periods.*
- **Currently gravity model is doubly-constrained; panel recommends either removing a "gravity" model for trip distribution or changing to one constraint**
  - *Response: Distribution model is being replaced by a new destination - mode choice model*
- **Carefully review model statistics to ensure that the model is adequately developed.**
  - *Response: Time-of-Day and Time-of-Day Shift prototype test results shows that using RMSE statistics, the AM Peak assignment is improved by 2% lower RMSE; PM Peak period is improved by 4% lower RMSE; RMSE for Midday stayed the same and Night period RMSE improved by 4% lower RMSE.*

Expert Panel Review – HDT Model

Panelists:

Garland Chow – *University of British Columbia*
Scott Drumm – *Port of Portland*
Jose Holguin-Veras – *Rensselaer Polytechnic Institute*
Becky Knudson – *Oregon DOT*
Michael Meyer – *Georgia Institute of Technology (Co-Chair)*
Rolf Moeckel – *Parsons Brinckerhoff*
Maren Outwater – *Puget Sound Regional Council*
Rolf Schmitt – *FHWA*
Frank Southworth – *Georgia Institute of Technology (Co-Chair)*

Date: June 8, 2009

Expert Panel Review – HDT Model

Important Issues

- **Internal HDT Trip Generation: Improve trip rates by collecting new truck travel data**
  - *Response: The Team has conducted and collected the following truck travel data:*
    - *2009/2010 Establishment surveys to derive good estimates of trip rates by land use*
    - *2009/2010 Truck GPS data from multiple GPS vendors to derive good estimates of trip rates by land use, land to land use trip interchanges, and trip length distributions.*
- **Internal HDT Trip Distribution: Develop generalized cost function into the gravity model and collect enough data to support 8x8 land use types and 3 GVW HDT types**
  - *Response: The Team has compiled and processed truck GPS data from three vendors that provided enough data to produce statistically significant parameters, trip lengths by GVW and land use-to-land use interchange matrix:*
    - *Calmar GPS Data – 1,677 Heavy HDT trips*
    - *Trimble GPS data – 530,825 Light and Medium HDT trips*
    - *ATRI GPS Data – 573,176 Heavy HDT trips*

Expert Panel Review – HDT Model

- **External HDT Model: Replace existing FAF2 data with new TRANSEARCH commodity flow database**
  - *Response: The Team reviewed and processed TRANSEARCH commodity flow database, and updated the external HDT model:*
    - *County to county TRANSEARCH flows were disaggregated to internal TAZs;*
    - *New external station counts were used to calibrate the external HDT model by GVW.*
- **Special Generators: Update port trips, develop intermodal terminal trips, and track secondary trips**
  - *Response: The Team improved the special generator trips as stated below:*
    - *Port HDT Trips – Conducted new terminal gate surveys, obtained new Quick Trip inputs from ports, and developed new Port HDT trip tables by time period;*
    - *Intermodal Terminal HDT Trips – Obtained intermodal inbound and outbound annual flows from six intermodal facilities in the region, and created HDT trip tables*
    - *Secondary HDT Trips - Data obtained from supply chain surveys of international shippers and third-party logistics service providers (3PLs) and data on warehouse land supply collected in this project were used to account for secondary truck trips in the HDT model.*

Expert Panel Review – HDT Model

- **Trip Assignment: Update HDT trip assignment model with new data**
  - *Response: The Team improved the HDT assignment procedures and model validation as stated below:*
    - *Values of time – Literature review was conducted on truck values of time, and new values of time were derived for 3 GVWs in the assignment model;*
    - *PCE factors – Fixed lookup PCE factor table was used to derive PCEs by truck type and grade;*
    - *Time of day factors – A combination of WIM station data and FHWA's VTRIS data were used to derive time of day factors;*
    - *Truck Classification Counts – A thorough QA/QC analysis was conducted on existing Caltrans counts, new class counts that were collected as part of this project, and LSA's arterial count program.*

Expert Panel Review – Activity-based Model

Panelists:

John Bowman – *Bowman Research and Consulting*
Mark Bradley – *Bradley Research and Consulting*
Cynthia Chen – *University of Washington*
Joel Freedman – *Parsons Brinckerhoff*
Keith Lawton – *Keith Lawton Consulting, Inc.*
Eric Pihl – *FHWA, Denver*
Eric Miller (Chair) – *University of Toronto*

Date: June 29, 2010

Next Review: Spring, 2012

Expert Panel Review – Activity-based Model

General Comments

- **Phase 1 model comparisons to 4-step results & base data are OK given use of DFW parameters, but much better fits required in Phase 2 – need to outperform the 4-step model**
  Results of Phase 2 model are much improved than Phase 1.

- **Capturing immigrants/minorities travel behavior**
  Using 2009 NHTS data for SCAG region, travel behavior and immigrants is analyzed. The findings will be included into the future model development.

- **Staff involvement in model estimation/calibration/validation and review**
  In Phase 3, SCAG staff will be heavily involved in model testing and operation, including PopGen/Household Evolution model, SE/LU simulator (CEMSELTS), Daily Activity-travel Pattern (CEMDAP) and Traffic Simulation (DTA).

Expert Panel Review – Activity-based Model

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Schedule and Priority

- **Panel suggested to focus on getting the model operational, with more advanced research questions addressed in subsequent phases.**
- **Should get the model converted to SCAG data /parameters before any changes are made in the model system**
- **Comprehensive car ownership and joint activity models and Dynamic Traffic Assignment to be dealt with in Phase 3 (July 2011 ->).**

SCAG staff and consultants took panel's advice. The Phase 2 model has been converted to SCAG data and parameters. The model is operational now.

Expert Panel Review – Activity-based Model

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Spatial Scale and Equilibrium

- **Block level in Phase 2 for non-motorized & transit access**
- **Computation feasibility**
- **Equilibrium Discussion**

Model running time has been reduced dramatically. Phase 3 model is planned to be enhanced to 12K TAZs that is based on Census block group geography.

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Thank you!

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Appendix D: Presentation – SCAG Travel Model Networks and Zone System

Peer Review Meeting – June 27, 2011

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Fourth Peer Review Panel

SCAG Travel Model Networks and Zone System

Yongping Zhang

6/27/2011

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Fourth Peer Review Panel

SCAG Travel Model Networks and Zone System

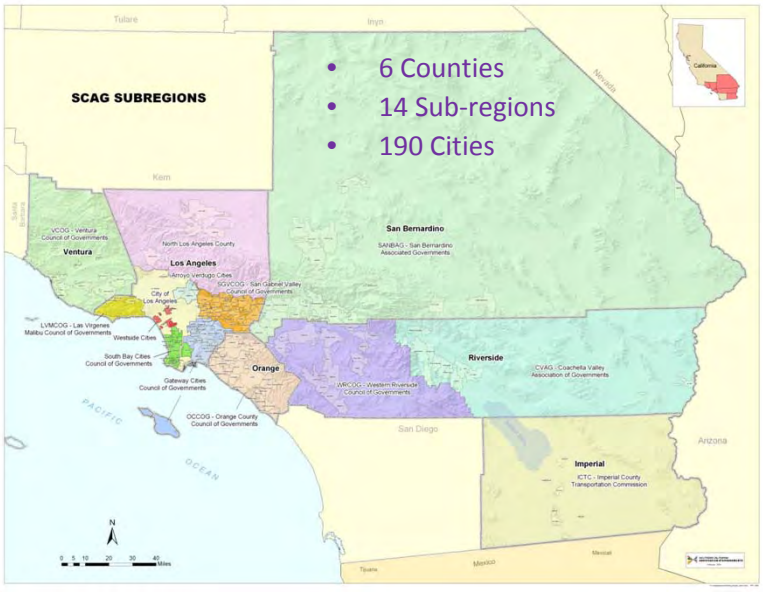
Yongping Zhang
6/27/2011

Outline

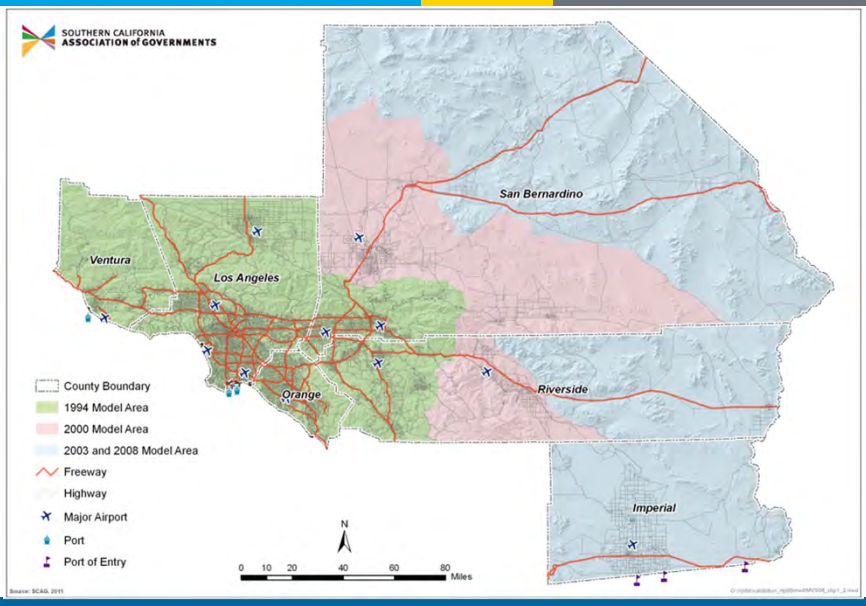
SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

1. SCAG Region Overview
2. Transportation Analysis Zones
3. Regional Highway Network
4. Regional Transit Network

SCAG Region



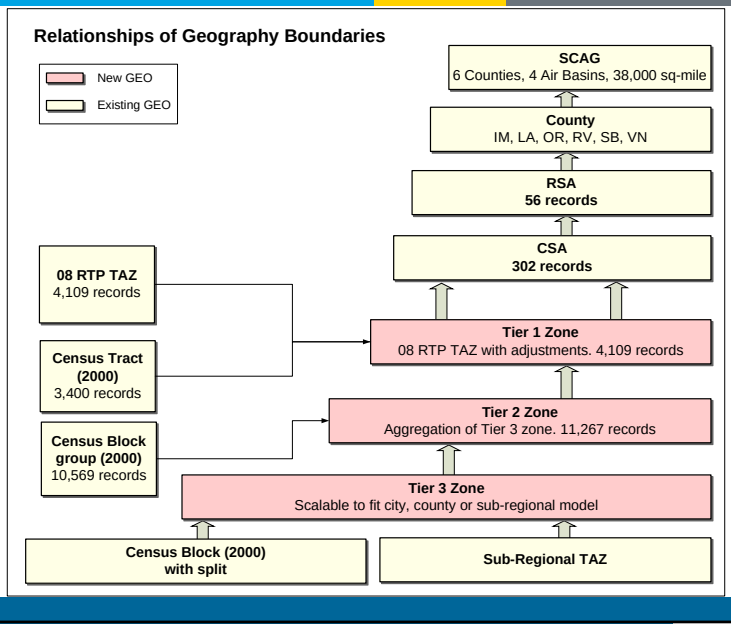
Modeling Area



TAZ: 3-tiered Zone System

- To enhance the precision of micro-level land use and smart growth analysis for SCS
- Tier 1: regional model (4,109 internal zones)
- Tier 2: regional model (11,267 internal zones)
  - nesting within tier 1 zones
- Tier 3: sub-region, city, or county
  - nesting within tier 2 zones
- Other zones coded in the network:
  - 40 cordon stations
  - 12 airport zones
  - 31 port zones

Relationships of 3 Tiers



TAZ: Methods (1)

- **Tier 3:**
  - based on sub-regional zones and MPUs (Census Block 2009 with some splits)
  - consistent with 2009 TIGER/Line Block boundaries
  - aggregated to Tier 2
- **Tier 2:**
  - consistent with 2009 TIGER/Line Tract boundaries
  - consistent with 2009 TIGER/Line Block group or sub-regional TAZ boundaries
  - aggregated to Tier 1
- **Tier 1:**
  - minor boundary adjustment based on local requests
  - consistent with 08RTP zones
  - consistent with 2009 TIGER/Line Tract boundaries

TAZ: Methods (2)

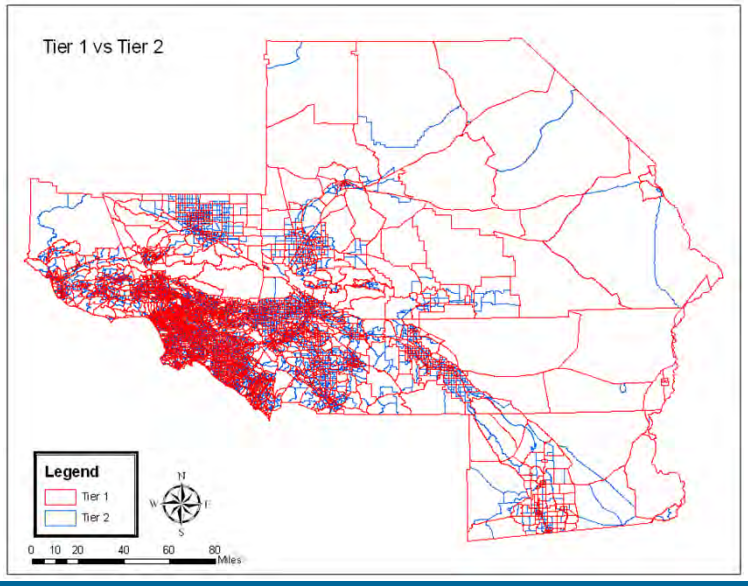
Other Considerations:

- Complement the Transportation System
- Homogeneous Land Use
- Similar Population/Employment Size
- Natural and man-made boundaries
- Other zonal creation criteria

TAZ: Procedure

- Collaboration with local jurisdictions
- Initial TAZs from cities, counties, and sub-regions
- GIS overlay of maps with existing TAZs, highway network, land use, and satellite images
- Developed a GIS tool to assist data processing and QC
- Extensive local review and revisions
- Analyses undertaken to ensure quality

Tier 1 vs. Tier 2



TAZ: Summary

Modeling Area	2000 Census Tract	2000 Census Block Group	RSA	CSA	08 RTP TAZ (Internal)	Tier 1 Zone (Internal)	Tier 2 Zone (Internal)
Imperial County	29	105	1	15	110	110	239
Los Angeles County	2,052	6,345	21	155	2,243	2,243	5,697
Orange County	577	1,826	10	43	666	666	1,741
Riverside County	343	804	11	38	478	478	1,532
San Bernardino County	244	1,099	7	34	402	402	1,395
Ventura County	155	390	6	17	210	210	663
Total	**3,400**	**10,569**	**56**	**302**	**4,109**	**4,109**	**11,267**

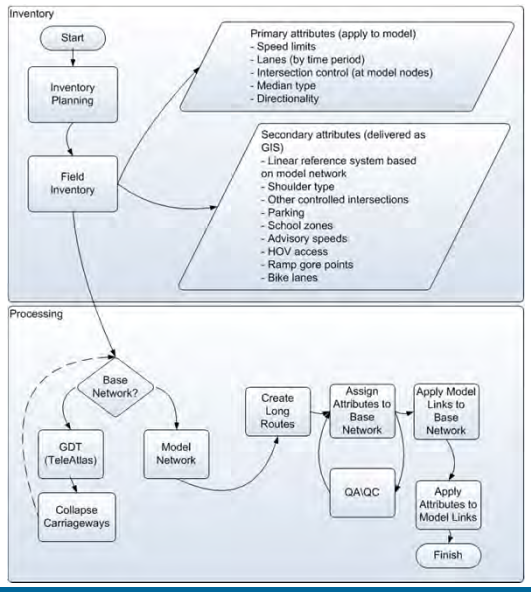
Highway Network: Method(1)

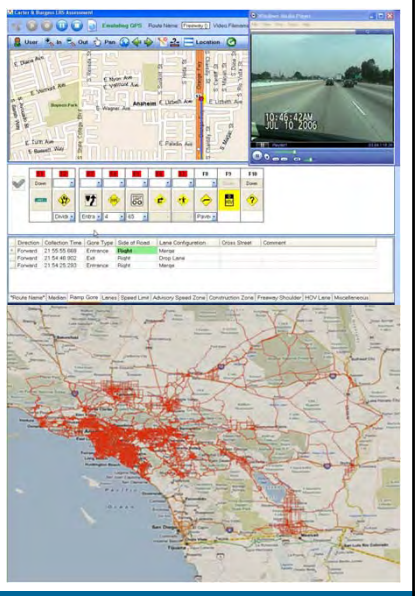
- Regional Highway Network Inventory program
  - created GIS-based network inventory
  - included (over 16,000 centerline miles) all freeways, arterials, urban major collectors
  - transferred attributes to SCAG's TransCAD network
- Base network: 08RTP 2008 network
- Local inputs from sub-regional and regional agencies

Highway Network: Method(2)

- Extensively reviewed by SCAG staff using aerial photos to examine coding accuracy
- Further reviewed by interested transportation commissions and Caltrans districts
- Sensitivity model runs performed to ensure proper flows and connectivity

Regional Highway Network Inventory Program





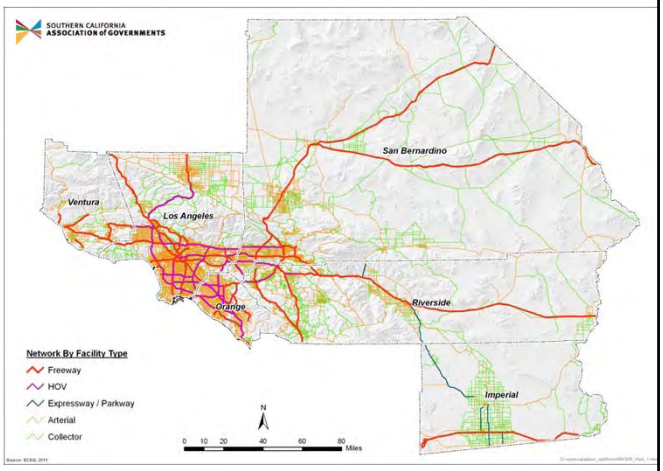
Highway Network Overview

- Over 65,000 street segments and 30,000 intersections
- Detailed coding of:
  - freeways (mixed-flow, HOV, auxiliary, acceleration/deceleration, toll, truck lanes)
  - arterials and collectors
- 5 time periods:
  - AM, MD, PM, EV, NT
  - roadside parking restrictions
  - lane changes

Facility Type

Consistent with Federal Functional Highway Classification System

- Freeways
- HOV
- Expressway/Parkway
- Principal Arterial
- Minor Arterial
- Major Collector
- Minor Collector
- Ramps
- Truck Lane
- Centroid Connector



Area Type: Definitions (1)

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3 business related area types: Core, CBD and UBD

- Categorized by employment density based on 100x100 (meter) grid
  - Core: > 100,000/sq mi
  - CBD: 25,000-100,000/sq mi
  - UBD: 3,000-25,000/sq mi

Note: excluding "Agriculture", "Construction", "Manufacturing", and "Trans.,Utilities" employment categories

Area Type: Definitions (2)

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4 residential area types: Urban, Suburban, Rural, and Mountain

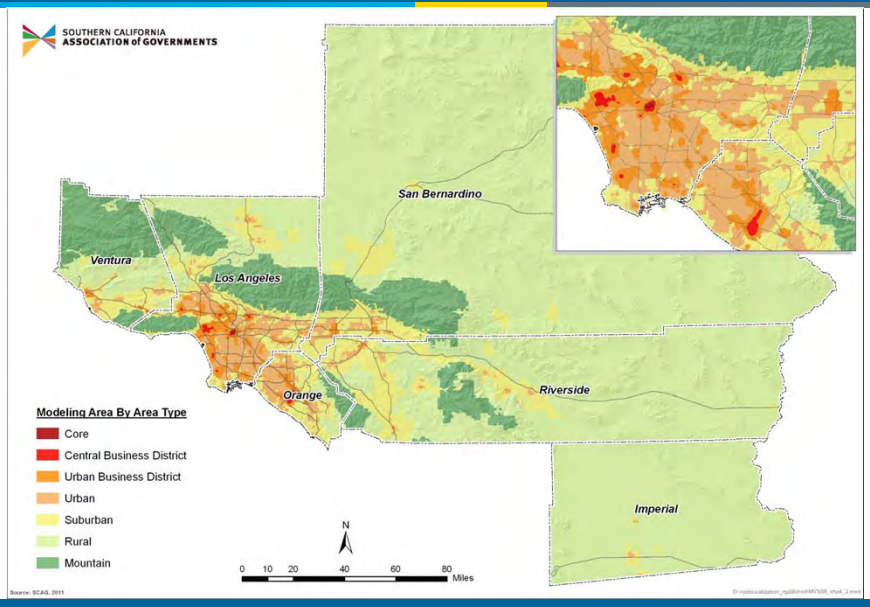
- Urban, Suburban and Rural categorized based on Trip-making Propensity (TP) by TAZ :

  TP = Population Density + (2 x Employment Density)
  - Urban: > 7,000/sq mi
  - Suburban: 300-7,000/sq mi
  - Rural: < 300/sq mi, outside of mountain areas

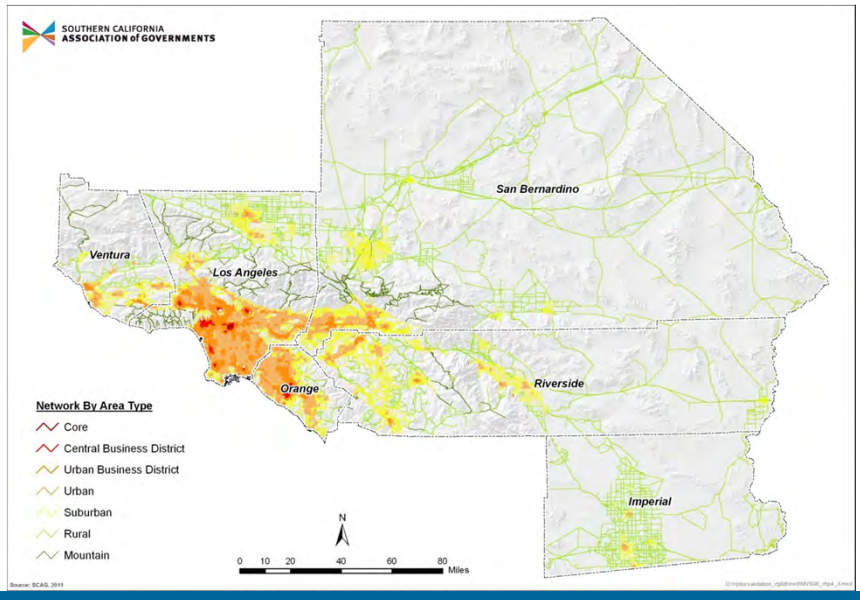
  Note: Employment density uses TOTAL employment density by TAZ

- Mountain refers to "Federal Forest" based on GAP GIS data
  - The Santa Monica Mountain is manually digitized because most of the area is owned by private

SCAG Region by Area Type



Highway Network by Area Type



Free Flow Speed: Arterial

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Posted Speed	AT1	AT2	AT3	AT4	AT5	AT6	AT7
	-- Principal Arterial --						
20	21	22	22	24	25	27	27
25	23	24	25	27	28	31	31
30	25	26	27	29	31	34	34
35	27	28	29	32	35	38	38
40	28	30	32	34	37	41	41
45	30	32	34	37	40	45	45
50	33	35	37	41	45	51	51
55	34	38	39	44	49	56	56
	-- Minor Arterial --						
20	19	20	21	23	24	27	27
25	21	22	23	25	27	30	30
30	22	24	25	28	30	34	34
35	24	26	27	30	33	37	37
40	25	28	29	32	36	41	41
45	27	29	31	34	38	44	44
50	29	32	33	38	43	50	50
55	30	33	35	40	46	55	55
	-- Major Collector --						
20	17	18	19	21	23	26	26
25	18	20	21	23	26	30	30
30	19	21	22	25	28	33	33
35	20	22	24	27	31	36	36
40	21	24	25	28	33	39	39
45	22	25	26	30	35	43	43
50	23	27	28	33	39	48	48
55	24	28	30	35	42	52	52

Notes: *Add 4% for divided streets*
AT1: Core
AT2: Central Business District
AT3: Urban Business District
AT4: Urban
AT5: Suburban
AT6: Rural
AT7: Mountain

Capacity: Arterial/Expressway

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On\Crossing	2-Lane	4-Lane	6-Lane	8-Lane
	-- AT1_Core --			
2-Lane	475	425	375	375
4-Lane	650	600	500	500
6-Lane	825	700	600	550
8-Lane	825	700	650	600
	-- AT2_Central Business District --			
2-Lane	575	525	475	475
4-Lane	725	675	550	550
6-Lane	875	750	650	600
8-Lane	875	750	700	650
	-- AT3_Urban Business District --			
2-Lane	600	525	475	475
4-Lane	750	675	575	575
6-Lane	900	775	675	625
8-Lane	900	775	725	675
	-- AT4_Urban --			
2-Lane	625	550	500	500
4-Lane	800	725	600	600
6-Lane	950	825	700	650
8-Lane	950	825	775	700
	-- AT5_Suburban --			
2-Lane	675	600	525	525
4-Lane	825	750	625	625
6-Lane	975	850	750	675
8-Lane	975	850	800	750
	-- AT6_Rural --			
2-Lane	675	600	525	525
4-Lane	825	750	625	625
6-Lane	975	850	750	675
8-Lane	975	850	800	750
	-- AT7_Mountain --			
2-Lane	575	500	425	425
4-Lane	750	675	550	550
6-Lane	925	800	700	625
8-Lane	925	800	750	700

Notes: *Capacities are in passenger car per lane per hour (pcplph).*
Lanes are mid-block 2-way lanes.
Add 20% for one-way streets.
Add 5% for divided streets.

Highway Network: Summary

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AM PEAK PERIOD

FACILITY	COUNTY						TOTAL
	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	
FREEWAY							
Centerline Miles	94	636	227	307	471	94	1,829
Lane Miles	375	4,576	1,606	1,693	2,472	503	11,225
MAJOR ARTERIAL							
Centerline Miles	103	2,167	651	338	575	254	4,088
Lane Miles	397	8,752	3,164	1,166	1,828	886	16,193
MINOR ARTERIAL							
Centerline Miles	325	2,923	887	1,108	1,616	355	7,214
Lane Miles	670	9,080	3,153	3,078	4,275	956	21,212
COLLECTOR							
Centerline Miles	1,203	1,706	195	1,595	2,775	306	7,780
Lane Miles	2,460	3,808	589	3,800	6,002	673	17,332
HOV							
Centerline Miles	0	227	119	37	48	0	431
Lane Miles	0	468	243	77	95	0	883
TOTALS							
Centerline Miles	1,725	7,659	2,079	3,385	5,485	1,009	21,342
Lane Miles	3,902	26,684	8,755	9,814	14,672	3,018	66,845

Transit Overview

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

- 130 operators
- 1,000+ lines
- 2.7 M daily boardings

Transit Network: Enhancements (1)

- **More coverage**
  - based on a more comprehensive transit database that covers key attributes of LACMTA TripMaster and NTD for 66 operators in 6 counties
- **More accurate**
  - developed a program to automatically separate out all route patterns that have different pairs of start and end stops to calculate headways and service hours more accurately
  - used TeleAtlas to associate census block level data to develop walk access links

Transit Network: Enhancements (2)

- **More efficient**
  - developed a tool to automatically convert TripMaster into TransCAD transit network
- **More detailed**
  - developed 15 transit networks to reflect transit operations by 5 times of day (AM, MD, PM, EV, NT) and 3 days of week (Mon-Fri, Sat, Sun) with detailed service start time and end time
  - coded in fares at the route level and fare factors at the carrier level

Transit Network: Procedure

- LOS data collection
- Built comprehensive transit database
- TripMaster to TransCAD transit network conversion
- Manually fixed problematic routes and stops not addressed by automation
- Manually added routes not included in TripMaster
- Updated transit network attributes based on data collected
- Extensive QC
- Reviewed by interested groups including LACMTA

Data Collection (1)

- From NTD, obtained data on Vehicles by Mode and Service Type, Cost/Revenue, Passenger Miles, etc.
- From TripMaster, obtained data on Lines, Stops, Schedules, and VRM/VRH
- Customized a spreadsheet for each transit operator
  - no duplicate questions asked if available in NTD or TripMaster
  - relieve the burden of operators to provide data to greatest extent
- Received excellent support from transit operators in the region, including LACMTA, OCTA, etc.

Data Collection (2)

- **Data collected:**
  - boarding (by TOD, line, fare type)
  - service (freq., route miles, pass. miles, stops, schedules, fares, VRM, VRH)
  - operation (cost/revenue, subsidy, vehicles by mode and service type)
  - performance (accident/road call rates, on-time rate)
  - operator contact info
  - other (on-board surveys, transfers, PNR)

TripMaster Database

- Maintained by LACMTA for transit scheduling, Trip Planner web application
- Covers 63 operators, 1,800+ routes/patterns in the region
- Major shake-ups twice a year
- Consists of six types of data tables
  - Carriers, Lines, Signs, Stops, Times, and Trips

Transit Database

- Composed a comprehensive transit database based on data collected
- Developed a program to:
  - automate the process of separating out shortlines/interlines based on unique start-end of bus run
  - keep the correspondence for pattern/line conversion
  - calculate more accurate headways and detailed service hours (start time and end time) by 5 times of day and 3 days of week

Transit Network Attributes

Routes Layer (nearly 3,400 patterns)

- route ID, route name, route head sign, transit operator, route distance, direction, transit modes, fares, fare factors
- detailed headway, frequency, start time and end time of the service for each of the five time periods

Stops Layer (over 160,000 stops)

- route ID, stop coordinates, milepost, corresponding highway node ID, etc.
- for rail transit: station-to-station rail time, rail station information
- for routes with zone-based fares: fare zones

Transit Modes

7 Transit Modes:

- Commuter rail: Metrolink, Amtrak
- Local rail: subway, light rail
- Local bus
- Rapid bus: limited stops, local streets
- Express bus: limited stops, via freeways
- Transitway : semi-dedicated guideway (El Monte Busway and Harbor Transitway)
- BRT: dedicated guideway (Orange Line)

Note: based on service characteristics and fare structures

Non-Transit Modes

2 Non-transit modes (transit access links):

- Walk access and egress links
  - coded as two-way links between a zone centroid and a transit stop location
- Park-and-ride lot to stop and transfers between stations links
  - coded as two-way walk links between a park-and-ride lot and a transit stop location, and connections between stations

Fares (1)

- **3 types of transit fares (route level)**
  - base boarding fares
  - transfer fares
  - zone fare matrix
- **3 types of fare factors (carrier level)**
  - base fare factor
  - transfer fare factor
  - fare factor matrix
- **Fares collected through the transit data collection program in 2008 dollars**
- **Used CPI factor to adjust to 1999 dollars**

Fares (2)

- Considering the complex fare structure for most carriers, the published full cash fares for initial boarding and transfers are used to represent the base fare and transfer fare
- To account for the revenue composition of different fare types, such as one-way walkup fares, daily/weekly/monthly passes etc., base fare factors and transfer fare factors are estimated from the boarding and revenue data provided by transit operators

Transit Network: Summary

Mode ID	Mode Number	Description	Route Patterns		Roadway Route Miles	
			Peak	Off Peak	Peak	Off Peak
10	1CR	Commuter Rail	33	25	2,864	2,495
13	2LR	Local Rail	14	12	206	184
14	3EX	Express Bus	136	96	3,756	2,601
22	4RB	Rapid Bus	83	70	1,230	1,025
11	5LB	Local Bus	1,663	1,365	22,077	18,811
30	6TW	Tranitway	67	40	1,704	1,121
31	7BR	Bus Rapid Transit	2	2	28	28
Total			1,998	1,610	31,866	26,266

Local Rail Network

Metrolink Network

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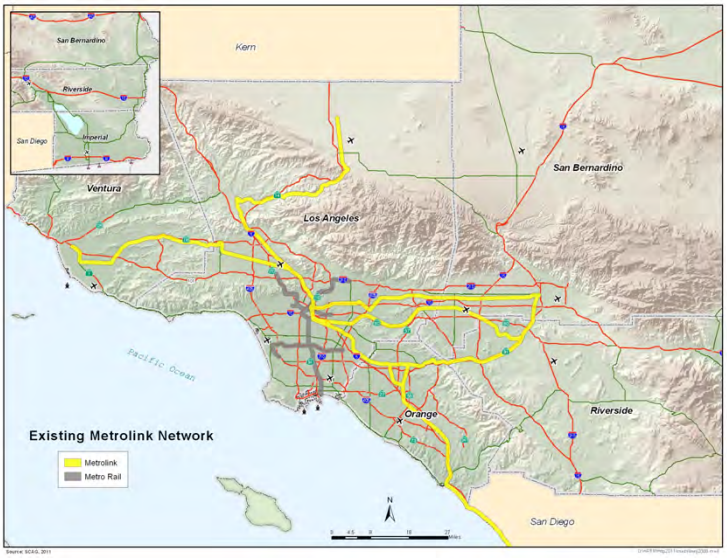

Express Bus Network

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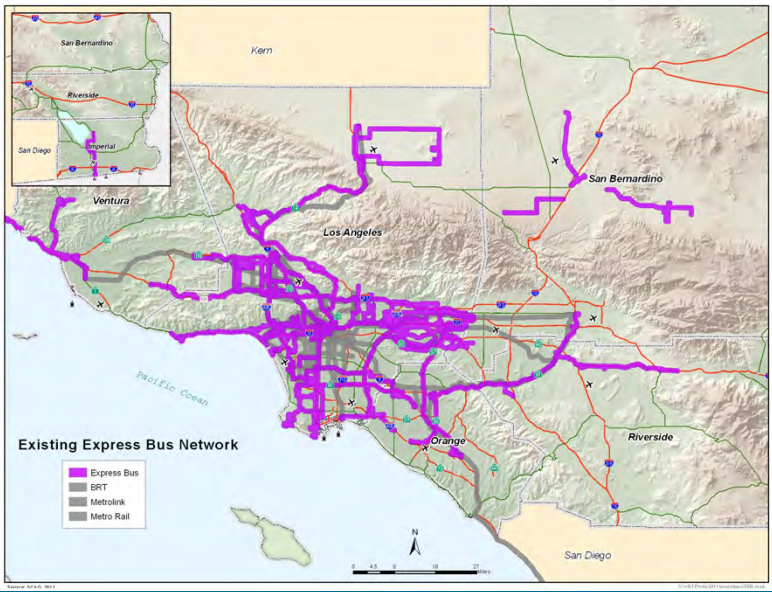

Local Bus Network

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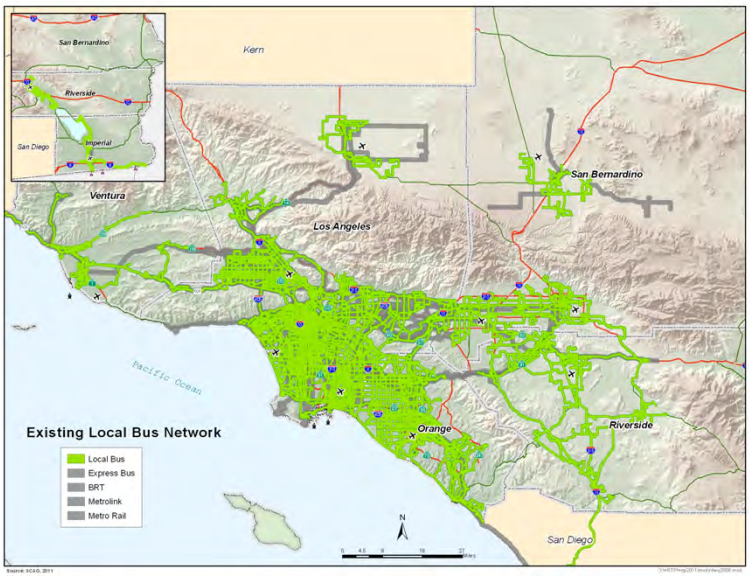

Transit Network

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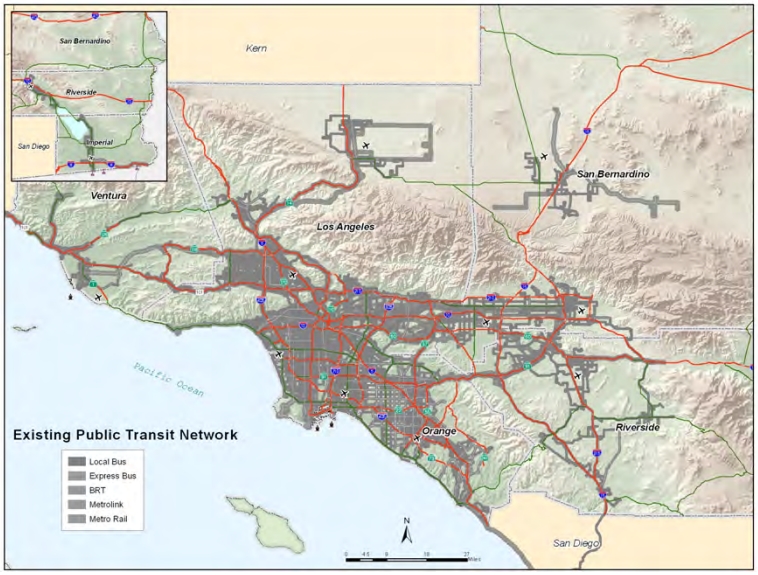


SOUTHERN CALIFORNIA
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Thank you!

Appendix E: Presentation – Socioeconomic Variables for SCAG Validation Peer Review

Peer Review Meeting – June 27, 2011

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Model Input Data: Socio-Economic Variables

for

SCAG Validation Peer Review

Simon Choi
Program Manager of Data/GIS & Forecasting

June 27, 2011

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Model Input Data: Socio-Economic Variables

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SCAG Validation Peer Review

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June 27, 2011

Contents

- What is New?
- Approach
- Milestones
- Geography
- Variable List
- Estimation Methods
- Sources of Data

What is New?

- Base Year: 2003 → 2008
- Geography: 4,109 TAZs →11,267 Tier2 TAZs with 5.5 Million MPUs
- Socio-economic Variables: 52 → 61 with 7 Joint distributions
- Data Sources: 2000 Census → 2010 Census, ACS
- Data Processing: more complex and longer

Approach

- Collect the latest information from diverse sources (e.g., federal, state, local, and private)
- Apply the estimation methods to produce the small area socioeconomic estimates (e.g., population, households, employment, etc)
- Collaborate with local jurisdictions to confirm the validity of the major socio-economic estimates.

Milestones

- Collected the latest information from diverse sources (e.g., federal, state, local, and private) (May 2008 - May 2009)
- Applied the estimation methods to produce the small area socioeconomic estimates (e.g., population, households, employment, etc) (June/July 2009)
- Collaborated with local jurisdictions to confirm the validity of the small area socio-economic estimates. (July 2009- February 2010)
- ACS 2005-09 Released (December 2010)
- 2010 Census PL-94 Released (March 2011)
- Updated the small area socioeconomic estimates (e.g., population, households) (April 2011)
- Work with local jurisdictions to confirm the validity of the small area socio-economic estimates. (May 2011- Present)

Geography:
SCAG Quick Facts

- Nation's largest Metropolitan Planning Organization (MPO) and Council of Governments (COG)
- Governed by a Regional Council of 84 local elected officials
- 6 counties, 190 cities, and 38,000 square miles
- Over 18 million residents (6% of US population) & 7.3 million jobs (15th largest economy in the world)
- 11,000 lane miles of freeway
- 4 major airports
- Nation's global gateway for trade

Geography

County	City		Tract		Block Group		Block	
	2000	2010	2000	2010	2000	2010	2000	2010
Imperial	7	7	29	31	105	96	8,133	8,875
Los Angeles	88	88	2,054	2,343	6,351	6,421	89,543	109,468
Orange	33	34	577	582	1,826	1,822	25,167	36,842
Riverside	24	26	343	453	804	1,030	28,282	35,718
San Bernardino	24	24	244	369	1,099	1,092	41,989	48,176
Ventura	10	10	155	173	392	429	9,920	14,811
SCAG	186	189	3,402	3,951	10,577	10,890	203,034	253,890

Source: US census Bureau, 2000 & 2010 Census

Geography

- Minimum Planning Unit (MPU) consists of 2000 Census Blocks (203,034) and Parcels (4.7 Millions).

Variable List
Population (7 variables)

- Total Population: total number of people living within a zone. Total population is composed of residential population and group quarters population.
- Group Quarters (Non-Institutional) Population: is primarily comprised of students residing in dormitories, military personnel living in barracks, and individuals staying in homeless shelters. Group quarters (non-institutional) population does NOT include persons residing in institutions.
- Residential Population: the number of residents NOT living in "group quarters."
- Group Quarters Population living in student dormitories: Population living in college dormitories (includes college quarters off campus).
- Population by Age (4 variables): the number of population for different age groups: 5-17, 18-24, 16-64, and 65+.

Variable List
Households (25 variables)

- Total Households: Household refers to all of the people who occupy a housing unit. By definition there is only one household in an occupied housing unit.
- Households by Household Size (4 variables): the number of one-person households, two-person households, three-person households, and four or more person households.
- Households by Age of Householder (4 variables): the number of households with age of householder between 18 and 24 years old, 25 and 44, 45 and 64, and 65 or older.
- Households by Number of Workers (4 variables): the number of households with no worker, with one worker, with two workers, and with three workers or more.
- Households by Household Income (4 variables): the number of households with annual household income (in 1999 dollars) below $25K, $25k-$50k, $50k-$100K, and $100K or more.

Variable List
Households (25 variables) - continued

- Households by Type of Dwelling Unit (2 variables): the number of households living in single-family detached housing, and living in other housing.
- Households by Number of College Students (3 variables): the number of households with no college student, with one college student, with two college students or more.
- Households by Number of Children age 5-17 (4 variables): the number of households with no child, with one child, with two children, with three children or more.

Variable List
School Enrollment (2 variables)

- K-12 School Enrollment: total number of K-12 (kindergarten through 12th grade) students enrolled in all public and private schools located within a zone. All elementary, middle (junior high), and high school students are included. This variable represents “students by place of attendance.”
- College/University Enrollment: total number of students enrolled in any public or private post-secondary school (college or university) that grant an associate degree or higher, located within a zone. This variable also represents "students by place of attendance."

Variable List
Workers (4 variables)

- Total Workers: total number of civilian workers residing in a zone. Workers are estimated by the place of residence.
- Workers by earning level (3 variables): the number of workers with earnings below $25K, $25K-50K, and 50K or more (in 1999 dollars)

Variable List
Median Household income (4 variables)

- Median Household Income by Income Categories (4 variables): Median Household Income is the median value of household income for all households within a zone. Household Income includes the income, from all sources, for all persons aged 15 years or older within a household. The median income is estimated for each of four different income categories: below $25K, $25K-$50K, $50k-$100K, and $100K or more (in 1999 dollars).

Variable List
Employment (17 variables)

- The employment variables represent all jobs located within a zone (i.e., employment by place of work). Jobs are composed of wage and salary jobs and self-employed jobs. Jobs are categorized into 13 sectors based on North American Industry Classification System (NAICS) code definition.
- Total Employment: total number of jobs within a zone.
- Employment by 13 NAICS Coded Industries: the number of total jobs for 1) agriculture & mining, 2) construction, 3) manufacturing, 4) wholesale trade, 5) retail trade, 6) transportation, warehousing, and utility, 7) information, 8) financial activity, 9) professional and business services, 10) education and health services, 11) leisure and hospitality services, 12) other services, and 13) public administration.
- Employment by wage level (3 variables): total number of jobs by three wage levels: below $25K, $25K-$50K, and $50K or more (in 1999 dollars)

Variable List
Joint Distribution of Selected variables

- Joint distribution of households by household income (Less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+), household size (1,2,3,4+ persons in household), number of workers (0,1,2,3+ workers in household), type of dwelling unit (single-family detached, other)
- Joint distribution of households by household income (less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+), number of workers (0,1,2,3+ workers in household), age of head of household (18-24, 25-44, 45-66, 65+ years old)

Variable List
Joint Distribution of Selected variables

- Joint distribution of households by household income (Less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+) and household size (1,2,3,4+ persons in household)
- Joint distribution of persons by age (0-4, 5-17, 18-24, 25+) and household income (Less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+).
- Joint distribution of workers by worker's earnings (Less than $24,999, $25,000 to $49,999, $50,000+) and household income (Less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+).

Variable List
Joint Distribution of Selected variables

- Joint distribution of households by number of college students (0, 1, 2+) and household income (Less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+)
- Joint distribution of households by number of children age 5-17 (0,1,2,3+) and household income (Less than $24,999, $25,000 to $49,999, $50,000 to $99,999, $100,000+)

Estimation Methods
Three Major variables

- MPU level household estimates are derived using the following process:
  1) add the new residential construction between 2000 and 2008 to 2000 MPU level housing estimates from 2000 Census;
  2) convert housing unit into households using the 2000 vacancy rate.
- The preliminary TAZ level household estimates are derived by summing MPU level household estimates within the TAZ.
- The preliminary 2008 TAZ level household estimates are further converted into residential population by using the 2000 household size.
- TAZ level total population is derived by adding group quarters population to residential population.
- TAZ level population and household estimates are further adjusted to be consistent with the 2008 city level population and household estimates.

Estimation Methods
Three Major variables - continued

- MPU level employment estimates are derived using 2000 CTPP and 2008 InfoUSA database.
- The preliminary TAZ level employment estimates are derived by summing MPU level employment estimates within the TAZ.
- The TAZ level employment estimates are further adjusted to be consistent with the 2008 county level employment estimates from CA EDD and 2008 city level employment estimates.

Estimation Methods
Secondary Variables

- Three major variables are further disaggregated into necessary attributes (e.g., age, persons per households, industry sectors, etc), as required in the transportation demand model development process.
- The additional attribute variables are defined as the secondary variables. These secondary variables at the TAZ level are estimated using the Small Area Secondary Variables Allocation Model (SASVAM).
- SASVAM is generally based on the probabilistic choice model reflecting the temporal change of the individual attributes and the changing relationship of the related attributes.

Estimation Methods
Joint Distribution of Selected Variables

- The marginal distribution of secondary variables developed by SASVAM is developed into joint distribution of selected secondary variables using the Population Generator (PopGen) 1.1
- PopGen 1.1 was developed by Arizona State University. PopGen 1.1 generates synthetic populations with attribute distributions, which become basis for computing the joint distributions.

Sources of Data

- 2000 Census (SF1, SF3)
- 2000 Census Transportation Planning Package (CTPP)
- 2010 Census (PL94)
- American Community Survey (ACS)
- California Department of Finance (DOF)
- California Employment Development Department (EDD)
- InfoUSA
- 2008 Existing Land Use
- 2008 County Assessor's Parcel Database.

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Appendix F: Presentation – 2012 Trip-Based Model: Overview of Model Components and Enhancements

Peer Review Meeting – June 27, 2011

2008 Regional Travel Demand Model Peer Review
June 27 & 28, Los Angeles, California

2012 RTP Trip-Based Model
Overview of Model Components and Enhancements

Rosella Picado
Parsons Brinckerhoff

2008 Regional Travel Demand Model Peer Review
June 27 & 28, Los Angeles, California

2012 RTP Trip-Based Model
Overview of Model Components and Enhancements

Rosella Picado
Parsons Brinckerhoff

Model Enhancements In Brief

- Updated highway and transit networks
- Multi-tiered zone system
- Household income trip market segmentation
- Enhanced sensitivity to land use form
- Updated auto ownership model
- Updated HBW trip productions model
- Entirely new destination choice models
- Entirely new mode choice models
- Additional time of day segmentation & model
- Updated highway assignment procedures
- Calibrated and validated to 2008 conditions

Trip Market Segmentation

Trip Purpose

Id	Description
HBWD	Home Based Work - Direct
HBWS	Home Based Work - Strategic
HBCU	Home Based College & University
HBSC	Home Based School
HBSH	Home Based Shop
HBSR	Home Based Social & Recreation
HBSP	Home Based Serve Passenger
HBO	Home Based Other
WBO	Non Home Based Work
OBO	Non Home Based Other

Trip Market Segmentation

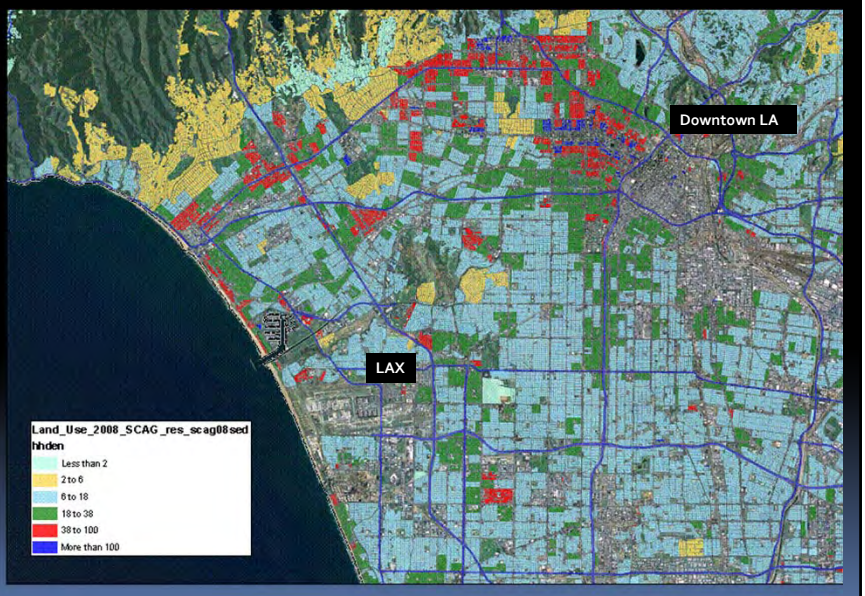
Household Attributes

Model	Income	Size	Workers	Autos	Housing Unit	Age of Head of Hhld.	Age
Auto Ownership	X	X	X		X		
Trip Production							
HBW, WBO	X		X			X	
HBSC, HBCU							X
HBO, OBO	X	X		X			
Trip Distribution							
HBW, WBO	X						
HBSC, HBCU	X						
HBO, OBO	X						
Mode Choice	X						

Trip Market Segmentation

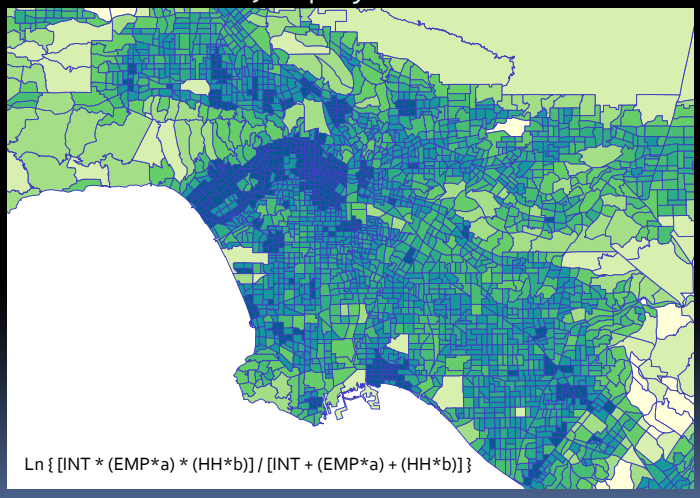
Annual Household Income	Quintiles	Census & ACS	2001 HIS	2001 MTA	2006 MTA	2010 OCTA	2008 Metrolink
Less than $7,500	Less than $19,360	X	X	X	X	X	X
$7,500 to $10,000				X	X		
$10,000 to $14,999		X	X				
$15,000 to $19,999		X		X	X		
$20,000 to $24,999	$19,361 to $36,340	X				X	X
$25,000 to $29,999		X	X	X	X		
$30,000 to $34,999		X				X	X
$35,000 to $39,999	$36,340 to $57,323	X	X	X	X		
$40,000 to $44,999		X					X
$45,000 to $49,999		X					
$50,000 to $59,999	$57,324 to $91,402	X	X	X	X	X	X
$60,000 to $74,999		X					X
$75,000 to $99,999		X	X				X
$100,000 to $149,999	$91,403 or more	X	X			X	X
$150,000 to $200,000		X	X			X	X
$200,000 or more							X

Land Use Form and Accessibility Indicators



Land Use Form and Accessibility Indicators

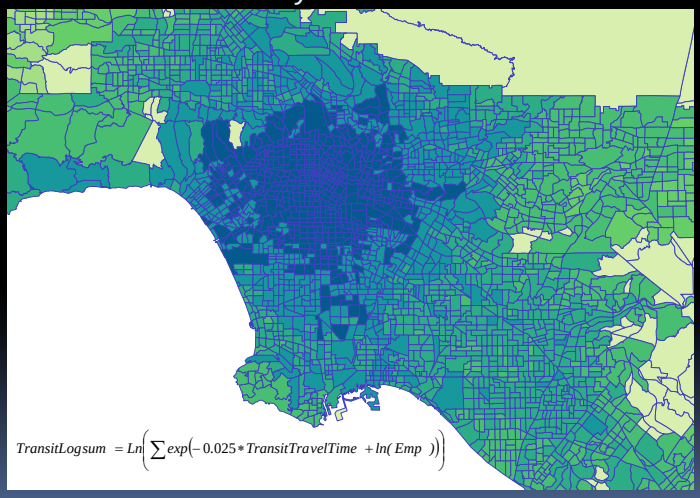
Mixed Residential, Employment and Intersection Density



Ln { [INT * (EMP*a) * (HH*b)] / [INT + (EMP*a) + (HH*b)] }

Land Use Form and Accessibility Indicators

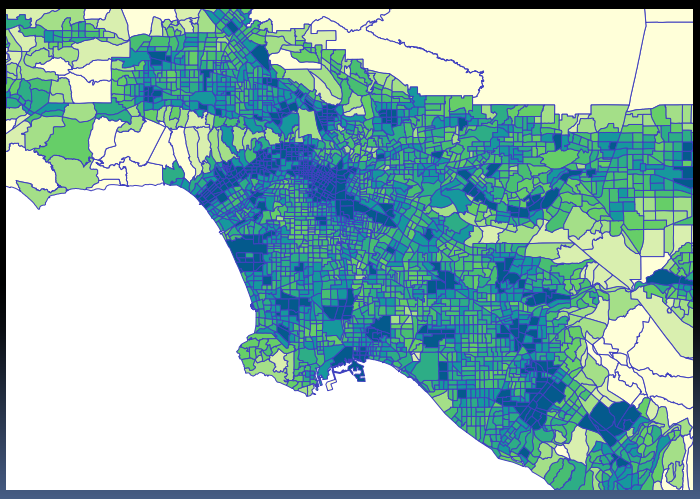
Transit Accessibility



$$TransitLogsum = Ln\left(\sum exp\left(-0.025 * TransitTravelTime + ln(Emp)\right)\right)$$

Land Use Form and Accessibility Indicators

Walk Accessibility



Auto Availability Model

- Multinomial logit model (0, 1, 2, 3, 4+ autos)
- Explanatory variables:
  - Household size – 1, 2, 3, 4 or more persons
  - Household income
    - Low income (less than $25,000)
    - Medium income ($25,000-$50,000)
    - High income ($50,000-$100,000)
    - Very high income ($100,000 or more)
  - Number of workers in household – 0, 1, 2, 3 or more workers
  - Type of housing unit (single family detached, other)
  - Transit accessibility to employment
  - Mix household, employment and intersection density
  - Walk accessibility to employment

Auto Availability Model

	Auto Availability Choice							
	1 Car		2 Cars		3 Cars		4+ Cars	
	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat	Coeff.	t-stat
Household Income								
Low	-2.835	-6.8	-4.744	-11.4	-5.576	-13.0	-6.187	-13.6
Medium	-1.339	-3.2	-2.590	-6.1	-3.011	-7.1	-3.623	-8.3
High	-0.312	-0.7	-0.756	-1.7	-0.921	-2.1	-1.157	-2.6
Household Size								
2 Person HH			+2.023	+33.2	+2.001	+18.6	+1.464	+8.9
3 Person HH			+1.811	+22.7	+2.420	+19.9	+1.665	+9.1
4+ Person HH			+2.098	+27.8	+2.346	+19.6	+2.349	+13.7
Workers in HH								
1 Worker HH	+0.8617	+10.3	+1.028	+10.7	+1.113	+9.0	+1.274	+6.9
2 Workers HH	+0.4839	+3.4	+1.578	+10.8	+1.831	+11.1	+2.096	+9.7
3+ Workers HH			+0.725	+4.0	+2.684	+14.1	+3.706	+15.5
Multi-Family Housing	-0.3545	-4.2	-1.1090	-12.2	-1.8553	-16.3	-2.2671	-13.7
Mixed Density	-0.0569	-1.5	-0.0775	-2.0	-0.0948	-2.3	-0.1101	-2.6
Walk Accessibility	-0.0378	-0.8	-0.0612	-1.2	-0.1035	-2.0	-0.1035	n/a
Transit Accessibility	-0.0859	-3.8	-0.0859	n/a	-0.0859	n/a	-0.0859	n/a
Constant	4.3911	9.9	4.2830	9.6	3.3968	7.4	2.8727	5.9

Observations:	14,868
Final log likelihood:	14941
Rho-Squared (zero):	0.376
Rho-Squared (constants):	0.245

Auto Availability Model

	Auto Availability Choice Coefficients				
	0 Car	1 Car	2 Cars	3 Cars	4+ Cars
Multi-Family Housing	0.0	-0.3545	-1.1090	-1.8553	-2.2671
Mixed Density	0.0	-0.0569	-0.0775	-0.0948	-0.1101
Walk Accessibility	0.0	-0.0378	-0.0612	-0.1035	
Transit Accessibility	0.0	-0.0859			

Trip Productions Model

- What's new?
  - Added a household income classification
  - Household income classification carried forward to trip distribution and mode choice
  - Replaces previous worker income segmentation in trip distribution
  - Avoids worker-to-household income conversions

Trip Production Models

HBW Trip Purpose

Workers	Age of Head of Household	Household Income ($1999)			
		<25K	25K-50K	50K-100K	>100K
1	18-24	1.098	1.383	1.463	1.463
1	25-44	1.164	1.383	1.540	1.540
1	45-65	1.310	1.326	1.428	1.409
1	66+	0.842	1.260	1.401	1.401
2	18-24	1.986	2.292	2.292	2.292
2	25-44	2.101	2.336	2.590	2.720
2	45-65	2.150	2.600	2.710	2.713
2	66+	2.099	2.304	2.304	2.304
3+	18-24	3.015	3.015	3.015	3.015
3+	25-44	3.424	3.458	3.945	3.945
3+	45-65	3.608	3.514	3.749	3.942
3+	66+	3.353	3.353	3.655	3.655

Trip Production Models

- HBSH, HBSR, HBSP and HBO Trips
  - Classifications based on auto availability, household size and household income
- HBCU Trips
  - Classification based on household income and persons by age group
- HBSC Trips
  - Classification based on persons by age group
- OBO Trips and WBO Trips
  - Productions based on household classifications to obtain totals, and then trip ends reallocated to employment locations

Trip Production Models

- Investigated the effect of land use form on trip production rates
- No strong evidence found for land use form effects on total trip productions based on 2001 household data
- At best, some indicators showed a weak negative effect on total person trips
- Recommended approach for SCAG is to account for the reductions in vehicle trips in mode choice
- Reductions in trip length emerge in trip distribution

Trip Attraction Models

- Re-estimated as size term variables for the destination choice models

Trip Distribution Models

- Gravity models for HBSC and HBCU
- Destination choice models for all other purposes

$$U_{ijm} = \theta \times LS_{ijm} + \sum_k \beta^k D_{ij}^k + \sum_k \delta_m^k N_m^k D_{ij}^k + \sum \gamma_m^k M_i^k IZ_j + Ln(A_{jm}) + C_j$$

- HBW stratified by household income
- Most other home-based purposes stratified by household income and auto ownership

Trip Distribution Models

- Model estimation approach
  - Based on the 2001 Post-Census Household Survey, combined with 2000 mode choice logsums, skims and employment data
  - Sampling-by-importance combined with an exploded sample to construct the destination choice set of each trip observation

$$W_j = A_j \times exp(-2D_{ij}/D)$$

$$P_j = \frac{W_j}{\sum_j W_j}$$

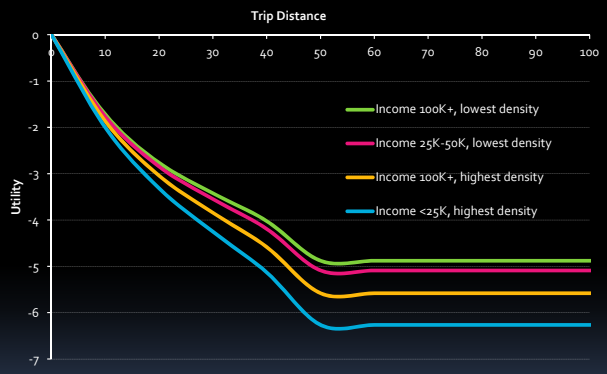
  - Size terms pre-calculated based on PUMS data (HBW) or household survey data

Trip Distribution Models

Explanatory Variable	HBWD		HBWS	
	Coefficient	t-Stat	Coefficient	t-Stat
Mode choice logsum	0.60	n/a	0.60	n/a
Distance	-0.2178	-24.5	-0.1803	-15.1
Distance squared	0.005025	10.5	0.003363	5.2
Distance cubed	-0.000052	-6.8	-0.000028	-2.7
Distance squared, off-peak			-0.001256	-3.1
Distance cubed, off-peak			0.000029	2.9
Intra-zonal indicator	0.404	4.4	0.533	3.9
Intra-zonal, off-peak			0.328	2.1
Intra-zonal, if IZ distance > 1.5 mi	0.023	0.6		
Intra-zonal * Density				
low density	0.5295	3.7	0.4857	2.5
medium density	0.9060	5.7	0.7056	3.1
high density	1.0247	7.3	0.9439	5.0
Distance * Density				
low density	-0.0108	-2.9		
medium density	-0.0158	-3.4	-0.00376	-0.8
high density	-0.0140	-3.4		
Distance * Household income				
low income	-0.0135	-2.4	-0.0344	-5.0
medium income	-0.0041	-1.0	-0.0095	-1.7
high income	-0.0015	-0.4	-0.0051	-1.1

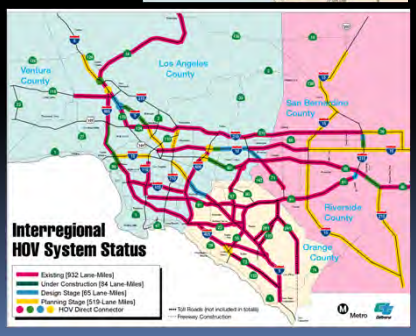
Trip Distribution Models

Distance decay function



Mode Choice Model

- Highway Choices
  - Over 10,000 lane miles of limited access roadways
  - 700+ lane miles of HOV 2+ roadways
  - 20 lane miles of HOV 3+ roadways
  - 2 dynamically-priced HOT lane facilities (soon to be operational)
  - Toll roads

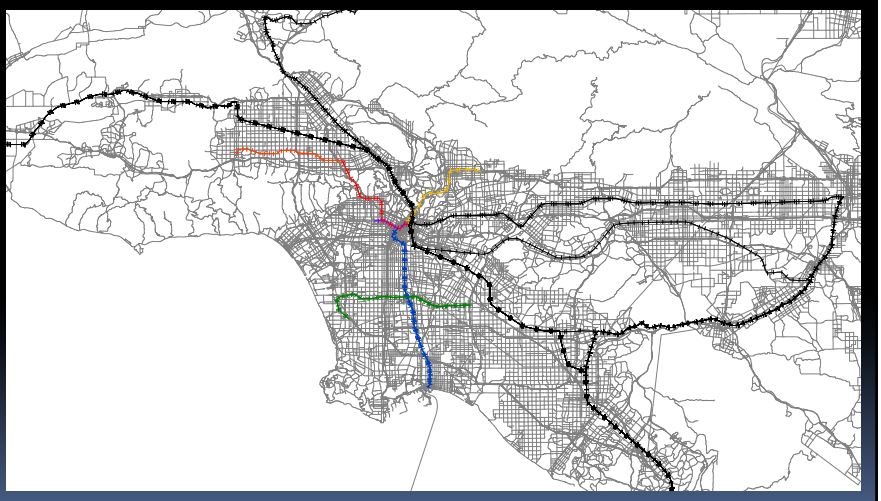


Mode Choice Model

- Transit Options
  - Over 40 different transit carriers
  - Wide variety of transit technologies & operations
  - Characterized by trip purpose, trip distance and type of traveler
    - Short distance local & rapid bus, mostly low income
    - Medium distance urban rail (expanding) and various types of express bus service, including transit-way buses & BRT
    - Long distance commuter rail, mostly high income, competing with express buses on some markets
    - High-speed rail (LAX to ONT, Sacramento to San Diego)

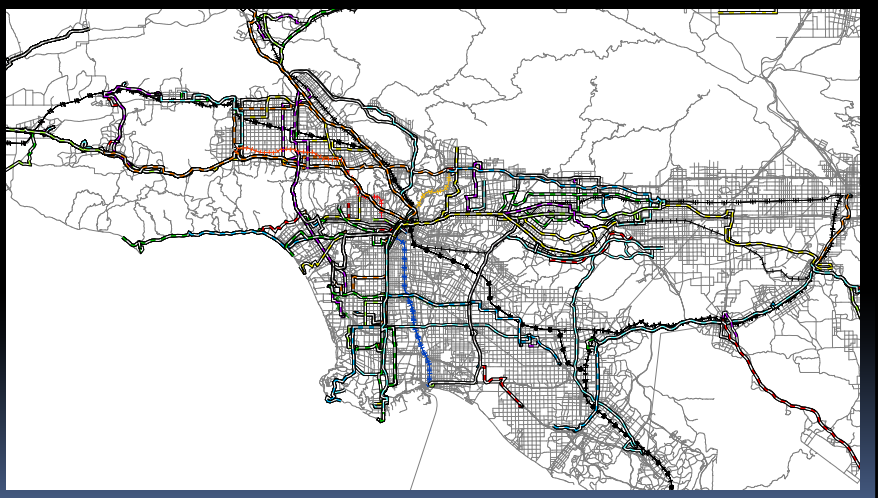
Mode Choice Model

Urban & Commuter Rail

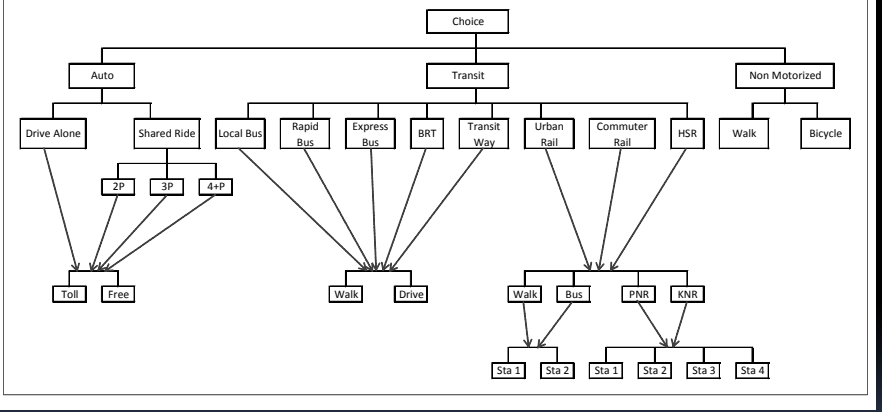


Mode Choice Model

Rail + Express Buses



Mode Choice Model



Mode Choice Model

- 2001 On-board surveys trip assignment
  - Ensure that travelers can be properly assigned to the transit network
  - Inform path building parameters and design of mode choice model
- Action items resulting from on-board assignment
  - Increase length of walk connectors
    - Reproduce observed long walk access distances
    - With improvement, only 2% local bus trips un-assigned (3% SCAG)
  - Adjust some survey expansion factors (and calibration target values)
  - Refine rail walk access in mode choice as two separate choices: direct walk access and walk/bus access

Mode Choice Model

- Transit path building
  - Hierarchy of transit modes

Primary Transit Mode	Support Transit Mode(s)
Local Bus	None
Rapid Bus	Local
Express Bus	Local, Rapid Bus
Transitway Bus	Local, Express, Rapid Bus
Bus Rapid Transit	Local, Rapid Bus
Urban Rail	Local, Express, Rapid, Transit-way Bus and BRT
Commuter Rail	Local, Express, Rapid, Transit-way Bus, BRT and Urban Rail
High Speed Rail	Local, Express, Rapid, Transit-way Bus, BRT, Urban and Commuter Rail

  - In-vehicle time weighted by 1.1 – 1.5 for supporting modes, and by 1.0 for primary line-haul mode

Mode Choice Model

- Bus Transit Path Building
  - Pathfinder minimizes generalized transit cost

Cost Component	Weight
Access, Egress, Transfer Walk Times	2.0
Wait Time	2.0
Primary Mode In-Vehicle Time	1.0
Support Mode In-Vehicle Time	1.1 – 1.5
Fare	

  - Paths are combined based on least cost path plus alternate paths close in cost

Mode Choice Model

- Rail Transit Paths
  - 4 sets of paths created to support station choice
    - Zone to station – bus & walk access allowed, no rail
    - Zone to station – only walk allowed, no rail
    - Station to zone – bus & walk access allowed, no rail
    - Station to station – only rail allowed
  - Best paths determined by the mode choice model by minimizing the entire utility of all station-to-station combinations for a given OD
  - Choice set consists of
    - Best 2 walk access stations
    - Best 2 bus access stations
    - Best 4 park-n-ride stations
    - Best 4 kiss-n-ride stations

Mode Choice Model

- Express Bus, Transit-way Bus, BRT Paths
  - All PNR and KNR locations explicitly identified as 'stations'
  - 2 sets of paths created to support walk and drive access
    - Zone to station—walk and support modes allowed
    - Station to zone—walk, support and primary line-haul mode allowed
    - Best drive access path computed 'on-the-fly'
- Drive to BRT
  - Common observed behavior is to transfer from BRT to Urban rail
  - Path building modified to accommodate this behavior

Mode Choice Model

Station choice coefficients

Attribute	Coefficient					
	HBW		HBO		NHB	
	Value		Value	t-Stat	Value	
In-Vehicle Time	-0.16650		-0.09756		-0.11964	
Drive Access Time	-0.41292	2.5	-0.24195	2.5	-0.25842	2.2
First Wait Time	-0.35298	2.1	-0.21073	2.2	-0.25842	2.2
Transfer Wait Time	-0.35798	2.2	-0.24195	2.5	-0.29073	2.4
Number of Transfers	-1.44400		-0.84584		-1.03761	
Walk Time	-0.25974	1.6	-0.21073	2.2	-0.25842	2.2
Parking Capacity	0.00023		0.00023		0.00023	
Drive Egress Time	-0.41292		-0.24195		-0.25842	
In-Vehicle Time (CRail only)	-0.12488		-0.07317		-0.08973	

Expressed at station choice level

Mode Choice Model

Mode choice coefficients

Coefficient	HBW	HBO	NHB
In-Vehicle Travel Time	-0.02500	-0.01321	-0.01620
Terminal Time	-0.05300	-0.02853	-0.03500
Transit Walk Time (<20 min)	-0.05300	-0.02853	-0.03500
Transit Walk Time (>20 min)	-0.06200	-0.03276	-0.03500
Walk Mode Time (<20 min)	-0.05300	-0.02853	-0.03500
Walk Mode Time (>20 min)	-0.07950	-0.04280	-0.03500
Drive Time	-0.02500	-0.01321	-0.01620
First Wait Time (<5 min)	-0.05300	-0.02853	-0.03500
First Wait Time (>5 min)	-0.02500	-0.01321	-0.01620
Second Wait Time	-0.05375	-0.03210	-0.0394
Cost – low income	-0.00426	-0.00681	-0.00551
Cost – medium income	-0.00142	-0.00227	
Cost – high income	-0.00100	-0.00158	
Cost – very high income	-0.00068	-0.00108	
Primary Mode Logsum	0.75	0.75	0.75
Sub Mode Logsum	0.60	0.60	0.60
Access Mode Logsum	0.60	0.60	0.60

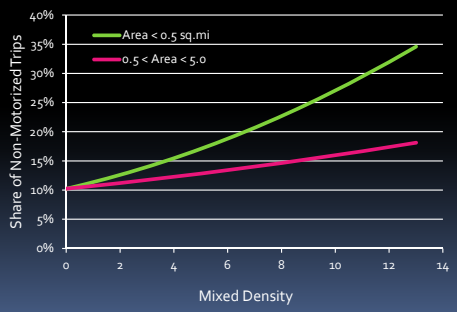
Mode Choice Model

- Bias constant specification
  - Calibration target values are stratified by income
  - Cost coefficients also stratified by income
  - Income-stratified constants:
    - Auto & non-motorized modes
    - Drive to transit, PNR, KNR
  - Primary transit mode constants common across income groups
  - Global transit constant
    - Stratified by income and trip distance
    - Includes a mixed density component, calibrated to reproduce transit shares as a function of density

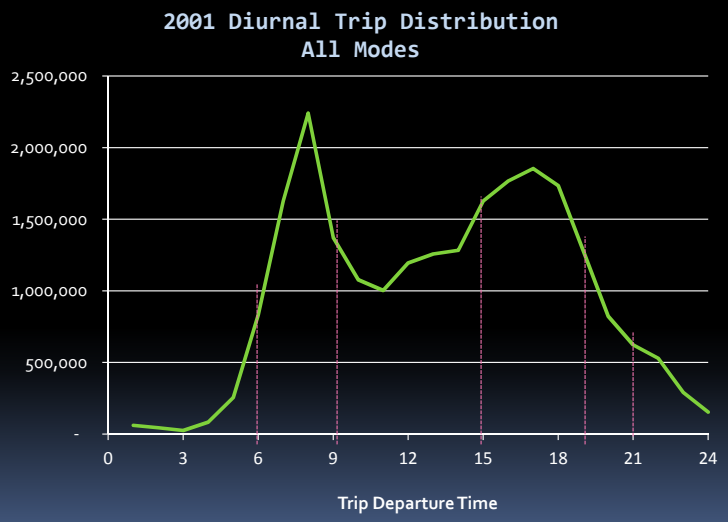
Mode Choice Model

- Intra-zonal non-motorized shares estimated as a function of mixed density and zone size
- Binary motorized/non-motorized logit model
- Based on 2001 Post-Census Household Survey

Variables	HBW	
	Coeff.	t-stat
Constant	-2.17	-11.3
Mixed Density	0.118	5.2
Mixed Density (if 0.5 <area <5)	-0.067	-3.8



Time of Day Segmentation



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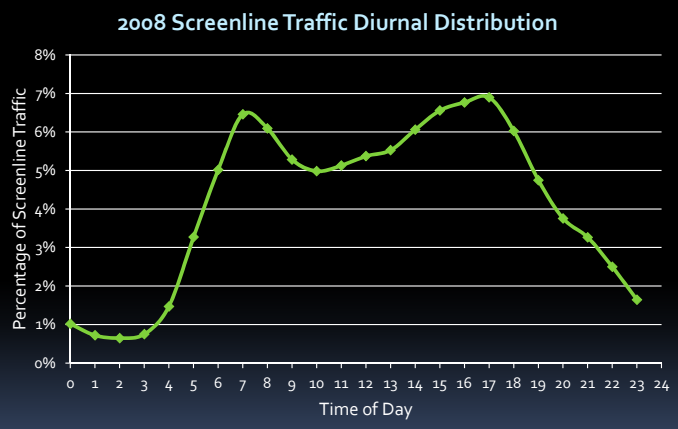


Highway Assignment

- Static user equilibrium
- Generalized cost (time, op. cost, toll/user fee)
- VOTs stratified by vehicle class and time period
- Vehicle classes:
  - Drive alone
  - Shared Ride 2 No HOV & Shared Ride 2 HOV
  - Shared Ride 3+ No HOV & Shared Ride 3+ HOV
  - Heavy Duty Trucks – Light, Medium, Heavy

Highway Assignment

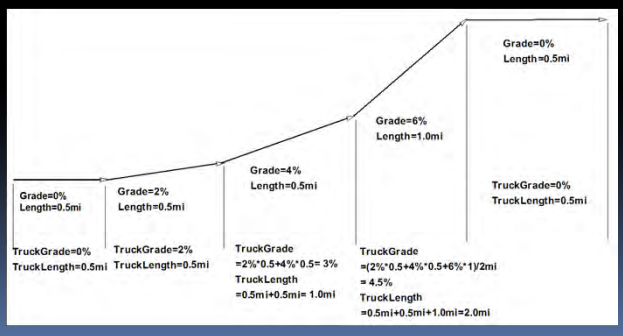
- Travel time feedback to trip generation
  - Up to 8 feedback loops performed
  - MSA applied to average volumes over loops (1/2 step size)

$$FlowAvg_n = FlowAvg_{n-1} + StepSize(Flow_n - FlowAvg_{n-1})$$

  - RMSE and other convergence statistics reported for each loop – AM DA travel time, AM DA trips, AM volumes
  - User has the option of additional loops to tighten convergence
  - Congested times calculated using the averaged volumes

Highway Assignment

- Passenger Car Equivalents
  - Function of link length, grade, truck volume and congestion level
  - Grade and truck link length calculation
    - Point elevation data obtained by polling the USGS website
    - Run grade calculator (custom utility) to compute grade & length



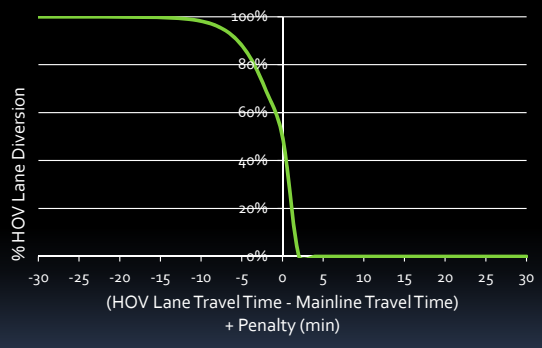
Highway Assignment

- Passenger Car Equivalents
  - PCE factor lookup tables - excerpt

% Trucks	Grade %	Length	PCE LT	PCE MT	PCE HT
2	4	0.25	1.2	1.2	1.5
2	4	0.50	1.4	1.4	2.0
2	4	0.75	1.5	1.5	2.0
2	4	1.0	2.0	2.0	3.0
2	4	1.5	2.5	2.5	3.5
2	4	1.5+	3.0	3.0	4.0

Highway Assignment

- HOV Pre-Route Diversion Model



Transit Assignment

- Trips assigned in PA format
- Same path finding rules as applied for building skims
- Rail trips assigned 'in parts'
- Auto access (and egress) trips assigned to highway network

Appendix G: Presentation – 2012 Trip-Based Model: Model Validation

Peer Review Meeting – June 27, 2011

2008 Regional Travel Demand Model Peer Review
June 27 & 28, Los Angeles, California

2012 RTP Trip-Based Model
Model Validation

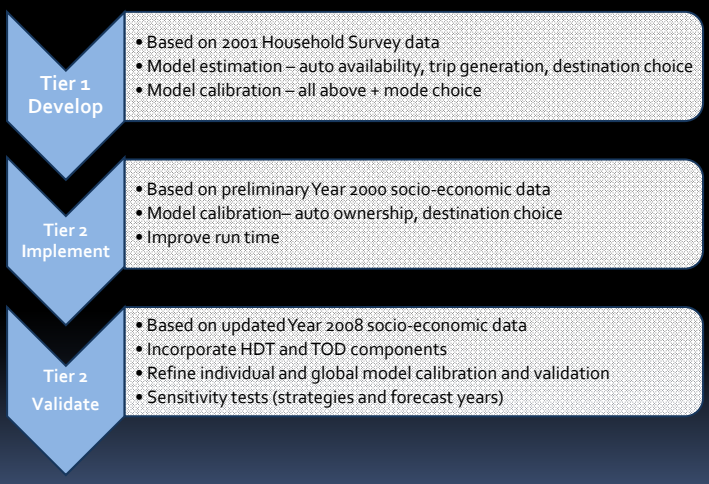
Rosella Picado
Parsons Brinckerhoff

2008 Regional Travel Demand Model Peer Review
June 27 & 28, Los Angeles, California

2012 RTP Trip-Based Model Model Validation

Rosella Picado
Parsons Brinckerhoff

Model Development Process



Primary Data Sources

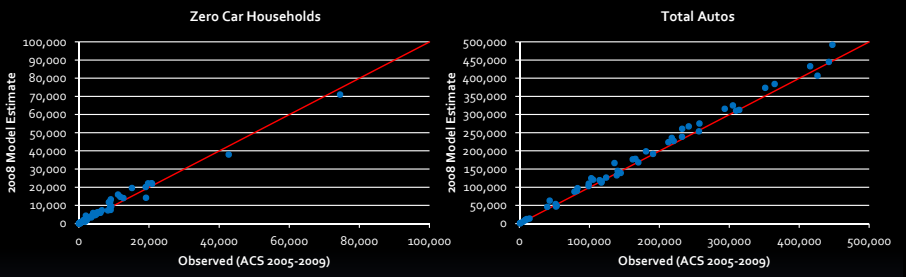
- 2001 SCAG Post-Census Travel Survey
  - 16,000 households region-wide
- 1999 Census Transportation Planning Package
- 2005-2009 & 2006-2008 American Community Survey releases
- 2008 National Household Travel Survey
- On-Board Surveys (2001, 2006, 2008, 2010)
- 2008 Transit Boardings
- 2008 Traffic Counts

Auto Availability

County-Level Validation

	ACS 2005-2009 Auto Availability					
Residence County	**0Cars**	**1Car**	**2Cars**	**3Cars**	**4+Cars**	**Total**
Imperial	5,022	14,658	16,371	6,919	3,435	**46,405**
Los Angeles	300,094	1,105,169	1,123,597	430,792	216,026	**3,175,678**
Orange	45,379	279,591	407,333	159,368	81,130	**972,802**
Riverside	29,360	191,759	254,724	112,203	57,038	**645,084**
San Bernardino	30,030	162,589	224,543	112,044	59,681	**588,887**
Ventura	10,497	67,105	103,869	49,793	25,876	**257,140**
Total	**420,382**	**1,820,871**	**2,130,438**	**871,119**	**443,186**	**5,685,995**
	Forecast Difference (%), County Normalized					
Residence County	**0Cars**	**1Car**	**2Cars**	**3Cars**	**4+Cars**	**Total**
Imperial	0.5%	0.0%	-0.5%	-0.1%	0.0%	0.0%
Los Angeles	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Orange	-0.2%	-0.6%	0.4%	0.3%	0.2%	0.0%
Riverside	-0.2%	-0.8%	0.5%	0.3%	0.2%	0.0%
San Bernardino	-0.2%	-1.1%	0.2%	0.6%	0.5%	0.0%
Ventura	-0.1%	-0.5%	0.2%	0.3%	0.2%	0.0%
Total	-0.1%	-0.3%	0.1%	0.2%	0.1%	0.0%

Auto Availability Model



Regional Statistical Area Validation

Auto Availability

Mixed Density Validation

Auto Availability	Mixed Density Level							
	ACS 2005-2009				2008 Model Estimate			
	7 or less	7 to 8.5	8.5 to 9.5	9.5 +	7 or less	7 to 8.5	8.5 to 9.5	9.5 +
0	3%	4%	7%	13%	3%	5%	8%	13%
1	24%	27%	32%	43%	27%	28%	33%	40%
2	42%	40%	37%	32%	39%	40%	38%	33%
3	20%	19%	15%	9%	20%	18%	15%	10%
4+	10%	10%	8%	4%	10%	9%	8%	5%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Auto Availability Model

Walk Accessibility Validation

Auto Availability	Walk Accessibility Levels							
	ACS 2005-2009				2008 Model Estimate			
	6 or less	6 to 8	8 to 10	10 +	6 or less	6 to 8	8 to 10	10 +
0	4%	8%	13%	25%	4%	8%	13%	21%
1	25%	33%	43%	43%	28%	33%	39%	44%
2	41%	37%	32%	26%	39%	38%	33%	25%
3	20%	15%	9%	4%	19%	15%	10%	6%
4+	10%	8%	4%	2%	10%	7%	5%	3%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Auto Availability Model

Transit Accessibility Validation

Auto Availability	Transit Accessibility Levels							
	ACS 2005-2009				2008 Model Estimate			
	9 or less	9.5 to 12	12 to 13.5	13.5 +	9 or less	9.5 to 12	12 to 13.5	13.5 +
0	5%	5%	7%	17%	4%	5%	8%	15%
1	29%	27%	33%	42%	31%	28%	33%	41%
2	40%	40%	38%	29%	38%	40%	38%	30%
3	18%	19%	15%	8%	18%	18%	14%	10%
4+	9%	9%	8%	4%	9%	9%	7%	5%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Trip Productions

+8 % households
-3% workers/hhld

Validation to 2001 Household Survey

Trip Purpose	2001 Household Survey	2000 Model Estimate	% Difference	2008 Model Estimate	2008 to 2000 Change
HBWD	7,951,000	8,245,000	4%	8,710,000	1.06
HBWS	2,496,000	2,575,000	3%	2,793,000	1.08
HBSc	4,605,000	4,755,000	3%	4,851,000	1.02
HBU	662,000	667,000	1%	685,000	1.03
HBSh	4,446,000	4,710,000	6%	5,293,000	1.12
HBSR	4,242,000	4,362,000	3%	4,671,000	1.07
HBO	7,598,000	7,965,000	5%	8,817,000	1.11
HBSP	6,595,000	6,720,000	2%	7,515,000	1.12
OBO	11,233,000	12,709,000	13%	14,355,000	1.12
WBO	3,248,000	3,433,000	6%	3,587,000	1.05
Total	53,078,000	56,341,000	6%	61,277,000	1.11

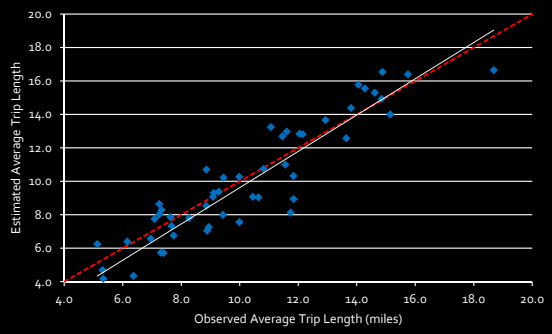
+8 % households
+12% autos/hhld

Trip Productions

Validation to 2008 NHTS

Trip Purpose	2008 Model Estimate	2008 NHTS
HBWD	8,710,000	7,908,000
HBO	34,625,000	36,813,000
NHB	17,942,000	15,658,000
Total	61,277,000	60,380,000

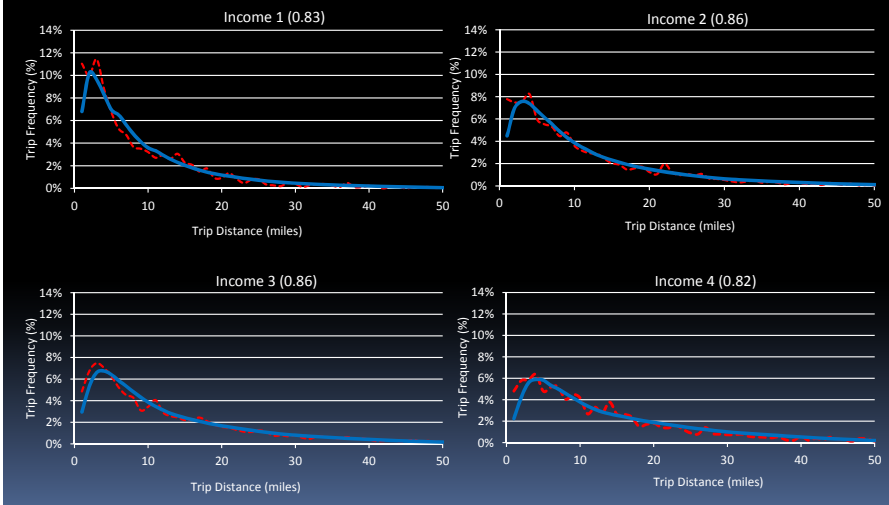
Trip Distribution



Validation of Average Trip Length to 2001 Household Survey
(points represent purpose/income/time periods)

Trip Distribution

Trip Length Validation
(coincidence ratio)



Trip Distribution Model

Trip Length Validation

Purpose	Income	Coincidence Ratio
HBW	1	0.83
HBW	2	0.83
HBW	3	0.86
HBW	4	0.82
HBSH	1	0.84
HBSH	2	0.85
HBSH	3	0.80
HBSH	4	0.78
HBSR	1	0.73
HBSR	2	0.75
HBSR	3	0.72
HBSR	4	0.74
HBSP	1	0.71
HBSP	2	0.81
HBSP	3	0.76
HBSP	4	0.74
HBO	1	0.81
HBO	2	0.83
HBO	3	0.82
HBO	4	0.79
WBO		0.82
OBO		0.90

2006-2008 ACS Worker Flows (in 1000's)

		25	37	59	65	71	111	SCAG
25	Imperial	81	1	1	1	0	0	84
37	Los Angeles	0	5,704	409	25	100	79	6,317
59	Orange	0	359	1,761	31	29	2	2,183
65	Riverside	2	81	109	809	165	4	1,169
71	San Bernardino	1	182	81	133	766	6	1,169
111	Ventura	0	113	3	1	1	408	526
	SCAG	84	6,439	2,363	1,000	1,062	499	11,447

2008 Estimated Work Trips / ACS Workers

		25	37	59	65	71	111	SCAG
25	Imperial	1.6	8.2	12.5	1.1	3.2	0.0	1.6
37	Los Angeles	1.0	1.4	2.2	1.6	1.7	2.1	1.4
59	Orange	13.5	2.0	1.5	2.0	2.4	3.9	1.5
65	Riverside	3.5	1.7	1.6	1.3	1.8	8.2	1.4
71	San Bernardino	4.8	1.4	2.2	1.9	1.3	8.2	1.4
111	Ventura	0.0	1.7	2.1	4.7	3.4	1.4	1.5
	SCAG	1.6	1.4	1.6	1.4	1.4	1.5	1.5

2001 Household Survey Trip Flows (in 1000's)

		25	37	59	65	71	111	SCAG
25	Imperial	425	23	1	4	1	0	*455*
37	Los Angeles	81	27,680	827	125	222	171	*29,106*
59	Orange	20	1,078	8,392	106	92	21	*9,707*
65	Riverside	3	155	192	4,976	273	4	*5,603*
71	San Bernardino	7	393	105	214	4,840	3	*5,562*
111	Ventura	4	235	16	5	7	2,137	*2,405*
	SCAG	*540*	*29,563*	*9,533*	*5,431*	*5,434*	*2,337*	*52,838*

2008 Estimated Trips / Observed Trips (normalized to productions)

25	Imperial	1.0	0.2	2.6	1.6	2.1	0.5	*1.0*
37	Los Angeles	0.0	1.0	1.2	0.6	1.4	0.9	*1.0*
59	Orange	0.0	0.9	1.0	0.8	0.8	0.3	*1.0*
65	Riverside	1.0	1.7	1.2	0.9	1.4	1.9	*1.0*
71	San Bernardino	0.2	1.3	1.8	1.5	0.9	3.4	*1.0*
111	Ventura	0.0	1.2	1.1	0.9	1.1	1.0	*1.0*
	SCAG	*0.8*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*

Mode Choice Model

- Development of Calibration Target Values
  - Auto & Non-Motorized Trips: Household Survey
  - Transit:
    - On-Board Surveys
    - National Transit Database & Agency Boarding Counts

Transit Agency	Sample Size	Transit Agency	Sample Size
Metro Bus	34,801	Alhambra	142
Metro Rail	15,452	Carson	179
Metro Orange Line (2006)	538	Cerritos	104
Metro Gold Line (2006)	2,880	Commerce	131
Metro Rapid Bus (2006)	1,512	Culver City	534
Metrolink (2002)	10,418	El Monte	100
Metrolink (2008)	9,261	Pasadena	149
OCTA (2001)	11,753	Santa Clarita	1,065
OCTA (2010)	13,133	Santa Monica	2,454
Foothill (Transit-way)	952	Torrance	681
LA DOT	451		

Mode Choice Model

Primary Mode

Calibration Target Values							
Income	DA	SR2	SR3	SR4+	Transit	Non Mot	Total
1	329,929	54,494	22,341	17,555	313,790	65,592	803,701
2	1,133,591	119,289	52,053	20,898	113,628	85,881	1,525,340
3	1,974,449	108,142	33,416	22,476	58,912	59,098	2,256,492
4	1,059,292	29,650	16,906	4,987	30,579	7,896	1,149,311
Total	*4,497,262*	*311,575*	*124,716*	*65,916*	*516,909*	*218,467*	*5,734,844*

2008 Estimated – Observed Trips

Income	DA	SR2	SR3	SR4+	Transit	Non Mot	Total
1	7,069	1,279	487	371	-4,549	-4,877	-220
2	4,820	454	198	82	-1,514	-4,421	-383
3	1,933	110	33	22	-618	-1,933	-452
4	-172	2	-2	-1	-492	272	-393
Total	13,650	1,844	716	473	-7,173	-10,959	-1,448

Mode Choice Model

Bus Line-Haul by Access Mode

Calibration Target Values										
Income	LOC_W	LOC_D	EXP_W	EXP_D	TWY_W	TWY_D	RPD_W	RPD_D	BRT_W	BRT_D
1	215,107	5,600	10,964	382	11,440	1,085	19,064	2,754	625	315
2	61,593	3,152	3,617	579	3,728	2,019	12,465	1,553	621	351
3	17,018	1,416	1,881	851	1,692	2,257	2,735	388	221	193
4	6,114	441	470	213	423	564	684	97	55	48
Total	*299,832*	*10,609*	*16,932*	*2,025*	*17,284*	*5,925*	*34,949*	*4,793*	*1,522*	*907*

2008 Estimated – Observed Trips

Income	LOC_W	LOC_D	EXP_W	EXP_D	TWY_W	TWY_D	RPD_W	RPD_D	BRT_W	BRT_D
1	-3,011	-1,851	-1,773	773	-2,528	1,997	5,302	-2,398	193	559
2	-3,255	-764	685	-203	-270	-509	-2,261	-1,181	-320	177
3	608	1,125	153	-429	25	-341	717	70	-135	376
4	-4	971	420	124	180	851	481	158	-28	392
Total	*-5,663*	*-519*	*-515*	*265*	*-2,644*	*1,998*	*4,238*	*-3,352*	*-290*	*1,504*

Mode Choice Model

Urban Rail by Access Mode

Calibration Target Values					
Income	Walk	Bus	PNR	KNR	Total
1	15,274	25,403	1,899	1,364	43,939
2	5,146	8,932	3,489	1,207	18,774
3	2,706	3,820	5,393	1,101	13,021
4	1,160	1,637	2,311	472	5,580
Total	24,286	39,792	13,093	4,143	81,314

2008 Estimated – Observed Trips

Income	Walk	Bus	PNR	KNR	Total
1	-6,631	3,774	1,056	-146	-1,946
2	-2,028	5,014	605	-539	3,052
3	-2,006	625	-45	-749	-2,176
4	-985	-195	1,319	-324	-185
Total	-11,825	7,776	-696	-1,905	-6,650

Mode Choice Model

Commuter Rail by Access Mode

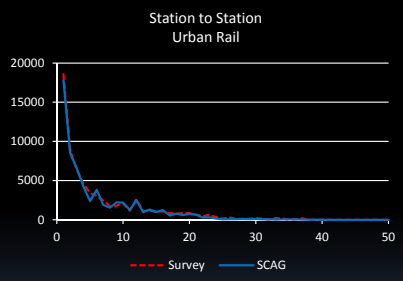
Calibration Target Values					
Income	Walk	Bus	PNR	KNR	Total
1	530	392	1,243	348	2,513
2	600	709	3,557	310	5,176
3	1,227	1,536	13,762	714	17,239
4	831	1,361	13,401	297	15,889
Total	3,189	3,998	31,963	1,668	40,817

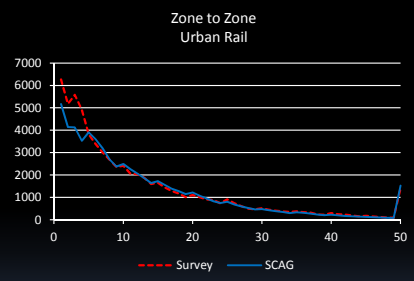
2008 Estimated – Observed Trips

Income	Walk	Bus	PNR	KNR	Total
1	-275	-107	-39	557	136
2	48	464	1,438	1,384	3,334
3	-825	-939	-235	1,439	-560
4	-690	-1,148	-3,121	1,107	-3,851
Total	*-1,743*	*-1,730*	*-1,957*	*4,488*	*-941*

Mode Choice Model

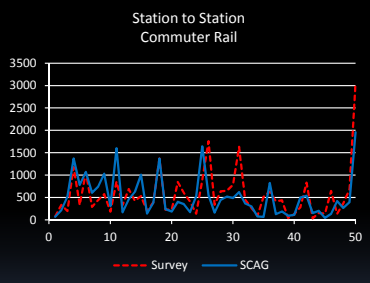
Urban Rail Trip Length
(2000 Base Year)

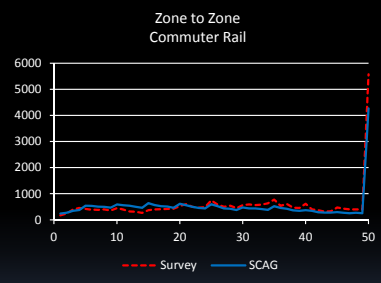




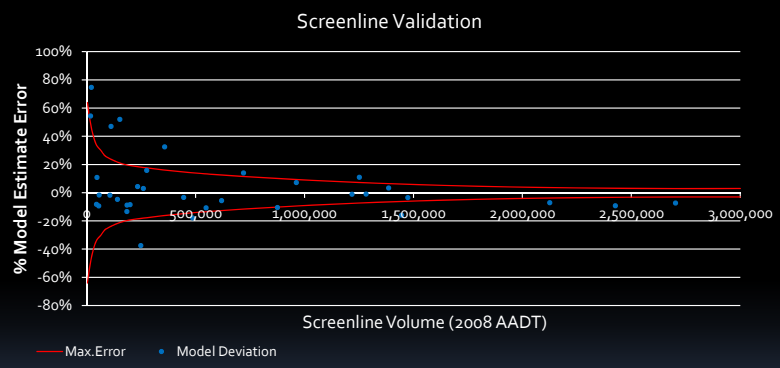
Mode Choice Model

Commuter Rail Trip Length
(2000 Base Year)

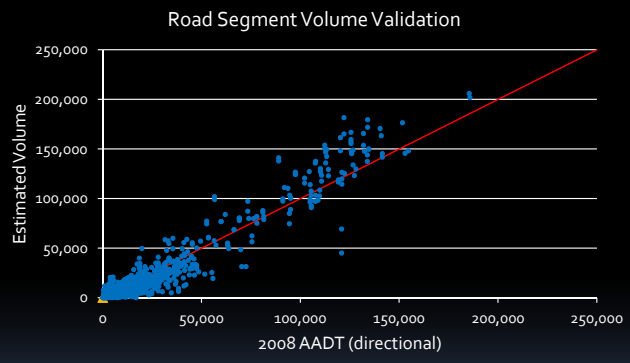




Highway Assignment Validation



Highway Assignment Validation



Highway Assignment Validation

Facility Type Validation

	2008 Traffic Volume			
Facility Type	**AADT Count**	**Model Estimate**	**% Error**	**% RMSE**
Freeways	13,177,474	14,204,193	8%	0.24
HOV Lane, 2+	699,569	624,509	-11%	0.41
HOV Lane, 3+	29,512	18,862	-36%	0.52
Expressways, divided interrupted	50,372	53,608	6%	0.28
Expressways, divided uninterrupted	150,422	165,915	10%	0.42
Principal Arterial, undivided	1,545,968	1,277,088	-17%	0.43
Principal Arterial, divided	1,680,119	1,522,114	-9%	0.39
Principal Arterial, continuous left turn	1,962,163	1,636,048	-17%	0.46
Minor Arterial, undivided	1,489,555	1,170,525	-21%	0.58
Minor Arterial, divided	337,512	238,237	-29%	0.44
Minor Arterial, continuous left turn	1,049,482	738,769	-30%	0.53
Major collector, undivided	360,540	245,731	-32%	0.99
Major collector, divided	62,786	52,790	-16%	0.49
Major collector, continuous left turn	45,659	29,262	-36%	0.62
Minor collector	26,458	18,128	-31%	0.95
All Facilities			-3%	0.38

Highway Validation

HPMS Validation - Autos

County		VC SCCAB	SCAB	MDAB	SSAB	TOTAL
Imperial	Model				5,427	5,427
	HPMS				4,660	4,660
Los Angeles	Model		187,628	7,736		195,363
	HPMS		205,014	8,472		213,486
Orange	Model		67,250			67,250
	HPMS		73,933			73,933
Riverside	Model		47,230	1,502	11,179	59,911
	HPMS		40,546	1,469	9,471	51,486
San Bernardino	Model		36,982	20,391		57,374
	HPMS		35,615	17,936		53,550
Ventura	Model	16,112				16,112
	HPMS	18,698				18,698
TOTAL	Model	16,112	339,090	29,629	16,606	401,437
	HPMS	18,698	355,108	27,877	14,131	415,814
	Ratio	0.86	0.95	1.06	1.18	0.97

Highway Validation

HPMS Validation - Trucks

County		VC SCCAB	SCAB	MDAB	SSAB	TOTAL
Imperial	Model				789	789
	HPMS				833	833
Los Angeles	Model		12,577	366		12,943
	HPMS		12,023	613		12,636
Orange	Model		3,341			3,341
	HPMS		3,475			3,475
Riverside	Model		2,724	709	1,428	4,861
	HPMS		3,461	621	1,675	5,757
San Bernardino	Model		2,713	4,178		6,891
	HPMS		3,335	3,809		7,144
Ventura	Model	957				957
	HPMS	965				965
TOTAL	Model	957	21,356	5,253	2,217	29,782
	HPMS	965	22,294	5,043	2,508	30,810
	Ratio	0.99	0.96	1.04	0.88	0.97

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Appendix H: Presentation - Model Integration and Software Implementation

Peer Review Meeting – June 27, 2011

Model Integration and Software Implementation

Jim Lam and Howard Slavin
Caliper Corporation
SCAG Travel Model Peer Review
June 27, 2011

Model Integration and Software Implementation

Jim Lam and Howard Slavin
Caliper Corporation
SCAG Travel Model Peer Review
June 27, 2011

Outline

- Caliper Role
- Modifications to TransCAD Procedures
- Issues
- Future Work

Caliper Role

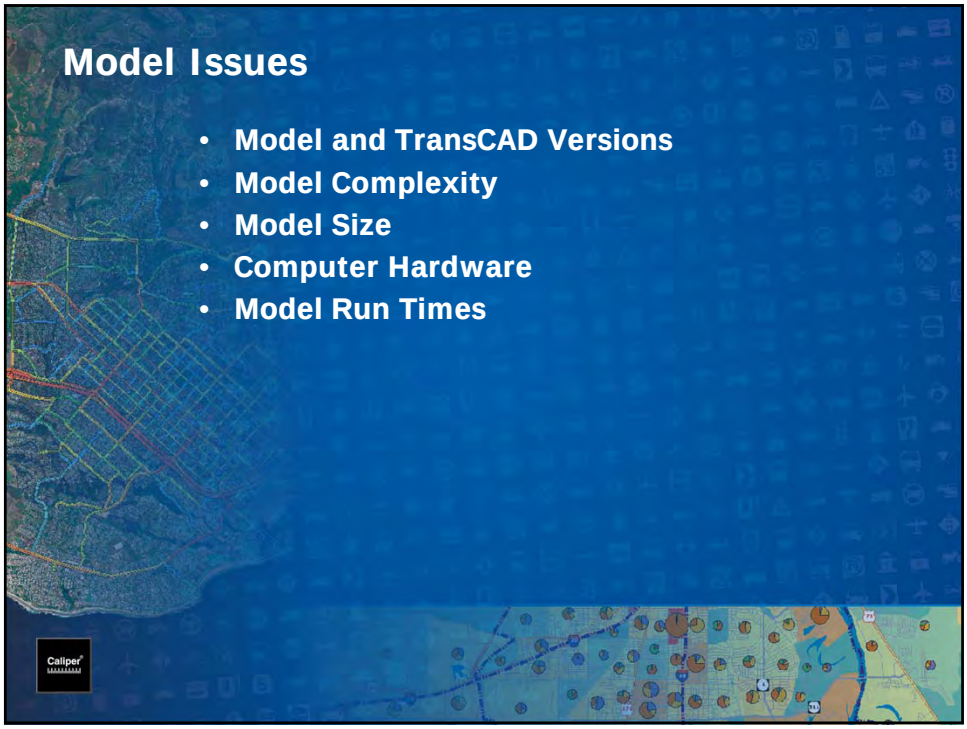
- Support for SCAG Staff
- Integration of Consultant Models
- Programming of New Models & Modifications of Existing Models
- Creation of Model Reports
- Data Development
- Performing Model Runs
- Model Testing

TransCAD Modifications

- Requested by SCAG or consultant
- Required modifications to TransCAD procedures
  - Origin TAZ Value of Time for Highway Skimming
  - Link and User-Class based PCE for Highway Assignment
  - Toll Diversion Assignment
  - HOV Diversion Model
  - Subregional/Sketch Tool
  - Mode Choice/Distribution Calibrator
  - On Lanes/Cross Lanes Capacity Calculator
  - Intermediate Stops Model
  - Scenario Generator
  - Highway/Transit Network Checker
  - Transit Walk Access Model

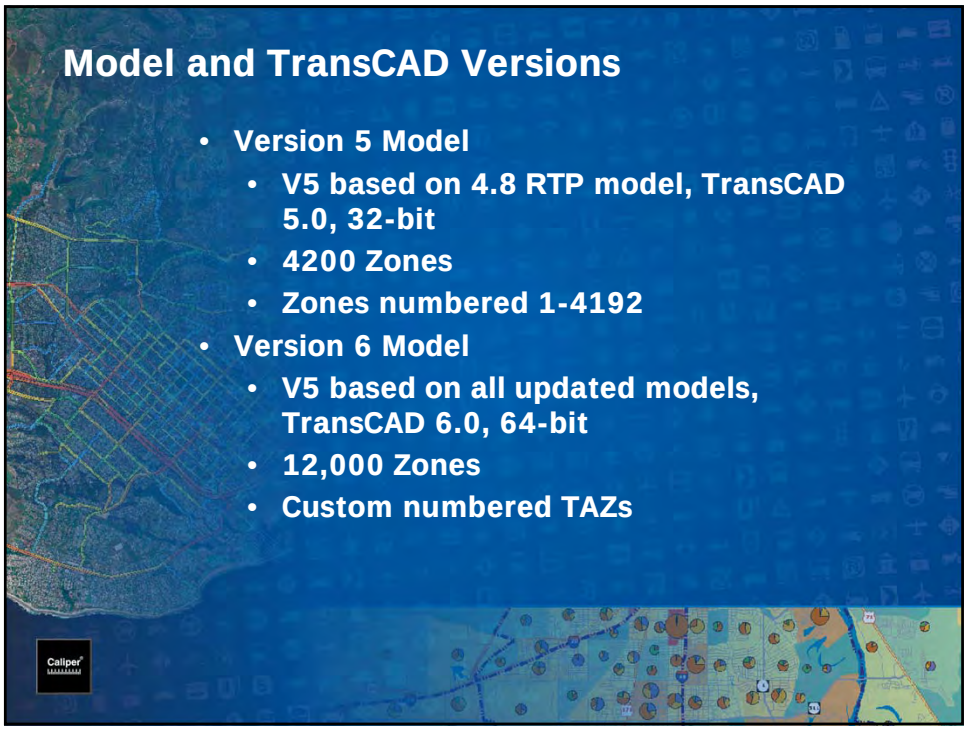
Model Issues

- Model and TransCAD Versions
- Model Complexity
- Model Size
- Computer Hardware
- Model Run Times



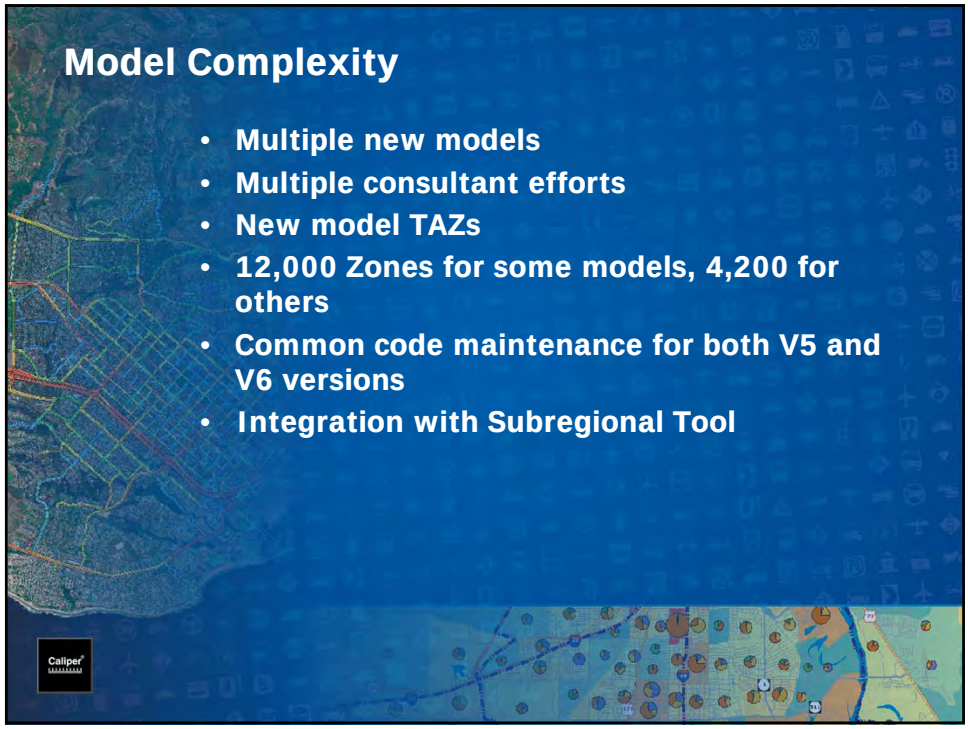
Model and TransCAD Versions

- Version 5 Model
  - V5 based on 4.8 RTP model, TransCAD 5.0, 32-bit
  - 4200 Zones
  - Zones numbered 1-4192
- Version 6 Model
  - V5 based on all updated models, TransCAD 6.0, 64-bit
  - 12,000 Zones
  - Custom numbered TAZs



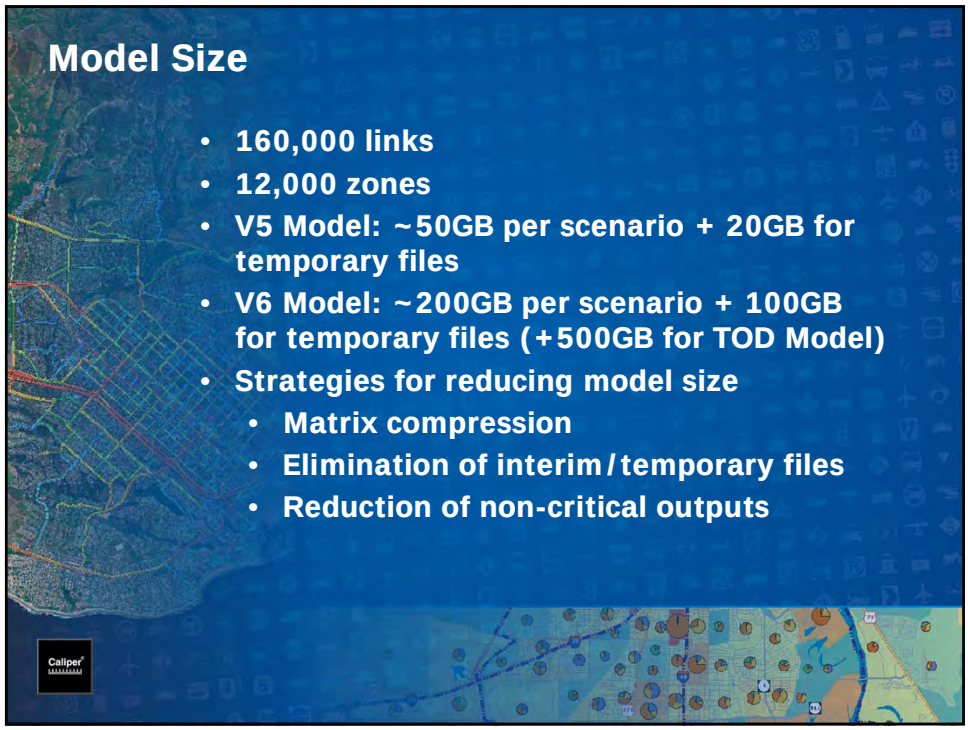
Model Complexity

- Multiple new models
- Multiple consultant efforts
- New model TAZs
- 12,000 Zones for some models, 4,200 for others
- Common code maintenance for both V5 and V6 versions
- Integration with Subregional Tool



Model Size

- 160,000 links
- 12,000 zones
- V5 Model: ~50GB per scenario + 20GB for temporary files
- V6 Model: ~200GB per scenario + 100GB for temporary files (+500GB for TOD Model)
- Strategies for reducing model size
  - Matrix compression
  - Elimination of interim/temporary files
  - Reduction of non-critical outputs



Computer Hardware

- Caliper Configuration
  - Desktop
    - Intel Core i7 920 @ 3.2GHz: 6 physical cores, 12 threads
    - 2 TB HDD
    - 24 GB RAM
  - Laptop
    - Intel Core i7 2820QM @ 2.3/3.2GHz: 4 physical cores, 8 threads
    - 560GB SSD
    - 8 GB RAM
  - SCAG Configuration
    - Intel Xeon X5680 @ 3.33 GHz (2-6 Core Processors, 24 threads)
    - 24 GB RAM

Model Run Times

- V5 Model: ~30 hours 8 loop feedback run, 24 hours for 5 loops
- V6 Model: ~1 day per loop (Desktop config.)
  - 12,000 zones = 8.2 X size of 4,200 zones
  - Mode Choice: ~4 hours/12 hours per loop
  - Destination Choice/Gravity: ~2.5 hours per loop
  - Time-of-Day: ~4.5 hours per loop
  - Truck Model: ~1.5 hours per loop
  - Skimming: ~5 hours per loop
  - Assignment: ~4 hours per loop

Future Work

- Continued Support for model changes
- Improvement of Model Run Times
  - Multi-threading
  - Distributed Computing
  - Code efficiency
  - Conversion of models into native TransCAD code
- Reduction of Model Size

Appendix I: Presentation – Computational Challenges and Advances in Transportation Computing

Peer Review Meeting – June 27, 2011

Computational Challenges and Advances in Transportation Computing

Andres Rabinowicz
Howard Slavin
Jonathan Brandon
Srini Sundaram

Caliper Corporation
May 2011

Computational Challenges and Advances in Transportation Computing

Andres Rabinowicz
Howard Slavin
Jonathan Brandon
Srini Sundaram

Caliper Corporation
May 2011

Current Computational Burdens are High and are Getting Higher

- Many more zones for conventional models with 5,000-12,000 and up being used.
- Dynamic Traffic Assignments can multiply the computing time needed for static assignments by more than an order of magnitude
- Numerous complex choice model evaluations
- Agent-based models with millions of agents are at the core of activity models and traffic microsimulation

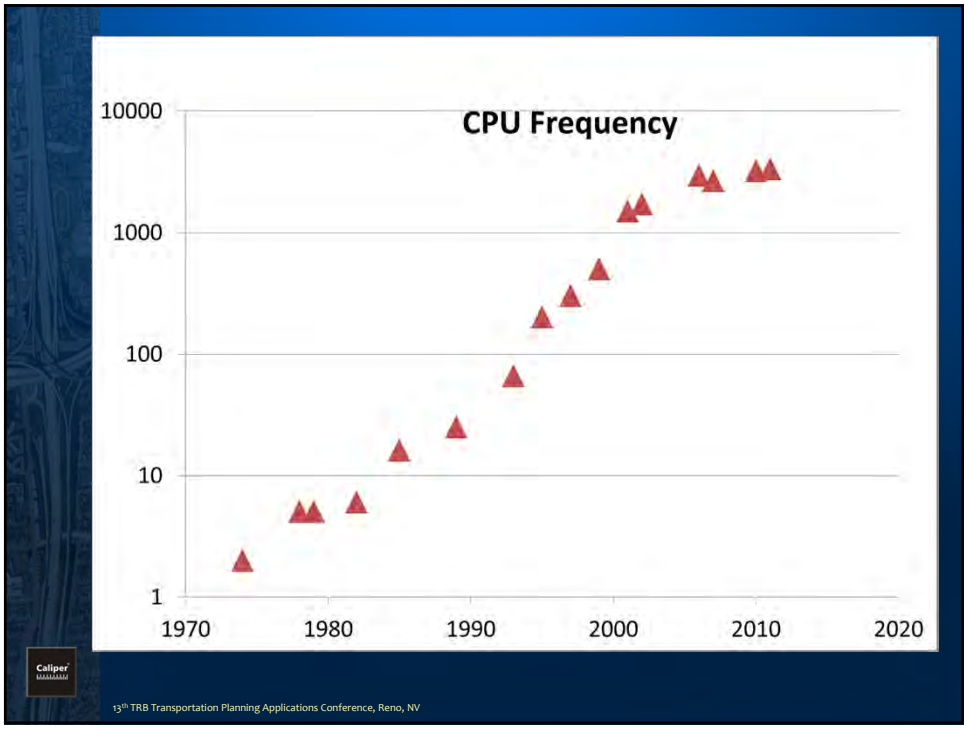
Computing Demands Keep Increasing

- Feedback Loops
- Calibration Runs
- Large numbers of scenarios
- Equilibrium Convergence Issues
- More complex and interdependent choices in disaggregate models of all types
- But run times need to be acceptable or compromises are made…

Progression of Intel Architecture

Processor	Year	GFLOP	MHZ
8080	1974		2
8086	1978		5
8088	1979		5
80286	1982		6
80386	1985		16
80486	1989		25
Pentium	1993		66
Pentium Pro	1995		200
Pentium II	1997		300
Pentium III	1999		500
Pentium 4/Xeon	2001	7	1500
Pentium M	2002	2	1700
Core Duo	2006	23	2930
QuadCore	2007	42	2660
I5 650	2010	26	3200
I7 965	2011	52	3333

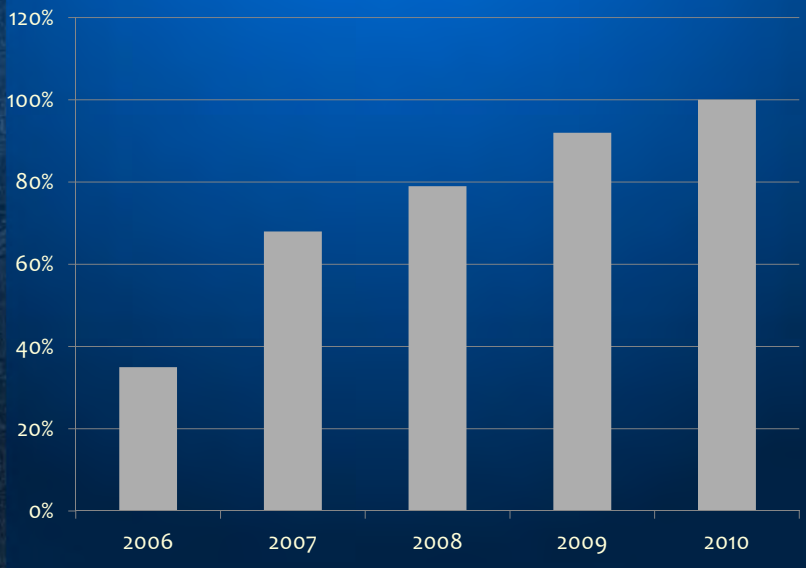
Source: http://www.intel.com/support/processors/sb/cs-023143.htm



History of the Multi-Core Processor

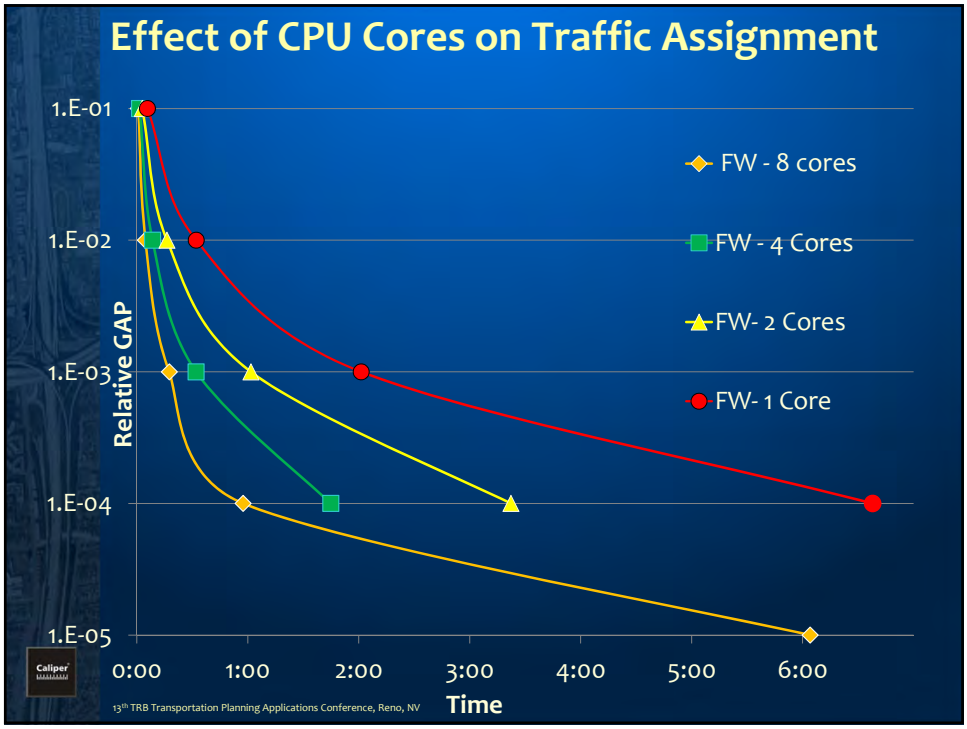
- Dual core chips introduced in 2005
- Cores are like multiple CPU with some shared components
- Currently chips with 6-10 physical cores are available
- PCs can have multiple chips with multiple cores
- Expectations are that the number of cores per chip will keep growing
- Speculation is that by 2017, computers will have 100s of cores

Multi-core Desktop Computer



Hardware Improvements Keep Coming

- Multi-core chips now in low-end machines
- Hyper-threading—2 threads per physical core is standard
- Turbo-boost increases the clock speed when some cores are unused
- 64-bit hardware commonplace
- Memory constraints of less importance
- There are more cores per chip each year, but multiple cores are not used unless the software is designed to use them.



Processing Time For NYMTC Model Run

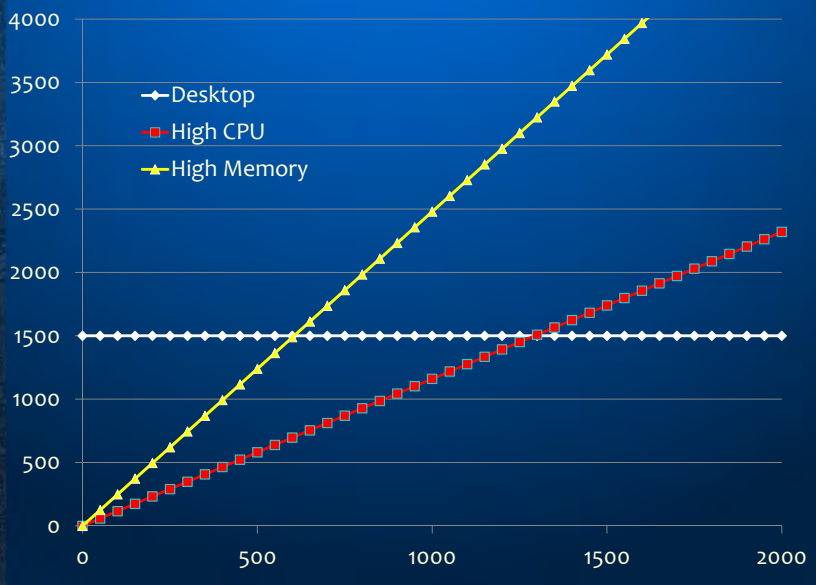
STEP	BPM PROCEDURE	1996 BASE	2002 BASE	2005 BASE (64 bit)
1	CREATE NEW SCENARIO	10 min.	10 min.	1 min.
2	RUN HIGHWAY NETWORK BUILDER	15 min.	5 min.	2 min.
3	NETPREP	20 min.	15 min.	11 min.
4	HIGHWAY PRESKIMS	12 hrs.	4 hrs 52 min.	1 hr 16 min.
5	TRANSIT NETWORK DATABASE & SKIMS	48 hrs.	18 hrs 35 min.	2 hrs 5 min.
6	ACCESSIBILITY INDICIES	2 hrs.	20 min.	15 min.
7	HOUSEHOLD AUTO JOURNEY (HAJ)	1 hrs.	15 min.	7 min.
8	MODE DESTINATION STOPS CHOICE (MDSC)	18 hrs.	5 hrs 20 min.	2 hrs 33 min
9	TRUCKS/COMMERCIAL VEHICLES MODEL	2 hrs.	2 hrs.	24 min.
10	EXTERNAL MODEL	5 min.	5 min.	1 min.
11	PRE-ASSIGNMENT PROCESSING/TIME OF DAY (PAP)	1 hrs.	1 hrs.	13 min.
12	HIGHWAY ASSIGNMENT	16 hrs.	16 hrs.	56 min.
13	TRANSIT ASSIGNMENT	72 hrs.	52 hrs 55 min.	3 hrs 30 min.
TOTAL		173 hrs.	87 hrs.	11 hrs 30 min.

10

Cloud Computing

- Good for parallel applications and distributed processing
- Low cost and peak capacity if needed for short periods of time
- Limited advantages for very large models with heavy data transfer requirements
- Somewhat slower than optimized hardware environments
- Potentially more expensive for heavy, continuous computing loads
- Private clouds can be optimized for demand models

Cloud Cost vs. Desktop Cost



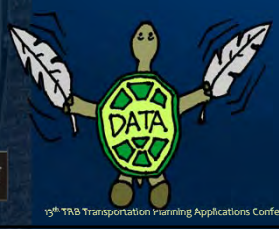
Cloud Computing: Data Transfer @ 1.5 Mbps

Model	Input GB	Output GB
PG County	1.2 (1:42)	8.6 (13:17)
SANDAG	5.5 (7:50)	18 (1 day 3:49)
NYMTC	11 (16:59)	34 (2 day 4:32)

Rolling Stones Get Off Of My Cloud Lyrics
(m. jagger/k. richards)

I live in an apartment on the ninety-ninth floor of my block
And I sit at home looking out the window
Imagining the world has stopped
Then in flies a guy who's all dressed up like a union jack
And says, Iive won five pounds if I have his kind of detergent pack

I said, hey! you! get off of my cloud
Hey! you! get off of my cloud
Hey! you! get off of my cloud



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Software Strategies for Improved Performance

- Distributed Processing-locally or in the cloud
- Multi-threaded shared-memory model computing
- GPU/APU assisted general computing
- All of the above in combination
- Of course, better algorithms and better implementation are always good.

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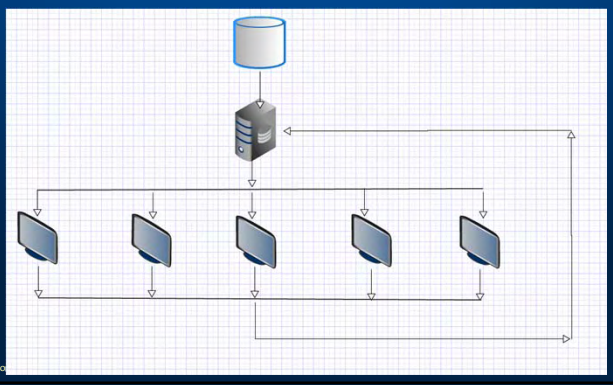
Distributed Processing on Multiple Computers

- Very simple to implement for independent processes such as different time periods
- Heavy overhead from data transfers
- Load balancing essential for good performance
- Requires user management



Multi-threading

- Benefits from shared memory
- Enables fine-grain parallelism unavailable from distributed processing
- Requires significant re-engineering of software components
- Yields enormous upside in performance
- Has a dark side if not done properly

Non-Threaded Program

F(x_1)
F(x_2)
F(x_3)
F(x_4)
F(x_5)
F(x_6)
F(x_7)
F(x_8)
...
...
...
F(x_n)

```
for   = 1 to
    {
        ()          [] [] [] [] []
    }
```

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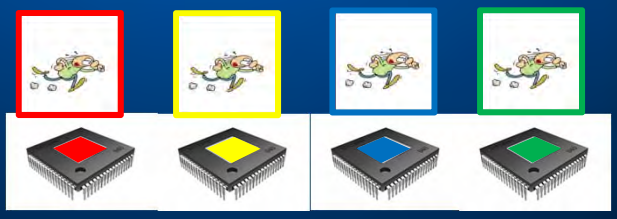
Threaded Program

F(x_1)
F(x_2)
F(x_3)
F(x_4)
F(x_5)
F(x_6)
F(x_7)
F(x_8)
...
...
...
F(x_n)

```
for   = 1 to
    {
        ()          [] [] [] [] []
    }
```



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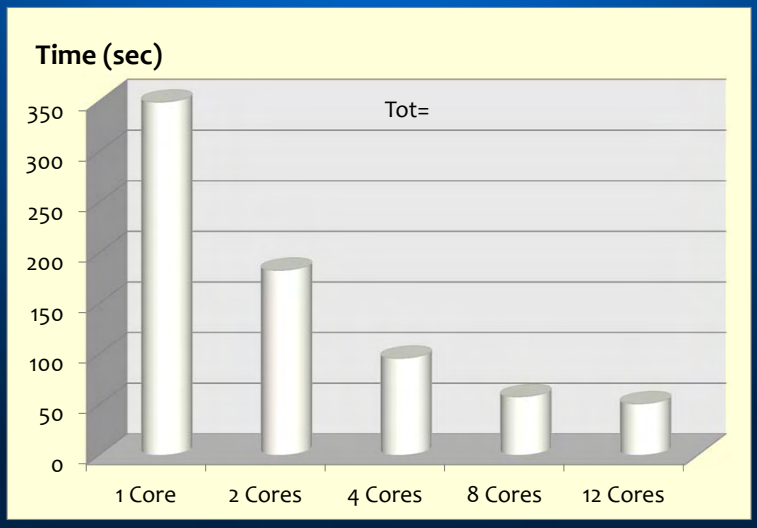
Favorable Candidates for Multi-Threading

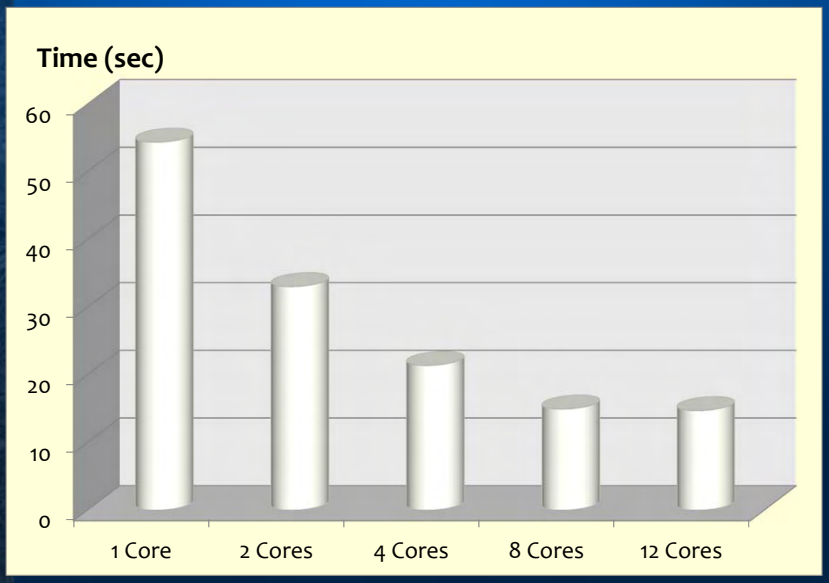
- Network Skims
- Traffic Assignments
- Matrix computations
- Nested Logit and more complex models
- Certain other activity model components
- Traffic micro-simulation

Multithreading: Matrix Operations



13th TRB Transportation Planning Applications Conference, Reno, NV

Multithreading: Transit Skims



Seattle Model: 1091 TAZ; 45000 links; 6000 nodes; 850 Routes; 28000 Stops

Multithreading: Large Scale Simulation

15 min period; 25,000 Trips; 80 square miles (downtown Phoenix and parts of Tempe; 634 miles of Freeway and Arterial links; 447 Signalized Intersections

New Frontier Transportation Modeling Problems will absorb any new computing power that we are given

- Regional High Fidelity Microsimulation faster than real-time for prediction
- Dynamic O-D Estimation from counts
- Activity and Tour Re-optimization
- Full equilibration of activity models
- Network Traffic Signal Optimization(needed for forecasting the future with traffic simulation)

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Appendix J: Presentation – Congestion Pricing Models for Express Travel Choices Study

Peer Review Meeting – June 28, 2011

SCAG Travel Model Improvement Program

Congestion Pricing Models

For

Express Travel Choices Study

Ed Regan
Kazem Oryani

Presentation For

SCAG 2008 Regional Travel Model Peer Review

Date of Peer Review: June 27-28, 2011
Place: SCAG Office

SOUTHERN CALIFORNIA
ASSOCIATION of GOVERNMENTS

ENGINEERS
PLANNERS
ECONOMISTS
WilburSmith
ASSOCIATES

SCAG Travel Model Improvement Program
Congestion Pricing Models

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WilburSmith ASSOCIATES

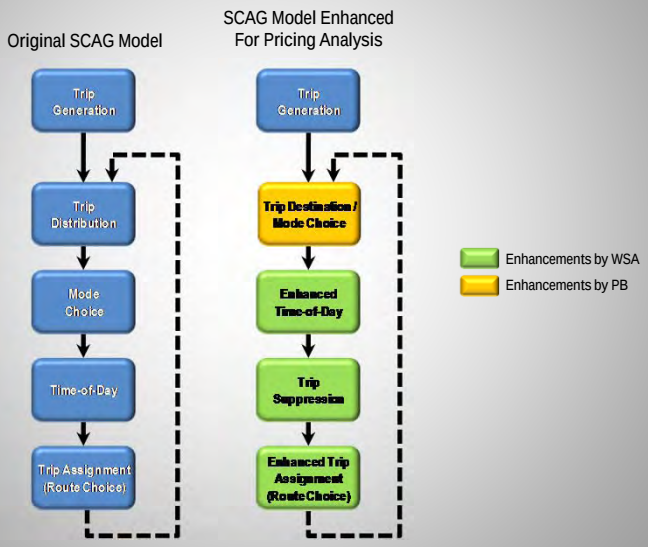
Relative Behavioral Responses to Different Pricing Options

Potential Pricing Applications	Don't Make Trip	Change Destination	Switch To Transit	Carpool	Change Travel Time (with time-of-day pricing)	Change Route
Facility Pricing	X	○	○	○	○	●
Regional Facility Pricing	◒	◒	●	●	●	●
Corridor Pricing	○	◒	◒	◒	◒	●
Managed Lanes	X	X	○	○	○	●
Cordon Pricing	◒	●	●	●	●	◒
Area Pricing	◒	●	●	●	●	◒
VMT Fees	◒	○	○	○	○	X (if applied equally)
Parking Fees	◒	●	●	●	◒	X

● Significant impact ◒ Some impact ○ Minimal impact X No impact

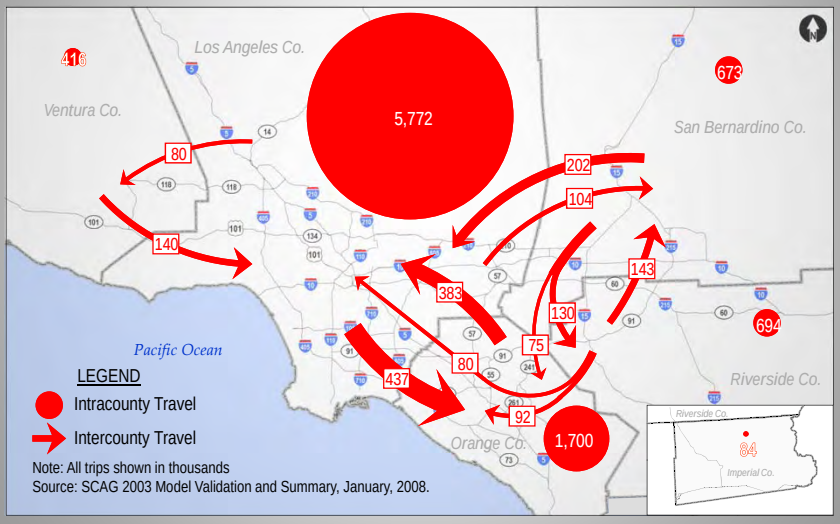
2

Model Steps:



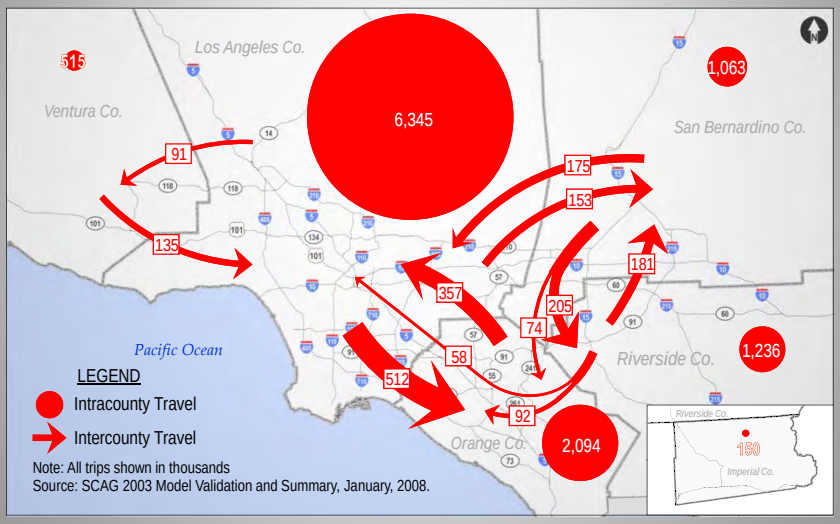
3

Year 2003 Home-based County to County Work Trip Flows



4

Year 2020 Home-based County to County Work Trip Flows



5

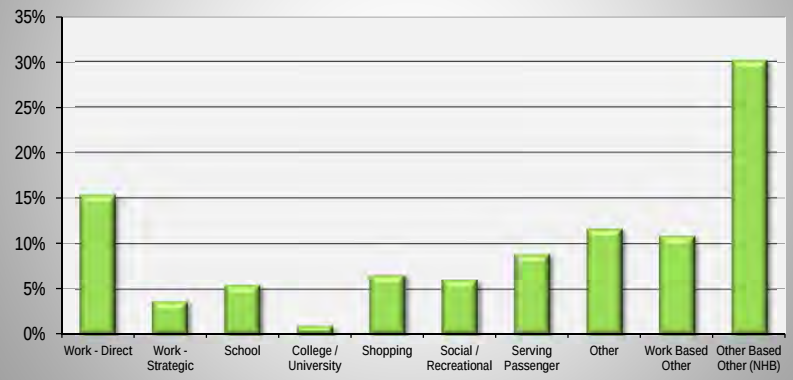
Data Analysis:

- Year 2001 SCAG Household Travel Survey
  - Person trip: 84,000
  - Activity episodes: 190,000
  - Distribution of survey trips by trip purpose
  - Home-based trips
    - Direct work trips: 15 percent
    - Strategic work trips: 4 percent
    - Home-Based Non-Work Trips: 29 percent
    - "Other" home-based trips: 12 percent
- Work-based Other Trips: 10 percent
- Non-Home-based Trips: 30 percent

6

Data Analysis:

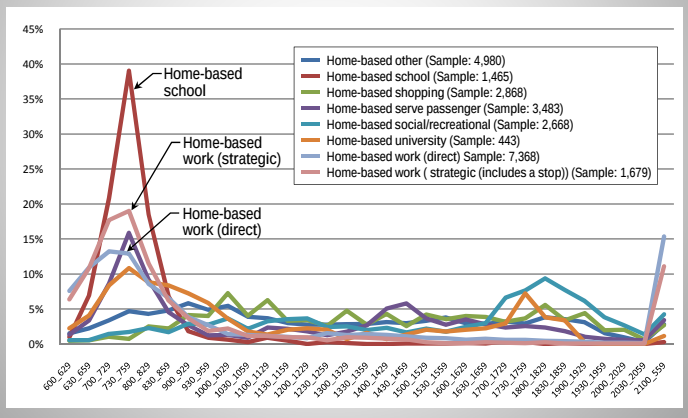
Distribution of Survey Trips by Trip Purpose



7

Data Analysis:

Departure Time Distribution by Purpose
Home-based Auto From-Home Trips

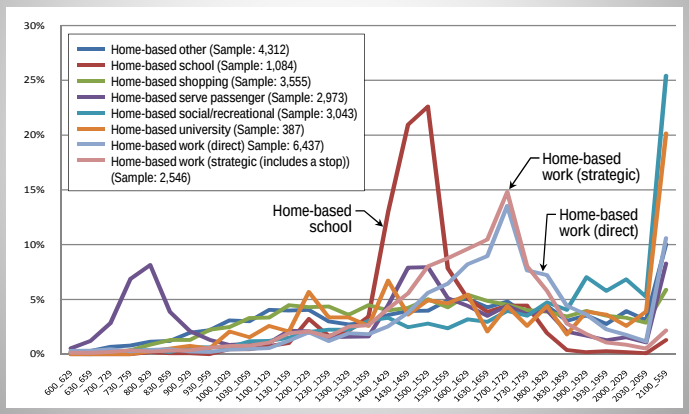


Time of Day

8

Data Analysis:

Departure Time Distribution by Purpose
Home-based Auto To-Home Trips

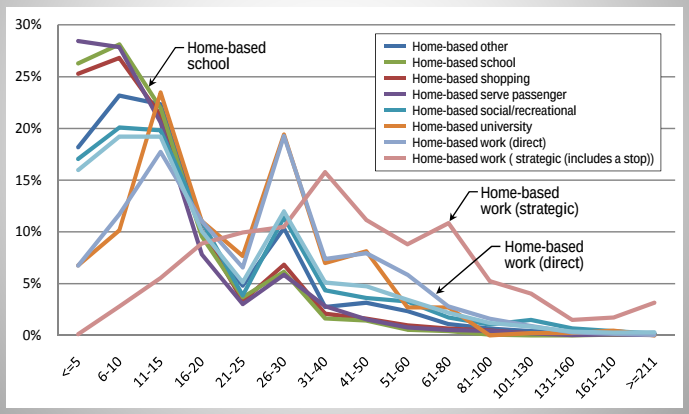


Time of Day

9

Data Analysis:

Travel Time (minute) Distribution by Purpose
Home-based Auto From-Home Trips



Time of Day

10

Data Analysis:

Year 2003 SCAG Model:

- Congested and free-flow travel times
- Distance
- Zonal population density
- Zonal employment density

11

Time-of-Day Model:

Time-of-Day Model Variables

Each time-of-day choice model includes a combination of the following variables:

- Origin zone characteristics (such as CBD, density, other)
- Destination zone characteristics (such as CBD, density, other)
- Trip purpose
- Mode
- Traveler's household size
- Traveler's household income
- Number of household workers
- Number of household vehicles
- Traveler's age
- Traveler's employment industry type

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Time-of-Day Model:

Model Estimated

1. Home-based work direct trips (HBWD) from home
2. Home-based work direct trips (HBWD) to home
3. Home-based work strategic trips (HBWS) from home
4. Home-based work strategic trips (HBWS) to home
5. Home-based shopping trips (HBSH) from home
6. Home-based shopping trips (HBSH) to home
7. Home-based other (including social and recreational) trips (HBSR) from home
8. Home-based other (including social and recreational) trips (HBSR) to home
9. Other-based other (OBO) trips

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Time-of-Day Model:

HBWD From-Home Trip Time-of-Day Choice Model Summary

Alternatives	Shift	Variables in Utility Functions													
		Constant	Delay	Distance	Delay Shift	Delay Shift^2	Distance Shift	Distance Shift^2	Inc_H	Inc_M_H	Inc_M_L	HH_Size	Age	Drive Alone	Pop_O
AM1	1.5	3.579 (7.647)	-0.032 (-5.342)	-0.014 (-3.600)	0.014 (2.626)		0.011 (3.279)		0.917 (8.559)	0.480 (5.948)	0.236 (2.787)	-0.257 (-11.041)	-0.008 (-2.697)	0.215 (2.125)	-0.003 (-1.397)
AM2	1	4.094 (8.770)													
AM3	0.5	4.409 (9.447)													
AM4	0	4.495 (9.624)			0.037 (1.579)	0.030 (-1.303)	-0.007 (-1.009)								
AM5	0.5	4.056 (8.661)													
AM6	1	3.858 (8.217)													
MD1	3	3.413 (7.085)	-0.010 (Constrained)	-0.024 (-7.908)					0.485 (4.842)			-0.197 (-7.054)	-0.011 (-3.437)	0.415 (3.292)	-0.006 (-1.874)
MD2	2.5	3.047 (6.305)													
MD3	2	2.408 (4.935)													
MD4	1.5	2.328 (4.763)													
MD5	1	2.195 (4.476)													
MD6	0.5	2.108 (4.289)													
MD7	0	1.858 (3.753)					-0.012 (-3.524)								
MD8	0.5	2.580 (5.300)													
MD9	1	2.445 (4.997)													
MD10	1.5	2.617 (5.352)													
MD11	2	2.597 (5.287)													
MD12	2.5	2.472 (4.997)													
PM1	3	2.469 (5.975)	-0.028 (-2.400)	-0.012 (-1.936)		-0.003 (-1.476)						-0.107 (-2.841)	-0.025 (-5.192)	0.429 (2.425)	-0.004 (-1.016)
PM2	2.5	2.324 (5.674)													
PM3	2	2.015 (4.883)													
PM4	1.5	2.158 (5.301)													
PM5	1	1.908 (4.623)													
PM6	0.5	1.868 (4.515)													
PM7	0	1.598 (3.783)					-0.052 (-2.048)	0.025 (2.408)							
PM8	0.5	1.747 (3.981)													
PM9	1	1.517 (3.302)													
PM10	1.5	0.973 (2.015)													
PM11	2	0.718 (1.543)													
PM12	2.5	0.000													
NT	0	3.725 (7.720)													

Note: Value in parentheses is the t-statistics.
Observations: 7,368
Final Log Likelihood: -19,733
ρ2 w.r.t. 0: 0.22

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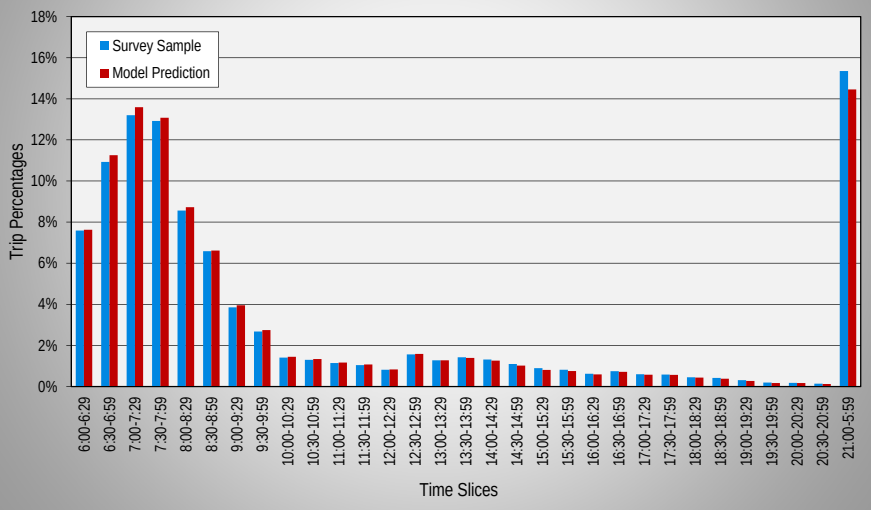
Model Replication: Time-of-Day by 31 Time Slices

Home-based Work Direct Trips (HBWD) From Home



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Model Replication: Time-of-Day

Home-based Work Direct Trips (HBWD) From Home

Aggregate Time Period	Percent of Daily Trips		
	Survey Sample	Model Prediction	Difference
AM (6:00 AM - 9:00 AM)	59.79%	60.89%	1.10%
MD (9:00 AM - 15:00 PM)	18.92%	19.10%	0.18%
PM (15:00 PM - 21:00 PM)	5.94%	5.56%	-0.39%
Night (21:00 PM - 6:00 AM)	15.35%	14.46%	-0.89%
Total	100.00%	100.00%	0.00%

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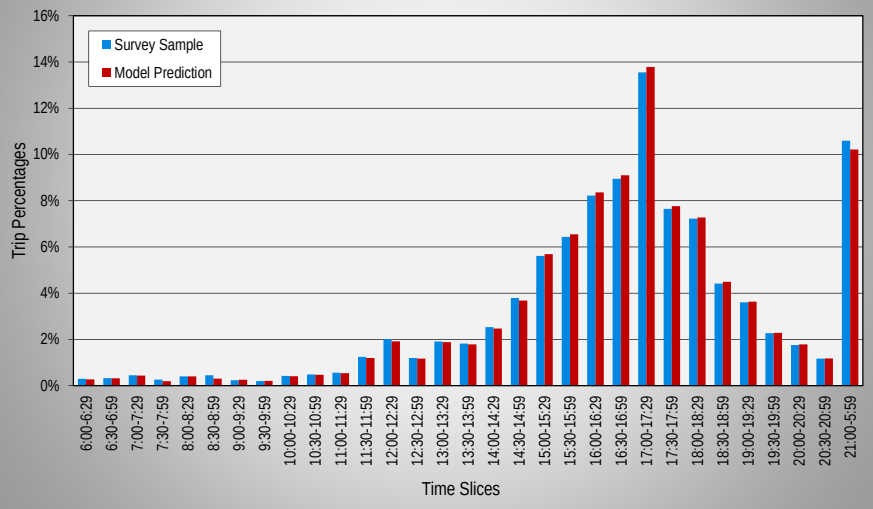
Model Replication: Time-of-Day by 31 Time Slices

Home-based Work Direct Trips (HBWD) To Home



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Model Replication: Time-of-Day

Home-based Work Direct Trips (HBWD) To Home

Aggregate Time Period	Percent of Daily Trips		
	Survey Sample	Model Prediction	Difference
AM (6:00 AM - 9:00 AM)	2.19%	1.92%	-0.27%
MD (9:00 AM - 15:00 PM)	16.39%	15.99%	-0.40%
PM (15:00 PM - 21:00 PM)	70.82%	71.88%	1.05%
Night (21:00 PM - 6:00 AM)	10.59%	10.21%	-0.38%
Total	100.00%	100.00%	0.00%

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Year 2010 Stated Preference Survey:

- Stated Preference Survey to Support Model Changes
  - Eight congestion pricing applications were combined into four different groups based on potential behavioral responses
    1. Individual Facility Pricing / Express Lanes
    2. Regional Facility Pricing / Corridor pricing
    3. Cordon / Area Pricing & Express Lane
    4. VMT Fee
  - Alternatives
    - Toll route during the peak period
    - Toll route before or after the peak period
    - Toll route in a carpool
    - Alternate route
    - Alternate destination
    - Transit
    - Occupancy

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Year 2010 Stated Preference Survey (cont'd):

- Attributes
  - Travel time
  - Toll cost
  - Departure time
  - Occupancy
- 3,600 survey record for all six SCAG counties
- Discrete choice model by trip purpose: work, business trips, non-work
- Time-of-day: peak, off-peak

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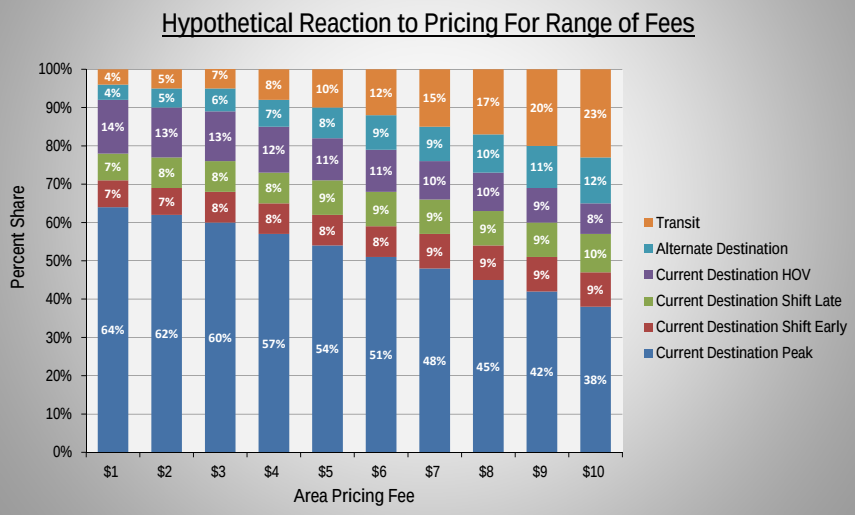
Year 2010 Stated Preference Survey:



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Hypothetical Reaction to Pricing For Range of Fees

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Year 2010 Stated Preference Survey:

Ability to Shift Time of Travel - Current Peak Period Travelers

Earlier	Later							
	Not at All later	Up to 5 minutes later	Up to 15 minutes later	Up to 30 minutes later	Up to 1 hour later	Up to 2 hours later	More than 2 hours later	Total
Not at all earlier	20.4%	3.0%	8.9%	9.1%	5.5%	1.7%	0.9%	49.6%
Up to 5 minutes earlier	1.9%	2.0%	1.1%	0.7%	0.3%	0.1%	0.0%	6.2%
Up to 15 minutes earlier	5.1%	1.5%	3.8%	2.0%	1.2%	0.1%	0.1%	13.8%
Up to 30 minutes earlier	4.2%	0.4%	2.3%	4.2%	1.6%	0.6%	0.4%	13.7%
Up to 1 hour earlier	3.9%	0.2%	0.8%	0.8%	2.3%	1.2%	0.8%	10.1%
Up to 2 hours earlier	1.6%	0.0%	0.0%	0.2%	0.3%	0.8%	0.4%	3.4%
More than 2 hours earlier	0.9%	0.0%	0.3%	0.1%	0.5%	0.3%	1.2%	3.3%
Total	38.0%	7.2%	17.2%	17.3%	11.6%	4.8%	3.9%	100.0%

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Year 2010 Stated Preference Survey:

Change in Tripmaking (Trip Suppression / Inducement)

Peak Non-work Trip

Toll Difference	Travel Time Difference				
	0	-5	-10	-15	-20
$0.00	+0.0%	+1.2%	+2.4%	+3.6%	+4.7%
$2.00	-3.8%	-2.6%	-1.5%	-0.3%	+0.9%
$4.00	-7.6%	-6.5%	-5.3%	-4.1%	-2.9%
$6.00	-11.5%	-10.3%	-9.1%	-7.9%	-6.7%
$8.00	-15.3%	-14.1%	-12.9%	-11.7%	-10.6%
$10.00	-19.1%	-17.9%	-16.7%	-15.6%	-14.4%

(Negative = Suppression, Positive = Inducement)

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Model Replication: Time-of-Day Scenario Analysis Flow Chart

D/MC:	Destination/Mode Choice
TOD MNL:	Multi-Nominal Logit Time-of-Day Model Base Run with No Pricing
Price/User Fee MNL:	Multi-Nominal Logit Time Shift Model including Pricing
Priced TOD:	Time-of-Day Matrices With Pricing Impacts
Base TOD:	Base Time-of-Day Matrices Without Pricing Impacts
Shift	Shifted Trips Due to Pricing
Shift Adj.:	Adjusted Amount of Shifted Trips
Adj. Price TOD:	Adjusted Time-of-Day Matrices Before Trip Suppression
Positive Adj. Shift:	Shifted Trips not Subjected to Trip Suppression
TS (0.1):	Trip Suppression (Factor to be determined for each Origin-Destination Pair based on Trip Suppression Model)

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Prototype Test Results - Comparison of Diurnal and TOD Method

- Improvement of Volume / Count Match (RMSE Statistics)
  - AM Peak - 2.2%
  - Midday - Similar
  - PM Peak - 4.3%
  - Night - 4.8%

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Count Locations

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Comparison of Diurnal and TOD Method

Assignment Summary Statistics Using Diurnal Method

	Diurnal Method AM Peak	Diurnal Method Midday	Diurnal Method PM Peak	Diurnal Method Night
Assigned Voume	3,057,779	5,395,084	5,178,890	2,835,355
PeMS Count	2,786,527	4,986,036	3,773,837	3,798,655
Volume/Coutnt Ratio	1.10	1.08	1.37	0.75
No.of Observation	212	212	212	212
RMSE	4,327	7,717	9,749	7,231
RMSE Percentage	32.9	32.8	54.8	40.4

Assignment Summary Statistics Using Time-of-Day Method

	TOD AM Peak	TOD Midday	TOD PM Peak	TOD Night
Assigned Voume	3,026,009	5,686,552	5,141,613	4,045,604
PeMS Count	2,786,527	4,986,036	3,773,837	3,798,655
Volume/Coutnt Ratio	1.09	1.14	1.36	1.07
No.of Observation	212	212	212	212
RMSE	4,032	7,614	8,990	6,382
RMSE Percentage	30.7	32.4	50.5	35.6

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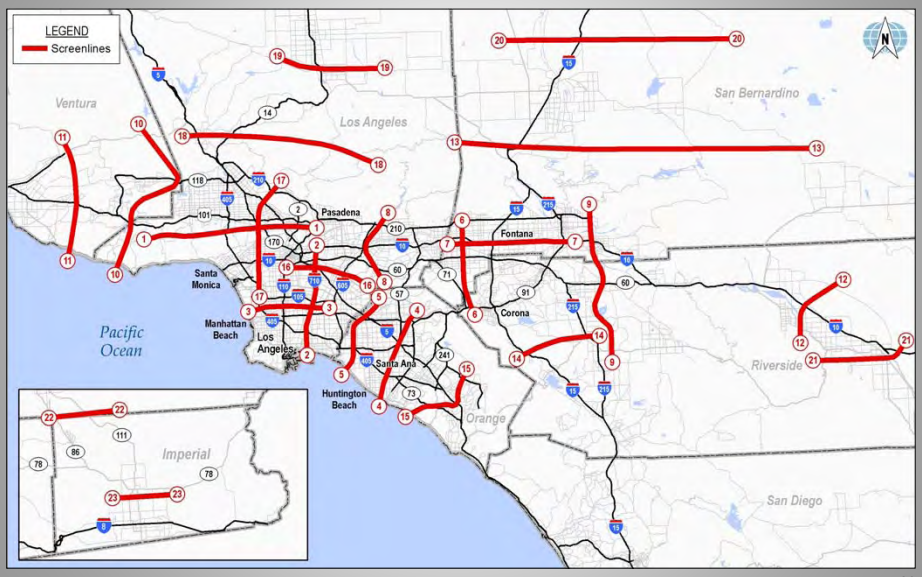
Regional Screenline Locations



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Prototype Tests Priced Cases

- VMT Charge $0.05 Per Mile, 3 Hour AM, 4 Hour PM Peak Periods
- Trip Table Effects
  - Reduction of 6.0 Percent in AM Peak Trip
  - Reduction of 5.8 Percent in PM Peak Trip
  - Increase of 5.0 Percent in Midday Trips
  - Increase of 7.3 Percent in Night Trips

Trip Table Effects
VMT Charges vs. No Toll
Pricing Assumptions - $0.05 Per Mile for AM and PM Peak Periods

	One-Way Trips by Time Period				
	AM Peak	PM Peak	Midday	Night	Daily
No-Toll	6,605,932	11,740,095	13,258,327	5,471,815	37,076,169
VMT Pricing	6,209,466	11,063,943	13,925,858	5,870,185	37,069,452
Difference	(396,466)	(676,152)	667,531	398,370	(6,717)
Difference Percentage	-6.0%	-5.8%	5.0%	7.3%	0.0%

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Prototype Tests Priced Cases (cont'd)

- VMT Charge $0.05 Per Mile, 3 Hour AM, 4 Hour PM Peak Periods
- Screenline Effects
  - Reduction of 6.2 Percent in AM Peak Trip
  - Reduction of 8.0 Percent in PM Peak Trip
  - Increase of 8.2 Percent in Midday Trips
  - Increase of 6.8 Percent in Night Trips

Screenline Comparison
VMT Charges vs. No Toll
Pricing Assumptions - $0.05 Per Mile for AM and PM Peak Periods

	Directional Screenline Volumes by Time Period				
	AM Peak	PM Peak	Midday	Night	Daily
No-Toll	3,492,010	6,744,495	6,663,342	3,800,802	20,700,649
VMT Pricing	3,275,283	6,203,378	7,207,711	4,057,612	20,743,984
Difference	(216,727)	(541,117)	544,369	256,810	43,335
Difference Percentage	-6.2%	-8.0%	8.2%	6.8%	0.2%

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Prototype Tests Priced Cases (cont'd)

- Regional Freeway Pricing
- Cordon Pricing
- Parking Pricing

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Summary of Prototype Tests

1. Use of TOD Improves Model Calibration / Validation Status
2. The Higher / Vaster Application of Pricing, the Higher Impacts in AM and PM Peak Trip Reduction
3. Targeted Cordon and Parking Pricing in Hypothetical Downtown LA Pricing:
   - Affected Trips About 2.0 Percent
   - Trip Reduction for AM and PM Peak From -1.0 to -0.3 Percent

Future Steps: Tests and Scenario Analysis With Integrated Model

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Changes to Traffic Assignment

- Pricing added as New Fields in Highway Network
  - Avoidable Pricing/Tolls
  - Unavoidable Pricing/Tolls (e.g. Cordon for Zones inside Area)
- Route Choice Diversion Routine
  - Embedded within Traffic Assignment
  - Path 1 = Minimizes Time + Distance
  - Path 2 = Minimizes Time + Distance (But Avoiding All Pricing/Tolls)
  - Path 3 = Minimizes Time + Distance (But for Zones Within a Cordon, Avoids Optional Pricing/Tolls Only)

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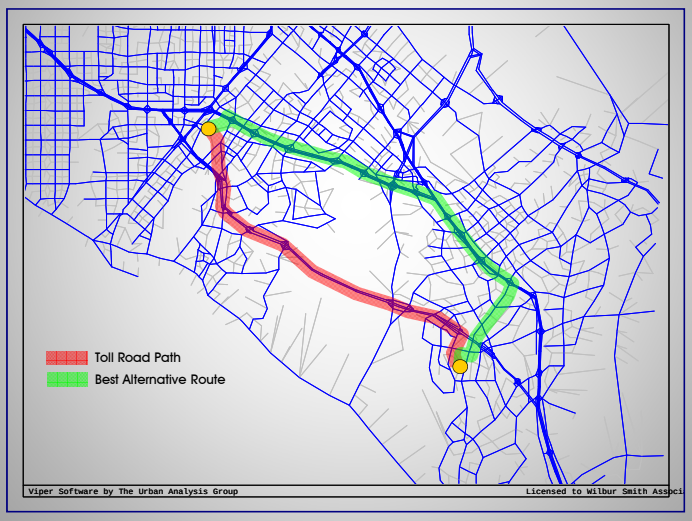
Typical Toll vs. non-toll Paths



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Changes to Traffic Assignment

- For Each O-D Pair:
  - Accumulates Time, Distance, Link-based Pricing
- Compares Generalized Costs in a Utility Function

  β_{time}*time + $\beta_{distance}$*distance + β_{price}*price / f(income)

  - Calculated for Path 1 and Path 2 or 3
- Logit Model - Calculates the Market Share of Drivers Willing to Choose the Priced Route vs. the Free Route and Assigns Each Component to the Corresponding Route
  - Estimated share of each total trip movement assigned to each path
- Iterates Within Assignment Routine

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Acknowledgement:
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Phone: 203-865-2191

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Appendix K: Presentation - SCAG Heavy-Duty Truck Model Development

Peer Review Meeting – June 28, 2011

SCAG HDT Model Development

Presented to:

Peer Review Panel Members

Presented by:

Arun Kuppam, Dan Beagan, Michael Fischer

June 28, 2011

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Transportation leadership you can trust.

SCAG HDT Model Development

Presented to:

Peer Review Panel Members

Presented by:

Arun Kuppam, Dan Beagan, Michael Fischer

June 28, 2011

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Transportation leadership you can trust.

Outline

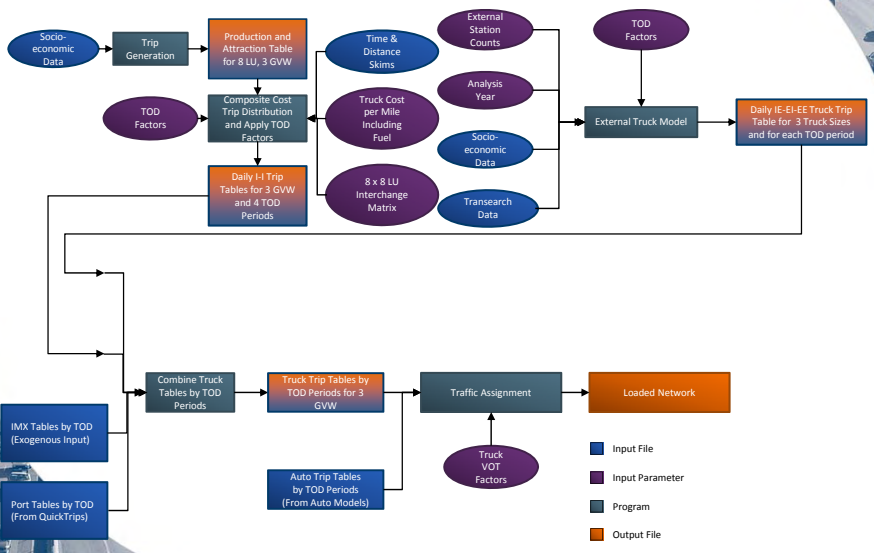
- HDT Model Structure
- External HDT Model
- Internal HDT Model
  - ✓ Trip generation model
  - ✓ Trip distribution model
- Port HDT Model
- Intermodal Terminal Trip Tables
- Secondary HDT Trips
- Time of Day Distribution
- Validation Databases
  - ✓ Screenline
  - ✓ Corridor
  - ✓ VMT
- Validation Summary of HDT model

2

HDT MODEL STRUCTURE

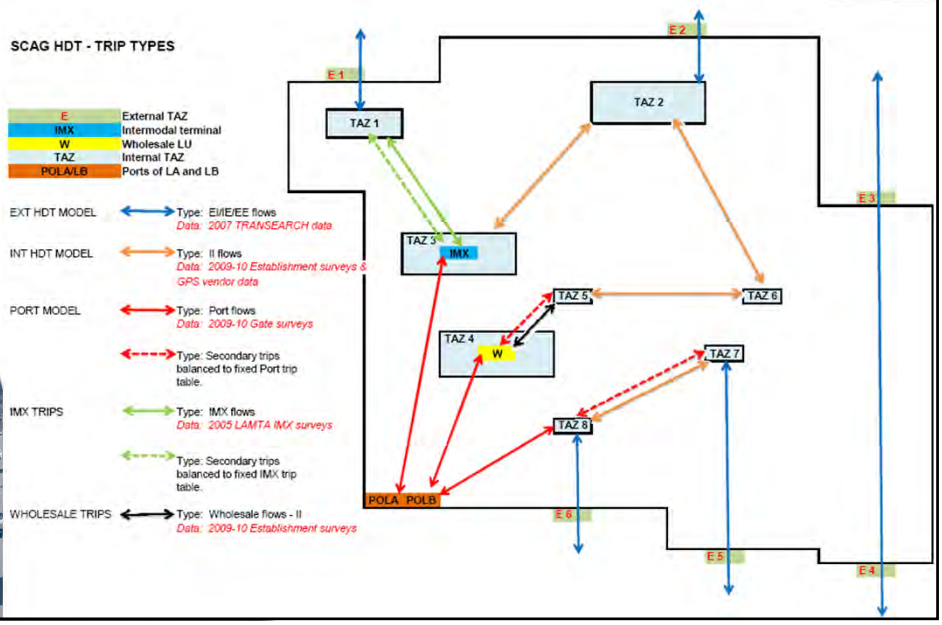
3

HDT Model Structure



4

HDT Trip Types



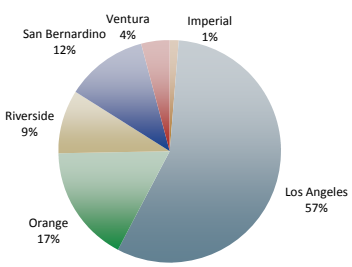
HDT Trip Type Summary

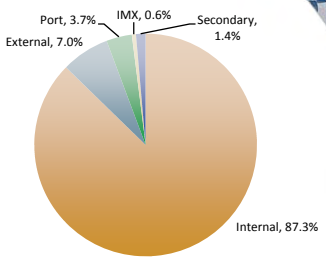
	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total	Percent
Internal	10,271	562,841	186,547	94,469	111,621	46,244	1,011,992	87.3%
External	4,816	38,794	6,815	11,183	18,140	1,271	81,020	7.0%
Port	25	37,060	2,499	855	2,752	165	43,356	3.7%
IMX	17	3,376	306	271	3,143	57	7,170	0.6%
Secondary	37	11,944	1,102	714	2,224	268	16,289	1.4%
Total	15,166	654,015	197,269	107,492	137,880	48,005	1,159,827	
Percent	1.3%	56.4%	17.0%	9.3%	11.9%	4.1%		

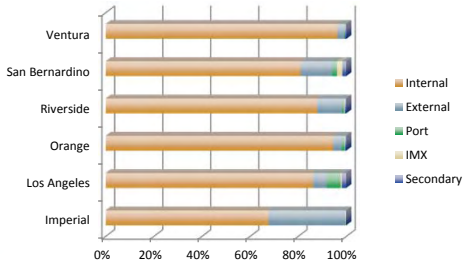
External-to-External through trips are not included here;
Trips connecting Ports, IMX and Secondary trips to external stations are not shown here.

6

HDT Trip Type Summary







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EXTERNAL HDT MODEL DEVELOPMENT

8

External HDT Model

- External truck trips based on Commodity Flow
- ITMS was used in HDT 2007---- TRANSEARCH is substitute
- TRANSEARCH OD flows in trucks per year converted to ITMS external geography.
  - ✓ Allows use of "external zone to SCAG external station" scripts written for HDT 2007
  - ✓ Functionally this meant expanding TS BEAs in CA to Counties in CA using shares from ITMS
  - ✓ Disaggregation of Commodity Flows for EI to SCAG Internal TAZs, and IE from SCAG Internal TAZs used HDT 2007 methods and 2008 data.
  - ✓ This meant 4 different disaggregations, two by direction and two commodity groupings, using TAZ employment.
- Through EE flows available in TS-- not previously available in ITMS
  - ✓ Combined EI and IE assignments to SCAG Externals to create EE allocations

9

External HDT Model

- Annual flows adjusted to Weekday flows based on Truck Counts at External Stations
- Only substantive change due to
  - ✓ change in proportion of
    - o trade partners/commodity/direction
  - ✓ in TRANSEARCH 2007 compared to ITMS
  - ✓ and use of 2008 Weekday Counts at External Stations
- TRANSEARCH used to develop forecast tables to replace ITMS growth factors

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External HDT Model Summary

Comparison of HDT Model Volumes and External Station Counts

External Station	TAZ	Location (County/Street)	Model			
			Count	Model	Diff	% Diff
1	4110	Ventura/U.S. 101	5,196	5,226	30	0.6%
5	4114	LA/I-5	9,422	9,261	(160)	-1.7%
8	4117	LA/Rt. 14	2,397	2,397	0	0.0%
12	4121	SB/Rt. 58	5,729	5,730	1	0.0%
13	4122	SB/U.S. 395	1,274	1,275	1	0.1%
19	4128	SB/I-15	8,519	8,433	(87)	-1.0%
21	4130	SB/U.S. 95 - Nevada Line	1,325	1,325	0	0.0%
22	4131	SB/Needles Hwy	1,353	1,353	(0)	0.0%
23	4132	SB/I-40	6,710	6,886	177	2.6%
26	4135	Riverside/I-10	9,760	9,612	(148)	-1.5%
27	4136	Imperial/I-8	2,439	2,408	(31)	-1.3%
29	4138	Imperial/Rt. 7	1,253	1,253	(0)	0.0%
30	4139	Imperial/Rt. 111	8,555	8,515	(40)	-0.5%
31	4140	Imperial/I-8 (San Diego)	1,962	1,878	(85)	-4.3%
36	4145	Riverside/I-15	8,867	8,724	(143)	-1.6%
40	4149	Orange/I-5	11,482	11,559	78	0.7%
		Total (key external stations)	**86,244**	**85,837**	**(407)**	**-0.5%**

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INTERNAL HDT MODEL DEVELOPMENT

12

Internal HDT Model
Trip generation model

Eight industry sectors

- Households
- Agriculture / Mining / Construction
- Retail
- Government
- Manufacturing
- Transportation / Utility
- Wholesale
- Other (service)

Three Gross Vehicle Ratings (GVW) HDT

- Light HDT (8,501 to 14,000 lbs)
- Medium HDT (14,001 to 33,000 lbs)
- Heavy HDT (33,000 + lbs)

13

Internal HDT Model
Trip generation model

Confidence Intervals of Trip Rates at 90 percent

		Mean				90 Percent CI		Percent Difference of CI Limits from Mean	
Industry Sector	Truck Type	Statistic	Standard Error	Standard Deviation	Variance	Lower Limit	Upper Limit	Lower Limit	Upper Limit
AG/MINE /CONS	LHDT	0.0846	0.013	0.286	0.082	0.064	0.105	-24%	24%
	MHDT	0.0819	0.011	0.258	0.066	0.063	0.101	-23%	23%
	HHDT	0.0735	0.008	0.189	0.036	0.060	0.087	-19%	19%
MFG	LHDT	0.0645	0.005	0.114	0.013	0.056	0.073	-13%	13%
	MHDT	0.0689	0.006	0.132	0.017	0.059	0.078	-14%	14%
	HHDT	0.0973	0.021	0.490	0.240	0.062	0.133	-36%	36%
RETAIL	LHDT	0.0698	0.006	0.132	0.018	0.060	0.079	-14%	14%
	MHDT	0.0697	0.005	0.125	0.016	0.061	0.079	-13%	13%
	HHDT	0.0740	0.007	0.168	0.028	0.062	0.086	-16%	16%
UT/TRAN / WHS	LHDT	0.1666	0.020	0.454	0.206	0.134	0.199	-20%	20%
	MHDT	0.1915	0.019	0.425	0.181	0.161	0.222	-16%	16%
	HHDT	0.3375	0.039	0.892	0.796	0.273	0.402	-19%	19%
WHOLESALE	LHDT	0.0964	0.008	0.193	0.037	0.082	0.110	-14%	14%
	MHDT	0.1019	0.008	0.192	0.037	0.088	0.116	-14%	14%
	HHDT	0.1385	0.014	0.320	0.103	0.115	0.162	-17%	17%

CI limits are within +/- 20 percent for most trip rates

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Internal HDT Model
Trip generation model

Employment-based HDT trip generation model

Industry Sector	LHDT	MHDT	HHDT	Source	Notes
Households	0.0147	0.0046	0.0072	GPS Data	Used trip rates directly as estimated with **no changes**
Governments	0.0296	0.0150	0.0148		
Other (service)	0.0095	0.0111	0.0151		
Ag/Mining/Const	0.0804	0.0778	0.0715	Establishment Surveys	Calibrated trip rates that are **92 percent of mean rates** but within 90 percent confidence intervals
Retail	0.0663	0.0662	0.0703		
Manufacturing	0.0613	0.0655	0.0924		
Transportation/Utility	0.1583	0.1819	0.3206		
Wholesale	0.0916	0.0968	0.1316		

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Internal HDT Trip Generation Model Summary

Productions equal to Attractions

Land Use	Light HDT Trip Ends	Medium HDT Trip Ends	Heavy HDT Trip Ends	Total Trip Ends	Percent of Total Trip Ends
Households	83,381	26,124	41,137	150,641	15%
Ag/Mining/Const	39,090	37,842	34,793	111,725	11%
Retail	55,618	55,538	58,964	170,120	17%
Governments	7,345	3,736	3,673	14,754	1%
Manufacturing	46,697	49,883	70,444	167,024	17%
Transportation/ Utility	57,035	65,560	115,543	238,138	24%
Wholesale	36,426	38,504	73,640	148,570	15%
Other	2,937	3,421	4,662	11,020	1%
Total	328,529	280,608	402,856	1,011,992	

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Internal HDT Model
Trip distribution model

- Conventional gravity model calculates all truck trips between zones i and j
  - ✓ Based on Productions in i, Attractions in j and Friction Factor (FF) between zones i and j
- Interchange gravity model calculates truck trips from the lane use in i to the land use in j
  - ✓ Based on Productions in i, Attractions in j and Friction Factor (FF) between zones i and j; and
  - Based on the percentage those land uses have of total productions or attractions for that exchange

$$T_{ilu_m jlu_n} = PctP_{lu_m lu_n} * P_{ilu_n} * \frac{PctA_{lu_n lu_m} * A_{jlu_n} * FF_{ij}}{\sum_j PctA_{lu_n lu_m} * A_{jlu_n} * FF_{ij}}$$

Internal HDT Model
Trip distribution model

- Friction Factors established as composite of time and costs
  - ✓ Time and distance skims, TAZ to TAZ, obtained from model
  - ✓ GPS surveys used to develop observed trip tables of LHDT/MHDT (Trimble) and HHDT (ATRI)
  - ✓ Coefficients for distance based costs ,and time based costs, determined from literature review, and applied to time and distance skims
  - ✓ Friction Factor curve developed from composite costs table and observed OD trips
- In application, distance/time skims used with coefficients to develop composite cost table.
- Frictions factors between TAZs calculated by applying those composite costs to the friction factor "curve".
- Fuel is included in cost as mileage times fuel cost times distance.
  - ✓ Varying the price of fuel will vary the distribution of truck trips.

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Internal HDT Model
Trip distribution model

Use of LU-to-LU exchanges to preclude illogical exchanges

- Trimble data for LHDT & MHDT

Destination Land Uses	Origin Land Uses: Households	Agriculture, Mining, and Construction	Retail	Government	Manufacturing	Transport/Utilities	Wholesale	Other (service)	Total
Households	52,576	2,930	29,957	975	14,746	4,449	2,452	15,398	**123,483**
Agriculture, Mining, and Construction	2,857	3,144	3,505	177	2,659	1,325	605	2,481	**16,753**
Retail	27,801	3,451	56,415	1,789	21,247	7,214	5,772	20,131	**143,820**
Government	882	191	1,847	1,199	1,057	1,132	197	1,448	**7,953**
Manufacturing	14,962	2,666	20,285	1,082	29,551	8,267	7,471	11,952	**96,236**
Transportation and Utilities	5,143	1,531	8,129	1,172	8,981	8,729	2,700	4,941	**41,326**
Wholesale	2,426	633	6,086	191	7,589	2,624	4,611	2,308	**26,468**
Other	14,539	2,374	19,378	1,561	11,696	4,424	2,415	18,399	**74,786**
Total	**121,186**	**16,920**	**145,602**	**8,146**	**97,526**	**38,164**	**26,223**	**77,058**	**530,825**

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Internal HDT Model
Trip distribution model

Use of LU-to-LU exchanges to preclude illogical exchanges

- ATRI Data for HHDT

Destination Land Uses	Origin Land Uses: Households	Agriculture, Mining, and Construction	Retail	Government	Manufacturing	Transport/Utilities	Wholesale	Other	Total
Households	25,199	5,172	7,040	1,365	17,145	12,261	8,324	29,384	**105,890**
Agriculture, Mining, and Construction	5,302	3,701	1,719	446	4,417	4,467	2,316	9,585	**31,953**
Retail	7,025	1,884	3,410	465	6,569	4,211	3,172	10,923	**37,659**
Government	1,389	375	372	608	655	668	354	2,379	**6,800**
Manufacturing	17,915	4,495	6,939	737	21,590	15,646	9,647	26,645	**103,614**
Transportation and Utilities	12,144	4,069	3,965	727	15,578	12,200	8,100	20,809	**77,592**
Wholesale	8,855	2,599	3,397	394	9,623	7,795	8,095	13,508	**54,266**
Other	26,901	9,523	9,532	1,974	23,141	19,361	11,699	53,271	**155,402**
Total	**104,730**	**31,818**	**36,374**	**6,716**	**98,718**	**76,609**	**51,707**	**166,504**	**573,176**

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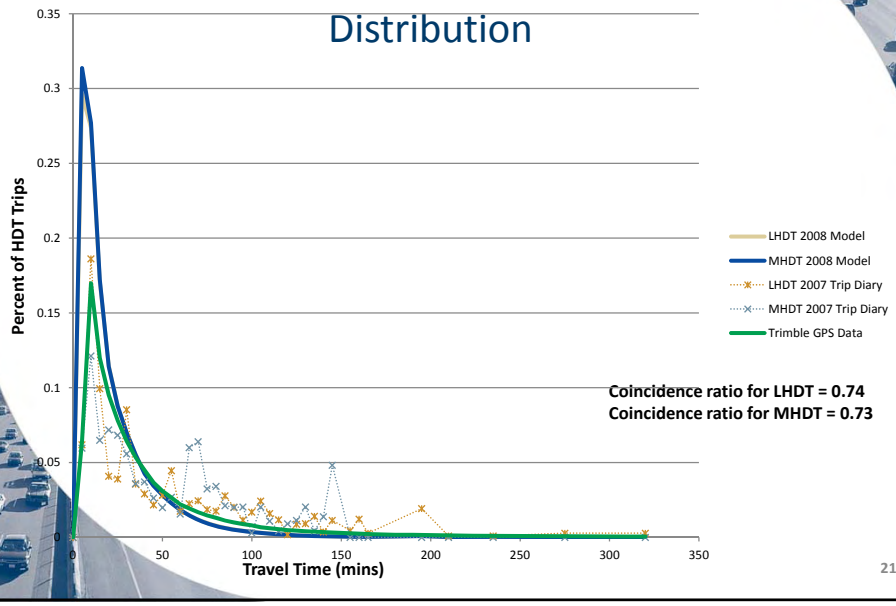
Internal HDT Trip Distribution

LHDT & MHDT Trip Length Frequency Distribution



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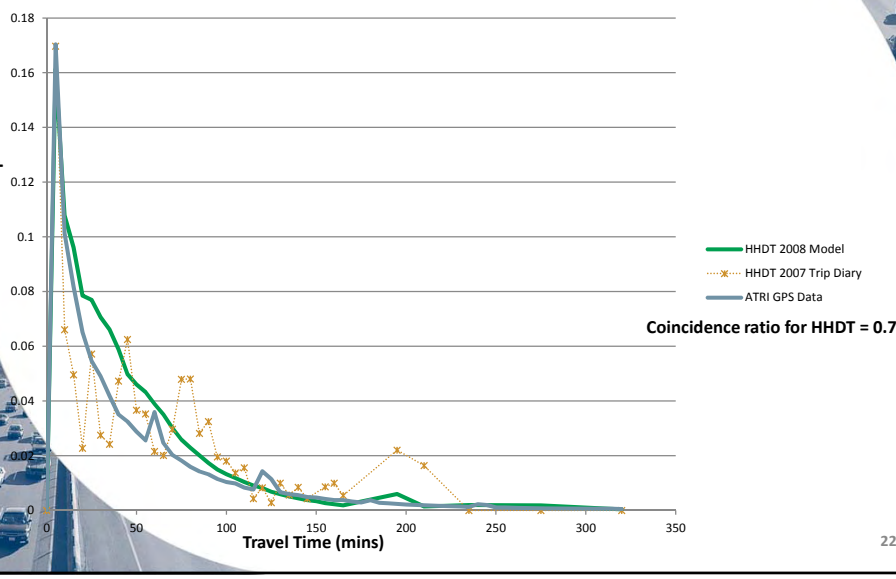
Internal HDT Trip Distribution

HHDT Trip Length Frequency Distribution



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PORT HDT MODEL DEVELOPMENT

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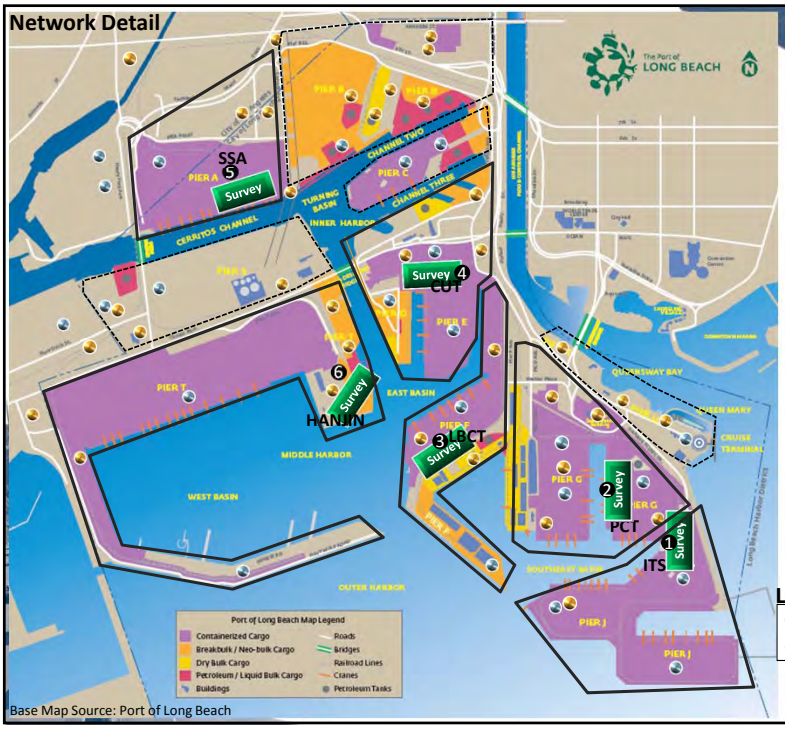
Network Detail



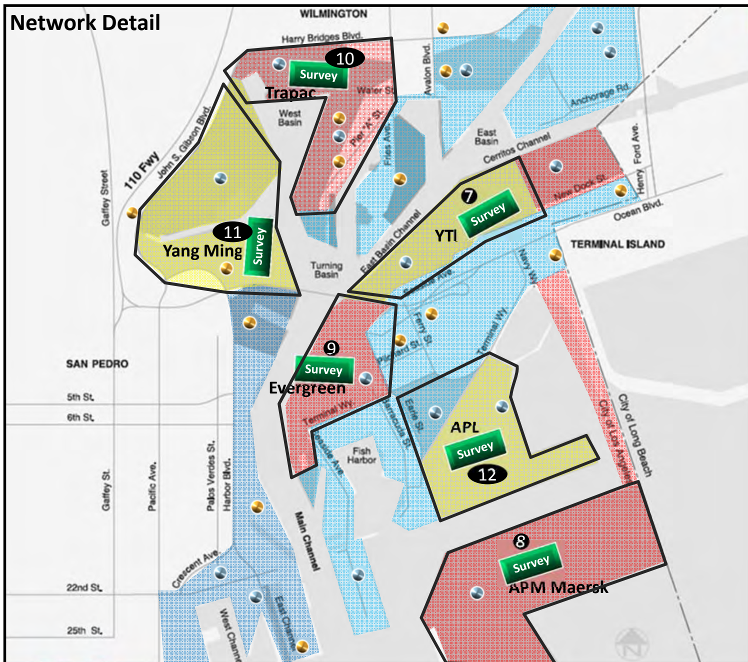
Base Map Source: Port of Long Beach

Port Of Long Beach

LEGEND

- SCAG RTP Zones
- Port TAM Zones

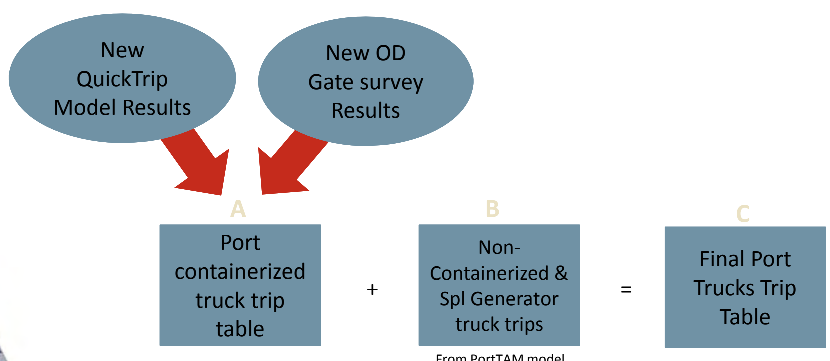
Network Detail



Port Of Los Angeles

LEGEND
- SCAG RTP Zones
- Port TAM Zones

Ports Modeling Process



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Port Truck Types

1. Bobtails (containerized trucks)

2. Chassis (containerized trucks)

3. Empty & Loaded Containers (containerized trucks)

4. Non-containerized trucks

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Quick trip model

- Multiple spreadsheets versus single spreadsheet
- Forecasts trip generation for each terminal separately or for all terminals at one shot.
- Reports Trip Gen and model results at
  - Each terminal separately
  - Each off-dock yard separately
  - All terminals together
  - Any combination

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New QuickTrip Model

Follow below three steps to run the QuickTrip model

QuickTrip Model

STEP-1 *Input Terminal assumptions in "Model Inputs1" and "Model Inputs2" worksheets*

STEP-2 *Press ModelRun buttons in "RunModel" worksheet*

STEP-3 *Examine model results in the outputs worksheets named;*

ResultsSummary
All terminals results
POLA terminals results
POLB terminals results
Pier GJ (ITS) results
Pier J South (PCT) results
Pier F (LBCT) results
Pier DE (CUT) results
Pier A (SSA) results
Pier T (HANJIN) results
Pier C results
Pier B results
Pier S results
TI East (YTI) results
Pier 400 (APM) results
TI West (Evergreen) results
Trapac results
Yang Ming results
Pier 300 (APL) results

DRAFT version

About | HowToRunTheModel | Model Inputs1 | Model Inputs2 | RunModel | ResultsSummary | Lookup

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New QuickTrip Model

Stage1 Inputs

		Terminal														
		Pier GJ (ITS)	Pier J South (PCT)	Pier F (LBCT)	Pier DE (CUT)	Pier A (SSA)	Pier T (HANJIN)	Pier C	Pier B	Pier S	TI East (YTI)	Pier 400 (APM)	TI West (Evergreen)	Trapac	Yang Ming	Pier 300 (APL)
6	Enter Railyard Area, (Acres)															
7	Enter Dynamic Capacity of Railyard (1=low 2=high)															
8	Enter Ratio (Average TEU/Container)	1.74	1.79	1.88	1.83	1.71	1.83	1.94	1.94	1.94	1.72	1.83	1.82	1.83	1.75	1.77
	Calculated Net Container Storage Area, (Acres)															
9	Enter Peak Monthly Throughput, in TEU's, If Known	75,844	96,937	67,916	32,532	86,524	162,625	28,274	0	0	93,317	177,117	115,816	63,506	88,808	114,956
10	*Enter Throughput Distribution & Dwell (Over the Dock)*															
10a	Loaded Local Imports	17.7%	19.0%	16.5%	22.7%	22.0%	20.6%	6.1%	6.1%	6.1%	23.3%	20.6%	19.1%	18.5%	25.7%	20.9%
10b	Loaded Local Exports	17.1%	14.6%	19.4%	20.4%	18.3%	5.4%	39.2%	39.2%	39.2%	15.7%	13.6%	2.9%	9.6%	8.7%	16.6%
10c	Empties	24.0%	25.3%	22.9%	15.7%	18.5%	32.8%	13.5%	13.5%	13.5%	17.9%	22.7%	34.0%	28.9%	22.6%	19.5%
10d	Loaded Transhipment	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
10e	Loaded Intermodal Imports - On Dock	17.2%	14.9%	15.5%	0.0%	23.5%	18.4%	0.0%	0.0%	0.0%	22.3%	14.1%	14.9%	0.0%	18.6%	27.6%
10f	Loaded Intermodal Imports - Off Dock	13.1%	15.6%	14.8%	29.7%	6.1%	11.7%	29.7%	29.7%	29.7%	9.0%	17.9%	17.7%	32.3%	13.0%	3.1%
10g	Loaded Intermodal Exports - On Dock	7.1%	6.2%	6.4%	0.0%	9.7%	7.6%	0.0%	0.0%	0.0%	9.2%	5.8%	6.2%	0.0%	7.7%	11.4%
10h	Loaded Intermodal Exports - Off Dock	3.8%	4.6%	4.4%	11.5%	1.8%	3.4%	11.5%	11.5%	11.5%	2.6%	5.3%	5.2%	10.8%	3.8%	0.9%
	Dwell Check (Total = 100%)	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
11	*Enter Gate Data*															
11a	Number of WeekDays Per Week Gate Will Be Open	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
11b	Allocation of Gate Traffic By Shift — Day	72%	70%	72%	76%	67%	68%	60%	60%	60%	63%	63%	63%	63%	63%	63%
	2nd	28%	30%	28%	24%	33%	32%	40%	40%	40%	37%	37%	37%	37%	37%	37%
	Hoot	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
12	*Variable Factors*	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
12a	Percent of Import/Export (Landside) Box Re-Use	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
12b	Percent of Intermodal (Landside) Chassis Re-Use	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
12c	Peak Week / Average Week Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12d	Percent Double Cycle Trucks	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%	45%
12e	Percentage of Weekly Gate Traffic Allocated to Weekend	11%	10%	11%	17%	9%	11%	13%	13%	13%	8%	8%	8%	8%	8%	8%
12f	Use Day Peaking Factor? (1=Yes, 2=No)	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
12g	Local Empty Loss Factor	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
12h	Intermodal Empty Loss Factor	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%	49%
12i	On-Dock W/B Empty Movement Factor	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
	Year 2008 EI model run data was used for base year	1 POLB	2 POLB	3 POLB	4 POLB	5 POLB	6 POLB	7 POLB	8 POLB	9 POLB	10 POLA	11 POLA	12 POLA	13 POLA	14 POLA	15 POLA

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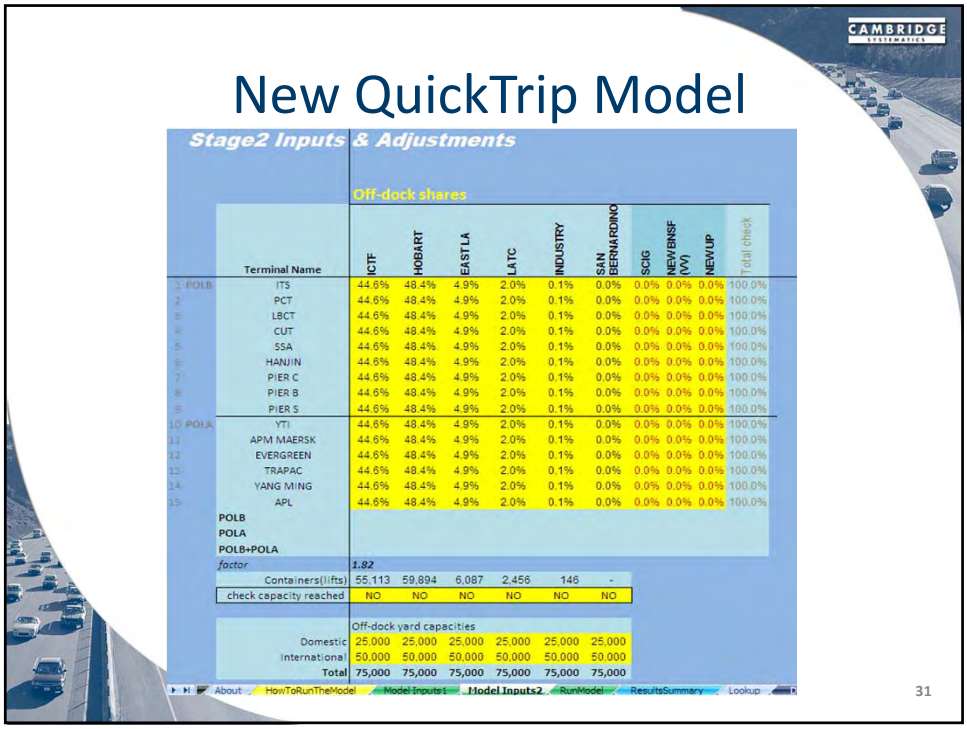
New QuickTrip Model



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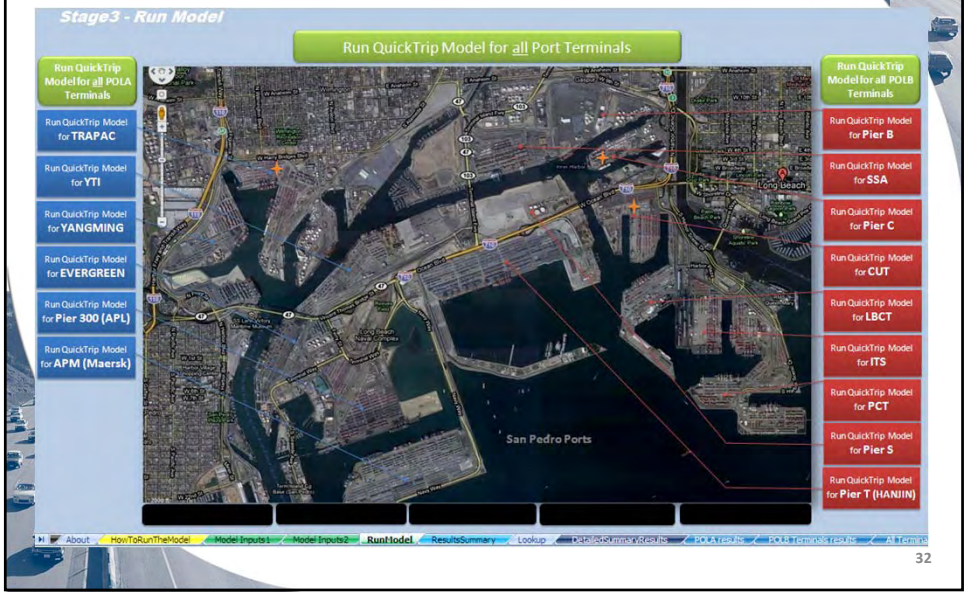
New Quick Trip Model



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New QuickTrip Model Output Example

Pier 400 (APM) results

MODEL RESULTS	THIS DATA CALCULATED FOR "KNOWN THROUGHPUT" ONLY									
4 Per Day Traffic Dist	Bobtails		Chassis		Loads		Empties		Total	
% of Truck Tr	35.5%		13.6%		30.3%		20.6%		100.0%	
Hour of the D	Arr.	Dep.	Arr.	Dep.	Arr.	Dep.	Arr.	Dep.	Arr.	Dep.
	36.1%	34.9%	16.2%	10.9%	19.9%	40.7%	27.3%	13.9%	99.5%	100.5%
12AM - 1AI	43	56	19	17	24	65	33	22	119	161
1 - 2 AM	41	43	18	14	23	50	31	17	113	124
2 - 3 AM	39	56	17	17	22	65	30	22	108	161
3 - 4 AM	0	52	0	16	0	61	0	21	0	150
4 - 5 AM	0	7	0	2	0	8	0	3	0	20
5 - 6 AM	0	0	0	0	0	0	0	0	0	0
6 - 7 AM	0	0	0	0	0	0	0	0	0	0
7 - 8 AM	36	0	16	0	20	0	27	0	100	0
8 - 9 AM	100	68	45	21	55	79	76	27	276	196
9 - 10 AM	113	102	51	32	63	119	86	41	313	293
10 - 11 AM	118	102	53	32	65	120	89	41	325	295
11 - Noon	85	116	38	36	47	136	64	46	234	335
Noon - 1 PI	63	70	28	22	35	82	48	28	173	201
1 - 2 PM	105	72	47	23	58	84	80	29	291	207
2 - 3 PM	116	111	52	35	64	129	88	44	320	319
3 - 4 PM	86	102	39	32	47	119	65	41	237	294
4 - 5 PM	63	75	28	23	35	87	48	30	173	215
5 - 6 PM	66	58	30	18	37	68	50	23	182	167
6 - 7 PM	64	57	29	18	35	66	48	23	176	163
7 - 8 PM	62	46	28	14	34	54	47	18	171	132
8 - 9 PM	58	53	26	17	32	62	44	21	159	153
9 - 10 PM	54	46	24	14	30	54	41	18	148	132
10 - 11 PM	48	29	22	9	27	34	37	12	133	83
11PM - 12A	45	39	20	12	25	45	34	16	125	112
r Day Tota	1,406	1,359	630	426	777	1,587	1,064	543	3,877	3,915
	2,765		1,057		2,364		1,607		7,793	

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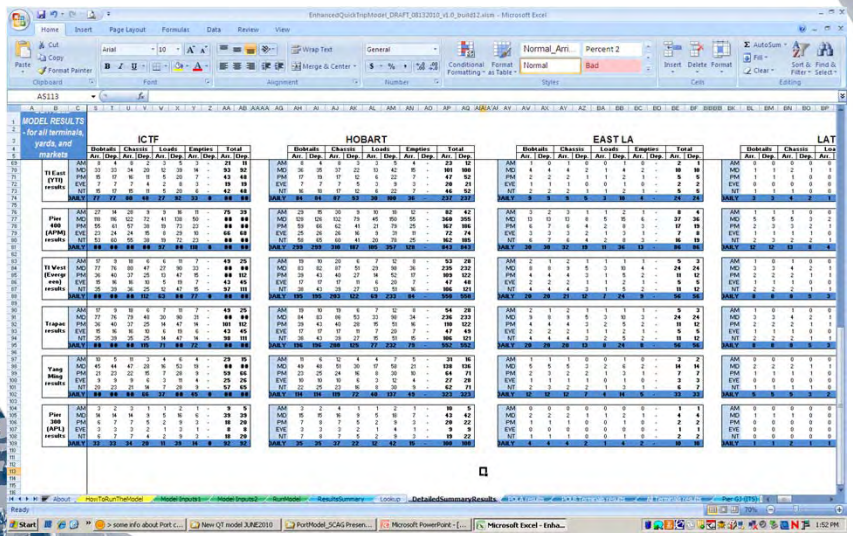
Detailed Results



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QuickTrip Models Comparison

		Previous QuickTrip model	New (Enhanced) QuickTrip model
Files		Multiple spreadsheets (one for each terminal)	One spreadsheet (for all terminals)
Market segments	Local	Generates as one component	Same
	On-dock	Generates as one component	Same
	Off-dock	Generates as one component	Generates trips for each off-dock yard separately (trip distribution for each off-dock yard is one of the inputs to the model)
Time of day		Trips are generated for each hour of the day	Same
Vehicle classes		Bobtails, chassis, Empties, and Loaded	Same
Output summary		Summaries for each terminal	More detailed summaries
Ease of use		Needs multiple files and lot of file management	Easy to use (all in one spreadsheet file)

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New Terminal Gate OD Surveys

- 23,030 surveys were distributed at 12 marine terminal gates with 3,559 returned
- 2,981 origin trips and 2,593 destination trips were fully completed and geo-coded for a total of 5,574 trips

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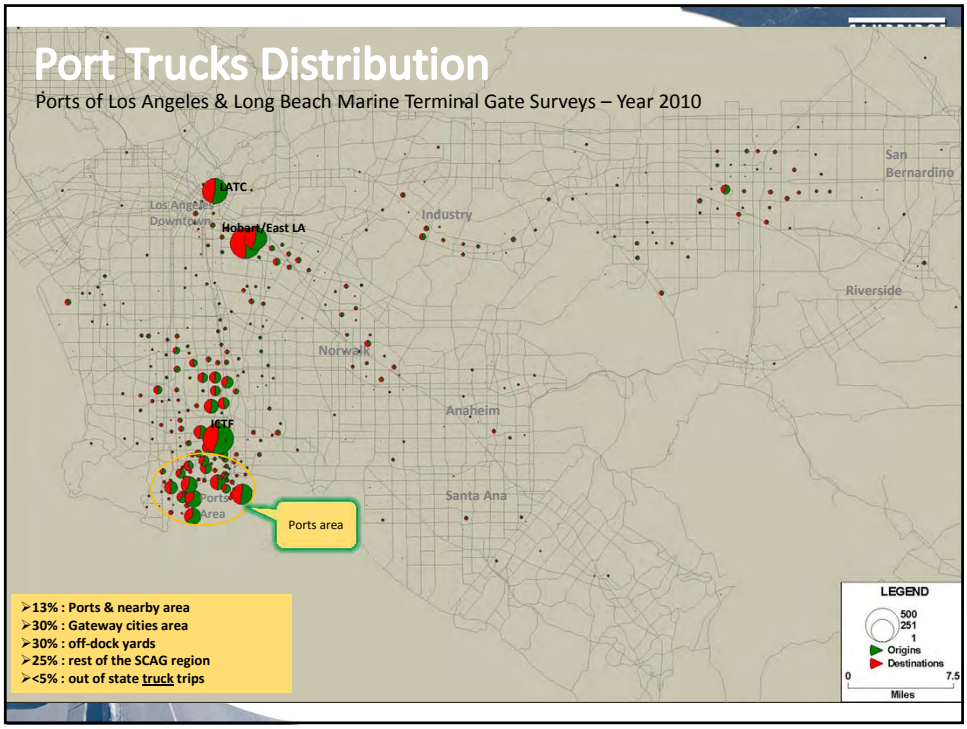
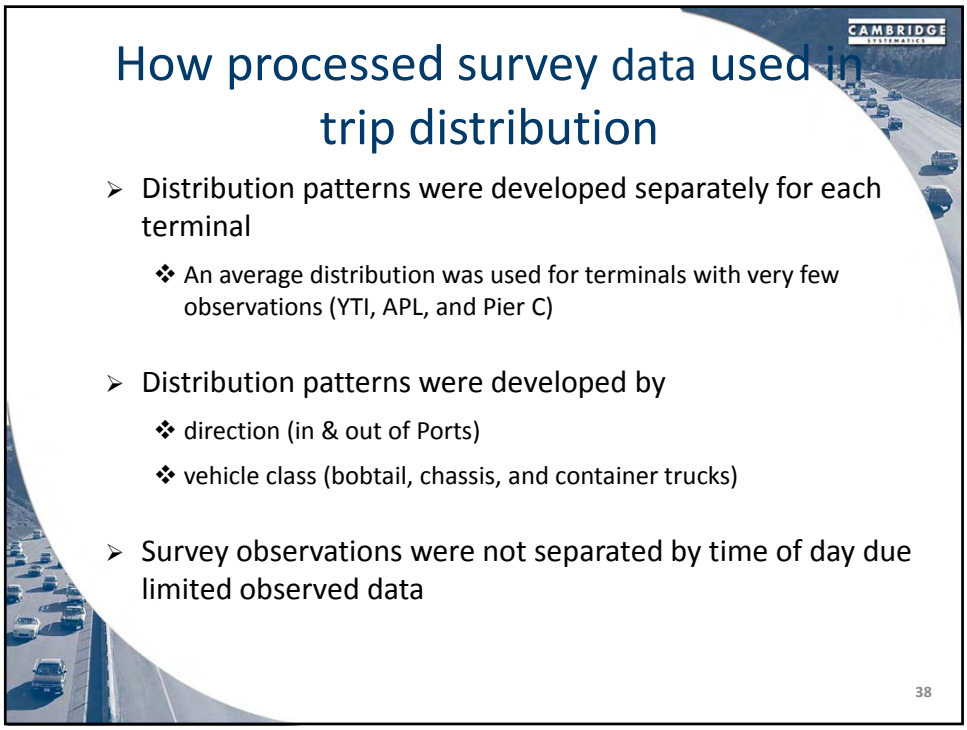

Port Trucks Distribution
Ports of Los Angeles & Long Beach Marine Terminal Gate Surveys – Year 2010
LATC
Hobart/East LA
Industry
San Bernardino
Riverside
Norwalk
Anaheim
Santa Ana
Ports area
Ports area
➢13% : Ports & nearby area
➢30% : Gateway cities area
➢30% : off-dock yards
➢25% : rest of the SCAG region
➢<5% : out of state truck trips
LEGEND
500
251
1
Origins
Destinations
0
7.5
Miles


How processed survey data used in trip distribution
➢ Distribution patterns were developed separately for each terminal
❖ An average distribution was used for terminals with very few observations (YTI, APL, and Pier C)
➢ Distribution patterns were developed by
❖ direction (in & out of Ports)
❖ vehicle class (bobtail, chassis, and container trucks)
➢ Survey observations were not separated by time of day due limited observed data
38

Cont……

- Survey distribution was used for;
  - Terminals to/from nonport and rest of the SCAG region zones
  - Inter-terminal trips
- Survey results were not used for off-dock yard distribution
  - Distribution assumptions from New QuickTrip model were used

39

Summary of Port Trip Tables

	Port Truck Trips	County Percent
Imperial	**25**	**0%**
Los Angeles	**37,060**	**77%**
Orange	**2,499**	**5%**
Riverside	**855**	**2%**
San Bernardino	**2,752**	**6%**
Ventura	**165**	**0%**
External Stations	**309**	**1%**
Total	**43,665**	
Inter-terminal trips	**4,518**	**9%**
TOTAL	**48,183**	

40

DOMESTIC INTERMODAL (IMX) HDT TRIP TABLE DEVELOPMENT

41

Domestic IMX Trip Tables

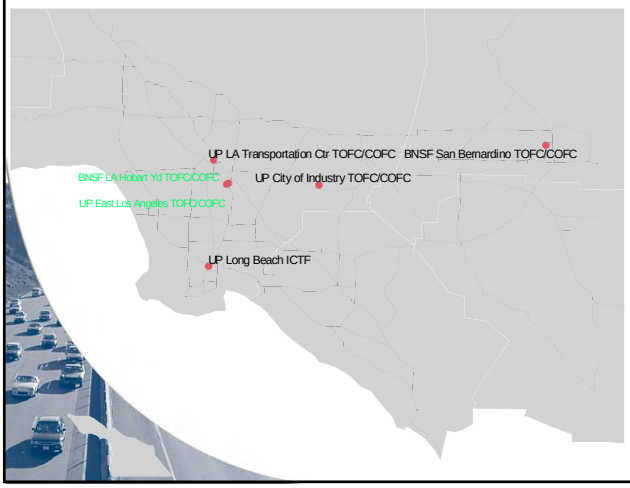
What are these and where do they fit within HDT model?

- HDT Trips to and from Intermodal Rail terminals
  - ✓ Generated by domestic intermodal movements
  - ✓ Off-dock intermodal trips are generated by the Port model
- Added as special generator truck trip table (same process as Port trip tables)
- Estimates of daily truck to/from SCAG TAZs

42

Domestic IMX Trip Tables

What and where are the different IMX Terminals in the region?



BNSF Hobart
BNSF San Bernardino
UP City of Industry
UP East LA
UP ICTF
UP LATC

43

Domestic IMX Trip Tables

Data sources used – 2005 LA Metro IMX survey

Inbound LTL Intermodal (Rail Terminal to Regional LTL Terminal)							
Zip Code	BNSF Hobart	BNSF San Bernardino	UP City of Industry	UP East LA	UP ICTF	UP LATC	Total
90023	1,032	-	73	68	1	18	1,993
90031	13,028	-	916	854	14	231	25,169
90040	16,485	2,621	1,159	1,081	18	293	31,847
90061	767	-	54	50	1	14	1,482
90220	4,275	-	301	280	5	76	8,260
90222	761	-	53	50	1	14	1,470
90241	795	-	56	52	1	14	1,536
90247	8,663	-	609	568	9	154	16,737
90248	7,330	-	515	480	8	130	14,161
90638	3,372	-	237	221	4	60	6,514
90640	4,343	2,621	305	285	5	77	8,390
90660	17,753	2,621	1,248	1,164	19	315	34,298
90670	11,936	5,241	839	782	13	212	23,058

Similarly, Outbound LTL, Inbound and Outbound TL annual tonnage flows were used to develop an IMX HHDT trip table

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Domestic IMX Trip Tables

Creation of IMX Tables

- Zip code level data allocated to TAZs based on employment distribution
- Annual truck trips converted to daily truck trips; all IMX truck trips are considered to be HHDT
- LTL inbound and outbound, and TL inbound and outbound are combined to form IMX trip tables
- Truck trips were inserted in addition to those estimated by the Internal-Internal Wholesale HHDT trips
- Trips were not added to cells with Port TAZs as these trips between Port TAZs and IMX TAZs are from Port model

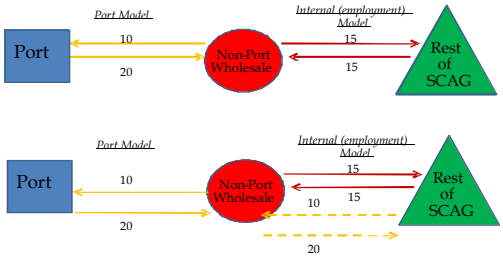
45

SECONDARY HDT TRIPS

46

Secondary HDT Trip Ends

- Port trips to Internal TAZs that have Wholesale Ps or As are added onto Wholesale Ps and As
- IMX trips to Internal TAZs that have Wholesale Ps or As are added onto Wholesale Ps and As
- New Wholesale Ps or As (inclusive of "secondary" HDT trips) = Wholesale Ps or As (from Internal HDT trip generation model) + Port trips + IMX trips



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Port and Intermodal Secondary Trip Balancing

- Port and intermodal trips tables
  - Truck trips to/from port(terminal) TAZs
  - Truck trips to/from non port(terminal) TAZs
- For non-port(terminals zones)
  - Internal Model Ps and As supplemented by As and Ps from port(terminal) trip table prior to Trip Distribution

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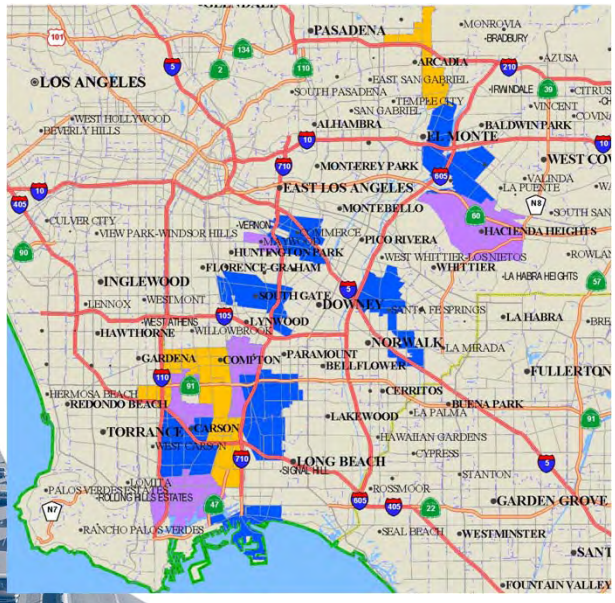
Intermediate stops (from CSULB data)



I. Most locations are near Ports and along I-710 corridor

II. Almost all locations are in Gateway cities

III. Useful in identifying intermediate stops where secondary trips are produced

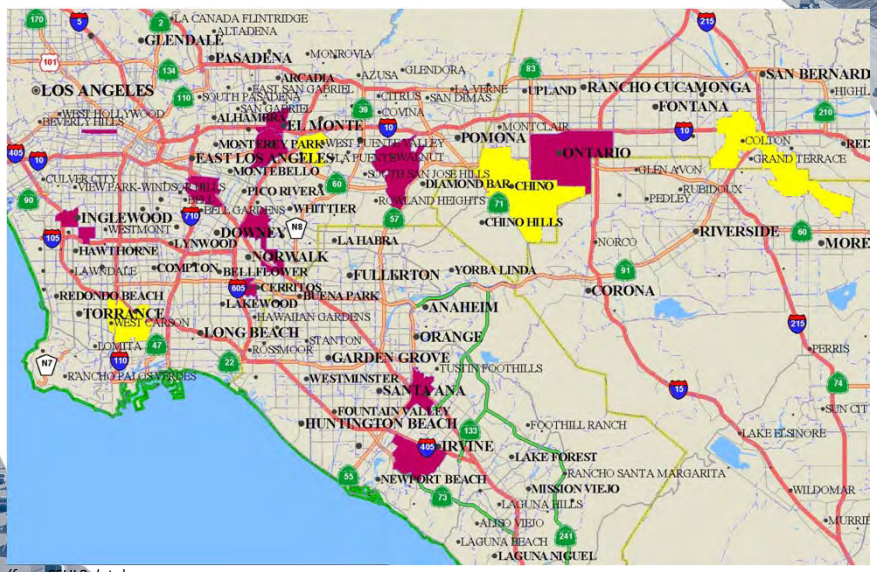
IV. Useful for model validation

V. Other stop reported is at warehouse / distribution center in Inland Empire

Purple = LMC Transload stops
Blue = LMC Warehouse stops
Orange = 3PL intermediate stops

49

Largest facilities in the Region by Shipper Type



(from CSULB data)

Red = Distributors
Yellow = Manufacturing

50

Secondary Trip Table Summary

Secondary HHDT trips resulting from Ports and IMX Terminals are added to Internal Wholesale HHDT Productions and Attractions

Truck Type/PA	Internal HDT	Port Model HHDT	IMX HHDT Trips	Total Wholesale HHDT
Wholesale LHDT P	35,129			
Wholesale LHDT A	35,129		N/A	
Wholesale MHDT P	37,133			
Wholesale MHDT A	37,133			
Wholesale HHDT P	50,470	12,885	3,405	66,760
Wholesale HHDT A	50,470	12,254	3,570	66,294

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TIME OF DAY

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Time of Day Distribution

- Classification Count Stations from Caltrans
  - ✓ Data from 24-hour continuous count classification stations used to derive weekday TOD factors
- Data from counts stored as FHWA Scheme F classifications as follows
  - ✓LHDT = FHWA Class 5
  - ✓MHDT = FHWA Class 6 and 8
  - ✓HHDT = FHWA Class 7 and 9 through 13
- Source of assignment by GVW is EPA Guidance

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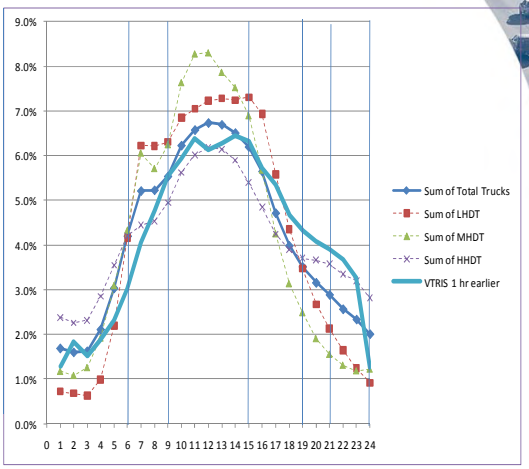
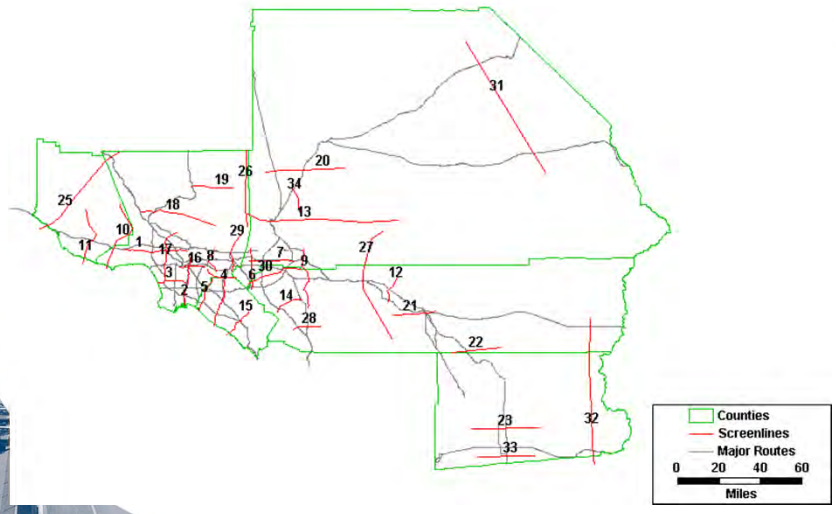
Time of Day Distribution Summary

- Trucks in SCAG region peak one hour earlier than the national average for trucks
- In addition, compared to national truck TOD
  - ✓ LHDT and MHDT trucks shifted from
    PM
    to
    AM & MD
  - ✓ HHDT trucks shifted from
    AM, MD, PM
    to
    EV, NT



54

VALIDATION



55

Validation Data

- Screenlines Validation
  - ✓Freeways / state highways) – 2010 Wiltec (adjusted), 2008 Caltrans
  - ✓Arterials – 2008 LSA counts
- Corridor Validation
  - ✓Data Sources – 2010 Wiltec (adjusted to 2008), 2008 Caltrans
  - ✓Count VMT = Section Length * AWDT on links with Counts
  - ✓Model VMT = Section Length * HDT Volume (on all links that make the section)
  - ✓Major freight corridors – I-10, I-5, SR-91, I-15, I-710, SR-60
- VMT Validation – Data derived by SCAG from Caltrans' HPMS samples and Classification counts

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Screenline Validation Summary

Screenline	2008 Counts	2008 HDT Model Flows	Difference		NCHRP Report 255	Target in MDP
2	170,610	189,663	19,053	11%	18-25%	25%
17	127,602	131,181	3,578	3%	18-25%	25%
4	115,399	105,958	-9,441	-8%	18-25%	25%
6	96,907	127,597	30,690	32%	25-28%	25%
16	92,897	112,084	19,187	21%	25-28%	25%
29	90,564	98,449	7,885	9%	25-28%	25%
88	89,217	87,242	-1,976	-2%	25-28%	25%
3	88,374	86,410	-1,965	-2%	25-28%	25%
8	85,020	103,344	18,324	22%	25-28%	25%
5	81,584	99,042	17,458	21%	25-28%	25%
7	74,030	50,948	-23,083	-31%	28-33%	25%
1	66,286	100,212	33,926	51%	28-33%	25%
30	64,148	52,466	-11,683	-18%	28-33%	25%
9	55,353	39,207	-16,145	-29%	33-45%	25%
18	36,153	35,031	-1,122	-3%	33-45%	25%
12	33,257	24,676	-8,580	-26%	45-55%	25%
14	29,667	20,903	-8,764	-30%	45-55%	25%
21	28,784	20,913	-7,871	-27%	45-55%	25%

Screenline	2008 Counts	2008 HDT Model Flows	Difference		NCHRP Report 255	Target in MDP
24	27,201	25,573	-1,628	-6%	45-55%	25%
25	25,932	23,756	-2,176	-8%	33-45%	25%
13	23,708	32,832	9,124	38%	45-55%	25%
20	22,785	25,539	2,754	12%	45-55%	25%
15	21,795	37,953	16,157	74%	45-55%	25%
27	21,221	26,467	5,245	25%	45-55%	25%
10	21,195	35,030	13,835	65%	45-55%	25%
28	20,973	15,473	-5,500	-26%	45-55%	25%
34	19,714	19,543	-171	-1%	55-60%	25%
19	16,159	8,409	-7,750	-48%	45-55%	25%
31	15,153	16,951	1,799	12%	45-55%	25%
11	13,841	24,382	10,540	76%	55-60%	25%
32	13,369	15,347	1,978	15%	45-55%	25%
23	5,727	6,362	635	11%	55-60%	25%
33	5,688	2,126	-3,562	-63%	55-60%	25%
22	4,353	6,047	1,695	39%	55-60%	25%
26	2,172	2,954	782	36%	55-60%	25%
Total (All)	1,706,839	1,810,069	103,231	6%		

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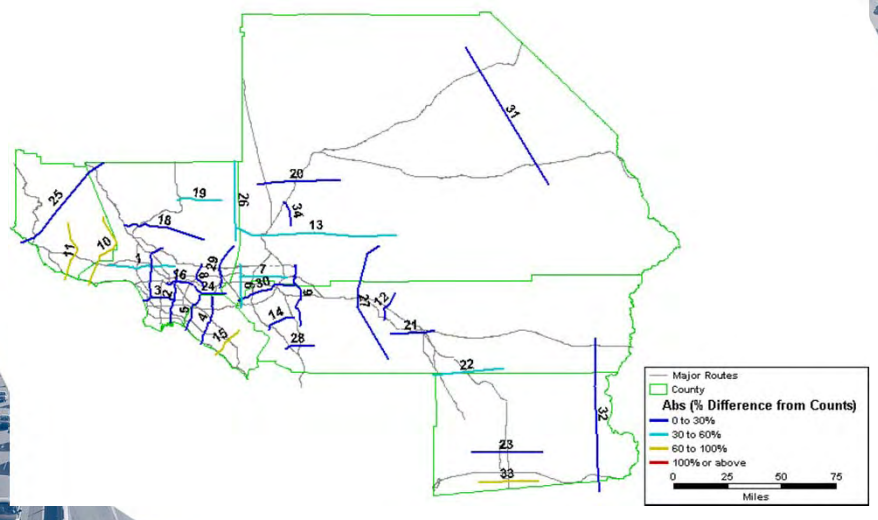
Screenline Validation Map

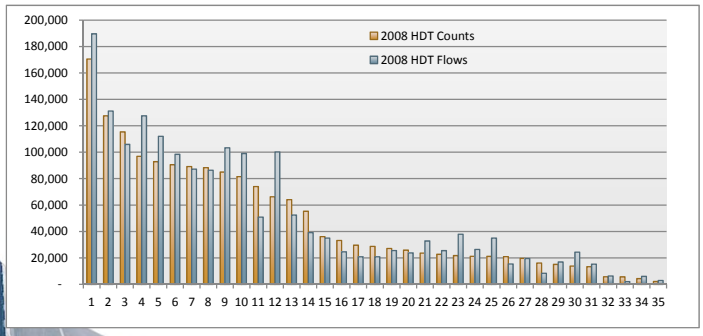


58

Validation of HDT model

Screenline summary:

2008 HDT Volumes vs. 2008 Counts (Screenlines ranked by counts)



59

Validation of HDT model

Corridor summary:

2008 HDT VMT vs. Counts Miles Traveled (CMT) on key freight corridors

Freight Corridor	Count Miles Traveled	HDT Model VMT	Difference	Percent Diff
I-10	3,833,141	4,336,253	503,112	13%
I-5	2,425,985	2,896,879	470,895	19%
SR-91	1,181,991	1,269,743	87,753	7%
I-15	2,706,120	3,127,223	421,103	16%
I-710	454,673	575,253	120,580	27%
SR-60	1,481,984	1,394,138	-87,845	-6%
TOTAL	**12,083,892**	**13,599,490**	**1,515,597**	**13%**

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Validation of HDT model

VMT summary: 2008 HDT VMT vs. 2008 Estimated VMT

2008 Estimated VMT	VC SCCAB	SCAB	MDAB	SSAB	TOTAL
Imperial	-	-	-	833,014	833,014
Los Angeles	-	12,023,419	612,798	-	12,636,217
Orange	-	3,474,615	-	-	3,474,615
Riverside	-	3,461,320	620,824	1,674,752	5,756,896
San Bernardino	-	3,334,764	3,809,126	-	7,143,890
Ventura	964,934	-	-	-	964,934
TOTAL	964,934	22,294,118	5,042,748	2,507,767	30,809,566
2008 Model VMT	**VC SCCAB**	**SCAB**	**MDAB**	**SSAB**	**TOTAL**
Imperial	-	-	-	785,799	789,468
Los Angeles	-	13,047,104	345,791	-	13,415,715
Orange	-	3,475,741	-	-	3,476,378
Riverside	-	2,897,894	707,457	1,453,910	5,059,261
San Bernardino	-	2,789,582	4,159,939	-	6,949,521
Ventura	989,731	-	-	-	991,946
TOTAL	989,731	22,210,321	5,213,188	2,239,709	**30,682,288**
Percent Difference	**VC SCCAB**	**SCAB**	**MDAB**	**SSAB**	**TOTAL**
Imperial	0%	0%	0%	-6%	**-5%**
Los Angeles	0%	9%	-44%	0%	**6%**
Orange	0%	0%	0%	0%	**0%**
Riverside	0%	-16%	14%	-13%	**-12%**
San Bernardino	0%	-16%	9%	0%	**-3%**
Ventura	3%	0%	0%	0%	**3%**
TOTAL	**3%**	**0%**	**3%**	**-11%**	**0%**

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HDT Model Summary

- External HDT – Based on 2007 TRANSEARCH and adjusted to match external station counts
- Internal HDT – Updated based on establishment surveys and truck GPS data
- IMX – New model component not modeled before; provides ability to track domestic HHDT trips that have trip ends at IMX facilities
- Secondary Trips – Distribution of secondary special generator trips along with all other wholesale HHDT trips
- Ports – Separate model with inputs from Ports (of LA and LB) and terminals gate surveys
- Overall Validation –
  - ✓ Most of high volume (>20,000 AWDT) screenlines meet targets
  - ✓ Regional and SCAB VMT meets targets, and most of sub airbasin VMT close to targets
  - ✓ All but I-710 corridor meet targets

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SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

Appendix L: Presentation – SimAGENT: A Report on the Development of an Activity-Based Travel Demand Model for SCAG

Peer Review Meeting – June 28, 2011

SimAGENT

A Report on the Development of An Activity-Based Travel Demand Model for SCAG

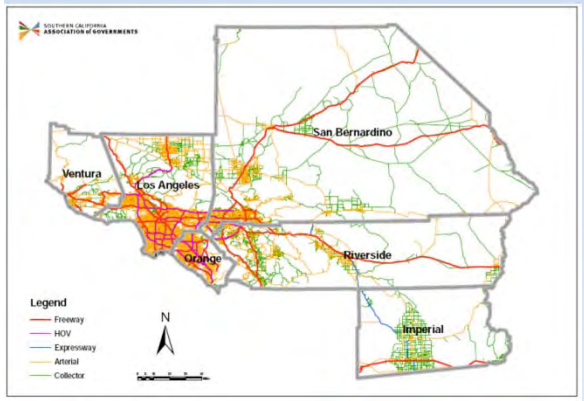
June 28, 2011

Kostas Goulias
& Yali Chen
+ others
University of California
Santa Barbara

Chandra Bhat
& Rajesh Paleti
+ others
The University of Texas
Austin

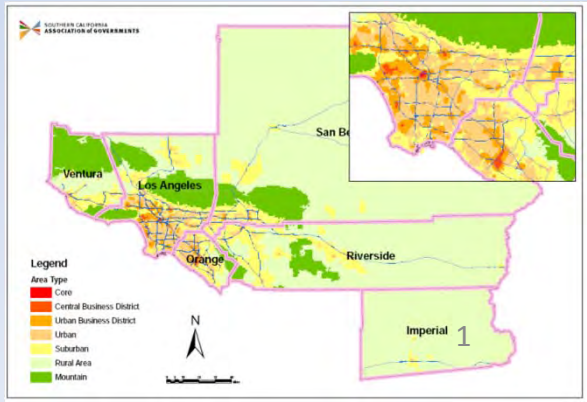
Ram Pendyala &
Karthik Konduri
+ others

Arizona State University
Tempe



Guoxiong Huang, Hsi-Hwa Hu
+ others
SCAG
Los Angeles+

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS



SimAGENT

A Report on the Development of An Activity-Based Travel Demand Model for SCAG

June 28, 2011

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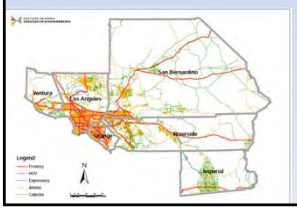
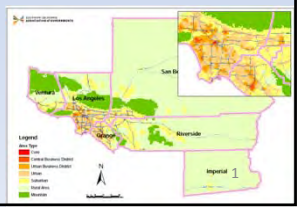




SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS

1

SimAGENT

Simulator of Activities, Greenhouse Emissions, Networks, and Travel

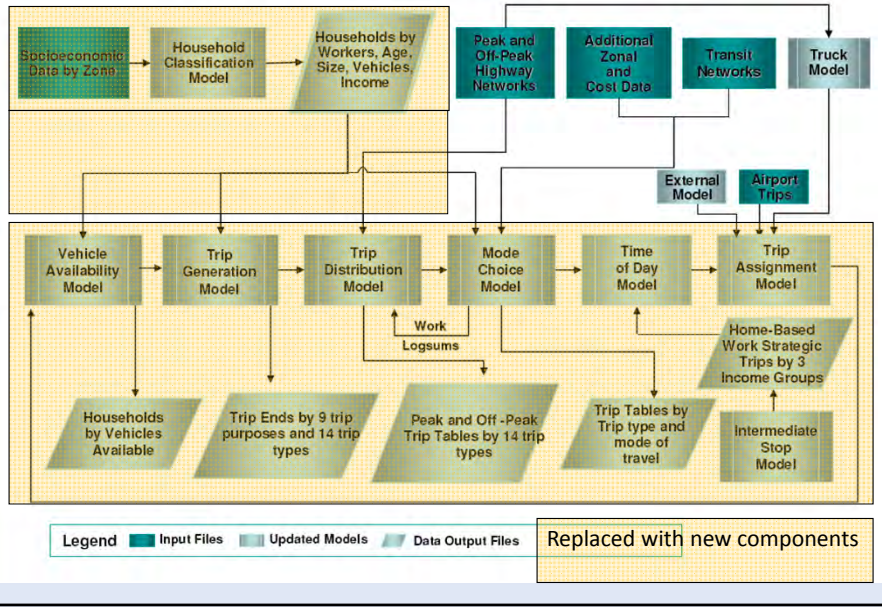
2

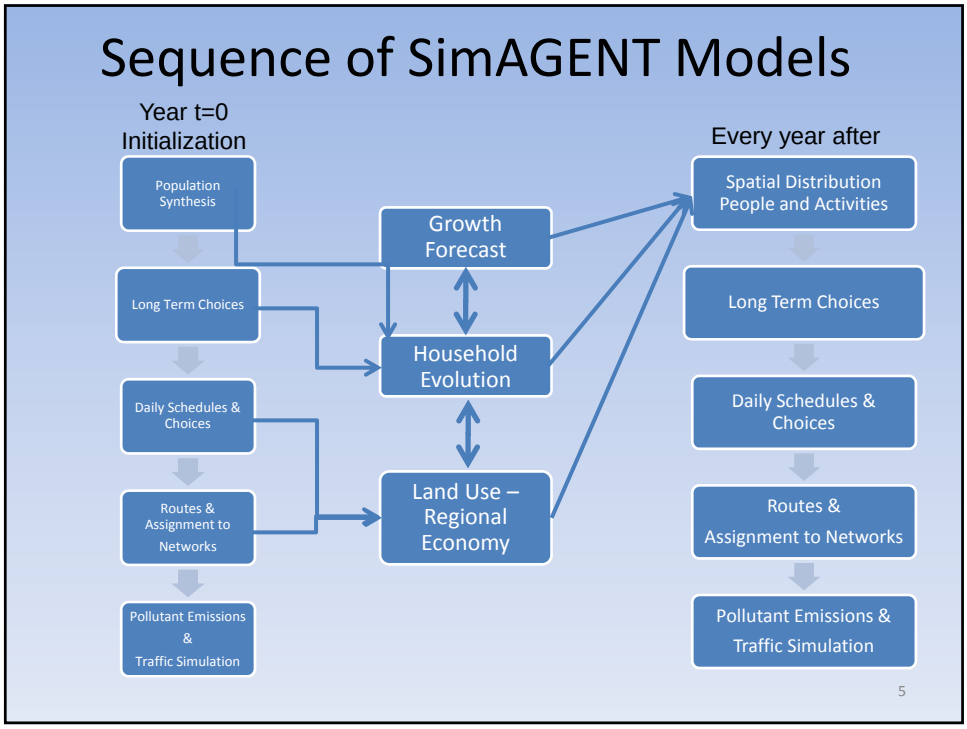
Modeling System and Definitions

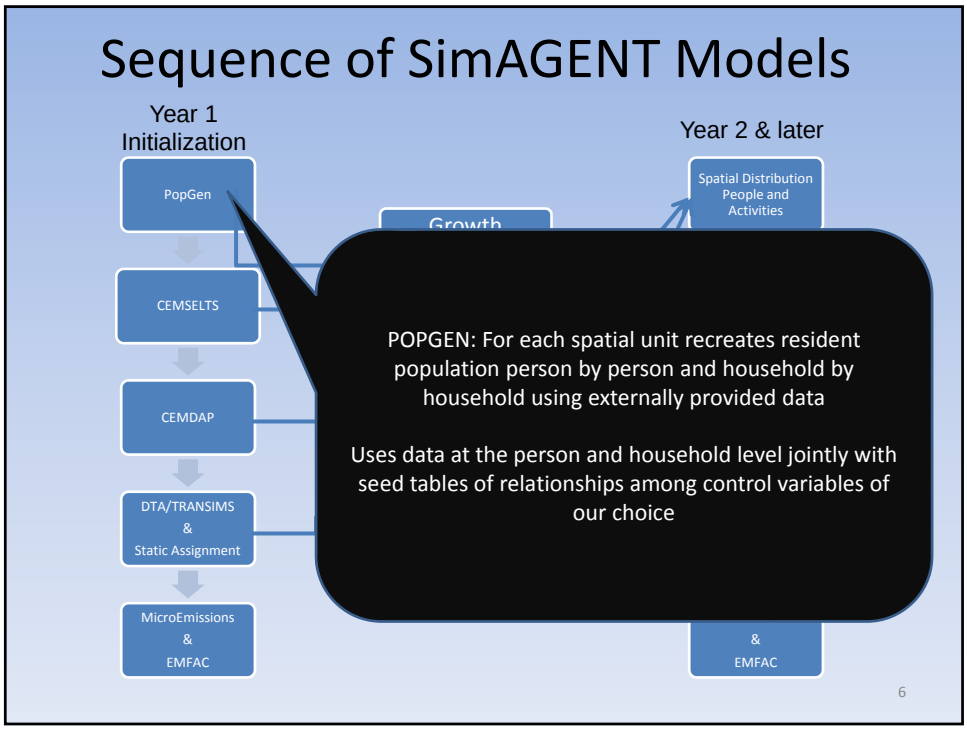
- PopGen - method and software to recreate the population (household and person characteristics) of an area, developed at ASU and used in a few places.
- CEMDAP (Comprehensive Econometric Micro-simulator for Daily Activity-travel Patterns) - method and software to give each person a daily schedule of activities and travel, developed at UT Austin and used in DFW.
- CEMSELTS (Comprehensive Econometric Microsimulator for Socioeconomics, Land-Use, and Transportation System) - method and software to give each household primary locations (home, work, school) and other important variables for CEMDAP, developed at UT Austin and used in DFW.
- SimAGENT = PopGen+GISMaps+CEMSELTS+CEMDAP+Networks+EMFAC
- Input - demographics, spatial structure, networks, policies
- Output - a day in the life of people in SCAG + trips + emission estimates.

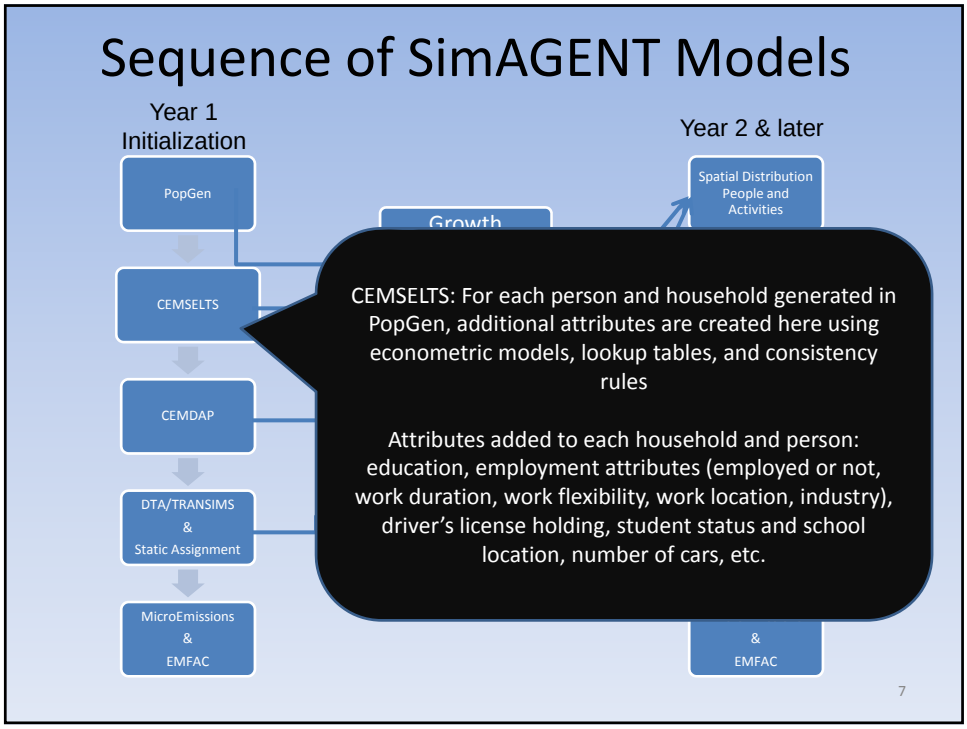
3

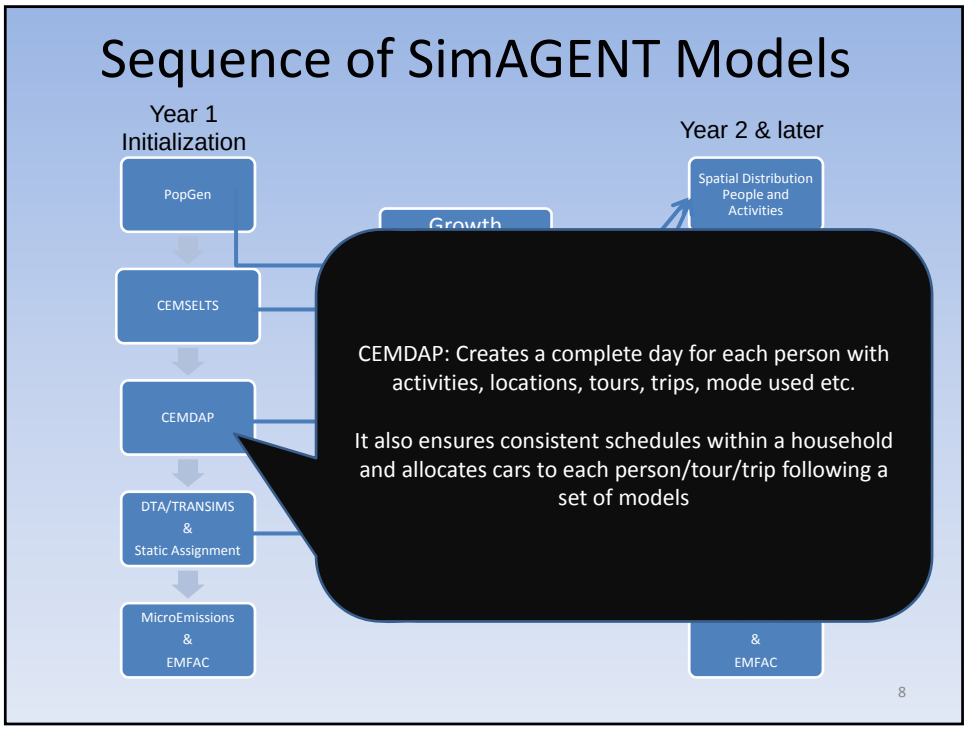
FIGURE 1-1.
SCAG REGIONAL TRAVEL MODELING PROCESS

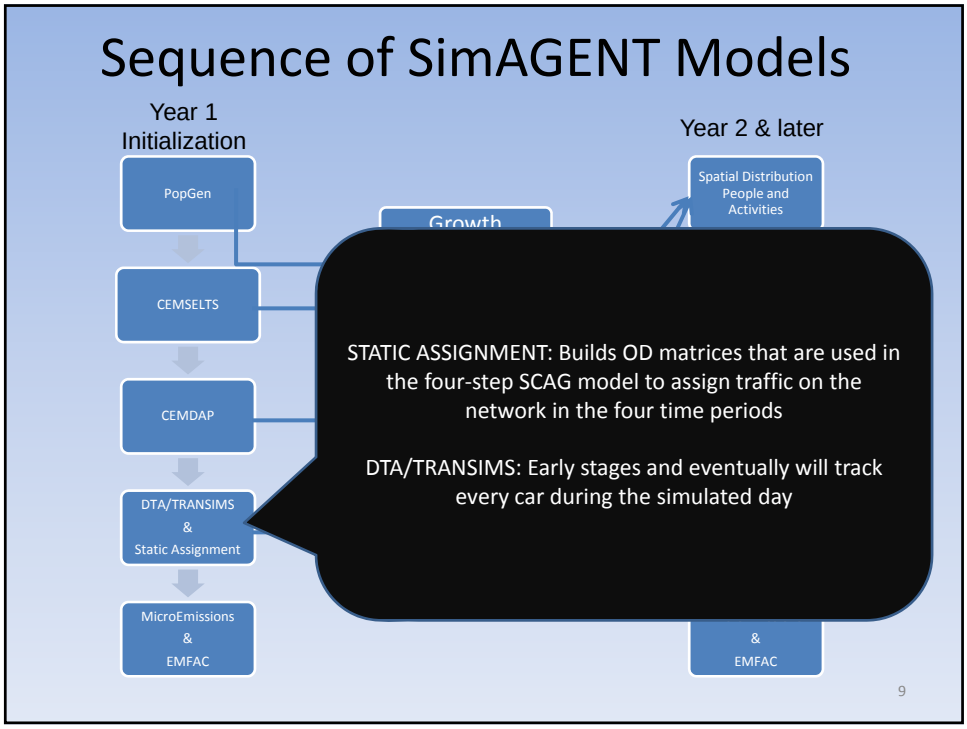



Sequence of SimAGENT Models
Year t=0 Initialization
Population Synthesis
Long Term Choices
Daily Schedules & Choices
Routes & Assignment to Networks
Pollutant Emissions & Traffic Simulation
Growth Forecast
Household Evolution
Land Use – Regional Economy
Every year after
Spatial Distribution People and Activities
Long Term Choices
Daily Schedules & Choices
Routes & Assignment to Networks
Pollutant Emissions & Traffic Simulation
5


Sequence of SimAGENT Models
Year 1 Initialization
PopGen
CEMSELTS
CEMDAP
DTA/TRANSIMS & Static Assignment
MicroEmissions & EMFAC
Year 2 & later
Spatial Distribution People and Activities
& EMFAC
POPGEN: For each spatial unit recreates resident population person by person and household by household using externally provided data
Uses data at the person and household level jointly with seed tables of relationships among control variables of our choice
6


Sequence of SimAGENT Models
Year 1 Initialization
Year 2 & later
PopGen
Spatial Distribution People and Activities
Growth
CEMSELTS
CEMDAP
DTA/TRANSIMS & Static Assignment
MicroEmissions & EMFAC
& EMFAC
CEMSELTS: For each person and household generated in PopGen, additional attributes are created here using econometric models, lookup tables, and consistency rules
Attributes added to each household and person: education, employment attributes (employed or not, work duration, work flexibility, work location, industry), driver's license holding, student status and school location, number of cars, etc.
7


Sequence of SimAGENT Models
Year 1 Initialization
Year 2 & later
PopGen
Spatial Distribution People and Activities
Growth
CEMSELTS
CEMDAP
DTA/TRANSIMS & Static Assignment
MicroEmissions & EMFAC
& EMFAC
CEMDAP: Creates a complete day for each person with activities, locations, tours, trips, mode used etc.
It also ensures consistent schedules within a household and allocates cars to each person/tour/trip following a set of models
8


Sequence of SimAGENT Models
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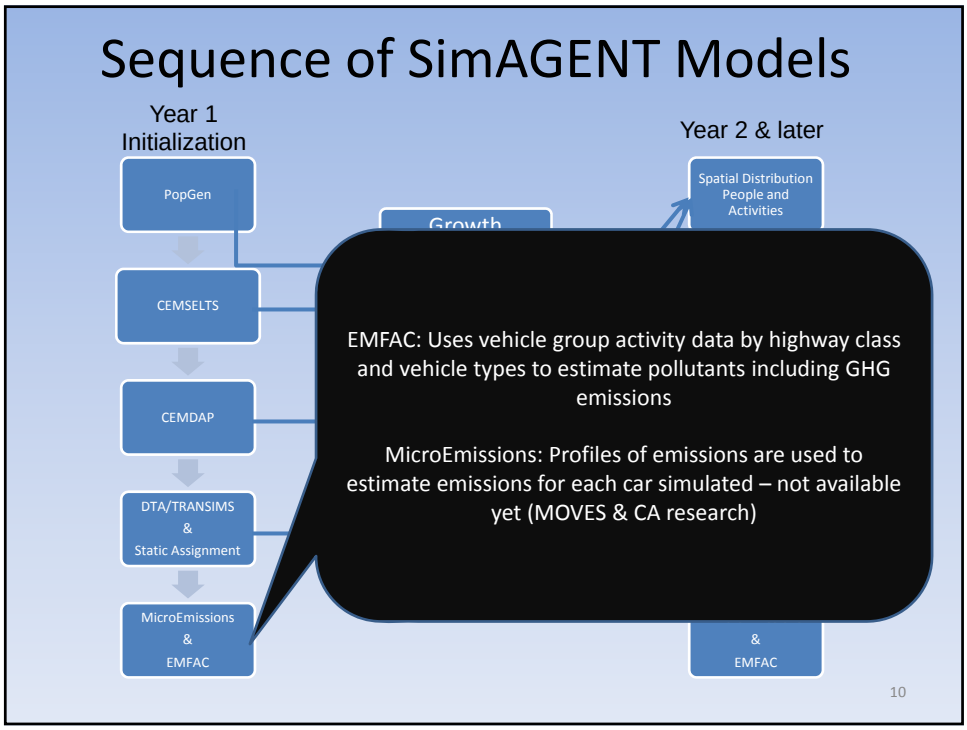
PopGen
CEMSELTS
CEMDAP
DTA/TRANSIMS & Static Assignment
MicroEmissions & EMFAC
Year 2 & later
Spatial Distribution People and Activities
Growth
& EMFAC
STATIC ASSIGNMENT: Builds OD matrices that are used in the four-step SCAG model to assign traffic on the network in the four time periods
DTA/TRANSIMS: Early stages and eventually will track every car during the simulated day
9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Growth
& EMFAC
EMFAC: Uses vehicle group activity data by highway class and vehicle types to estimate pollutants including GHG emissions
MicroEmissions: Profiles of emissions are used to estimate emissions for each car simulated – not available yet (MOVES & CA research)
10

PopGen: A New Population Synthesizer

- Incorporates a new Iterative Proportional Updating (IPU) algorithm for estimating household weights
- The algorithm estimates household weights such that ***BOTH*** household and person distributions are matched
- The algorithm is simple, practical, and computationally tractable
- Idea behind IPU
  - ***Reallocate weights among sample households of a type to account for differences in household composition***

11

PopGen Methodology

- Step 1: Estimate Household and Person Type Constraints
  - Iterative Proportional Fitting (IPF) is employed to estimate household and person type constraints
  - Inputs
    - Household and person sample data
    - Household and person marginal distributions
  - Corrections for zero-cell problem and zero-marginal problem are applied

12

PopGen Methodology (continued)

- Step 2: Estimate Household Weights
  - Iterative Proportional Updating (IPU) algorithm is employed to estimate household weights
  - Household weights satisfy both household and person type constraints
  - Inputs
    - Household and person sample data
    - Household and person type constraints (*from step 1*)

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PopGen Methodology (continued)

- Step 3.1: Estimate Frequencies
  - Apply rounding procedures to get the frequency of different household types in the synthetic population
  - Procedures implemented in PopGen
    - Arithmetic Rounding, Bucket Rounding, Stochastic Rounding
  - Input
    - Household type frequencies (*from Step 1*)
- Step 3.2: Estimate Selection Probabilities
  - Input
    - Household weights (*from Step 2*)

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PopGen Methodology (continued)

- Step 3.3: Draw Households
  - Select sample households based on selection probabilities to match the rounded cell frequencies
    - Drawing procedure is probabilistic
    - Fit of synthetic population is checked after each draw
    - Drawing procedure is repeated until a synthetic population with best fit is obtained
  - Inputs
    - Rounded household type frequencies
    - Selection probabilities

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SCAG Population Synthesis: Inputs

- Household and person sample
- Marginal distributions of attributes of interest

Synthesis	Source	
	Sample Data	**Marginal Distributions Data**
2003, 2035	Census 2000 - 5 percent PUMS	SCAG TAZ Data
2008	Census 2000 - 5 percent PUMS; ACS 2005-2007 - 3 percent PUMS*	SCAG TAZ Data

** The fit of synthetic population was not as good as that using PUMS 2000*

16

SCAG Population Synthesis: Attributes

Household attributes

280 household type constraints for 2003 Synthesis; 1120 household type constraints for 2008 Synthesis (income was the extra control variable); 280 household type constraints for 2035 Synthesis

- **presence of children (2 categories)**
  1) Yes; 2) No
- **household type (5 categories)**
  1) Family: Married Couple; 2) Family: Male Householder, No Wife; 3) Family: Female Householder, No Husband; 4) Non-family: Householder Alone; 5) Non-family: Householder Not Alone
- **household size (7 categories)**
  1) 1 Person; 2) 2 Persons; 3) 3 Persons; 4) 4 Persons; 5) 5 Persons; 6) 6 Persons; 7) 7 or more Persons
- **age of householder (2 categories)**
  1) 15 – 64 years; 2) 65 years and over
- **family type (2 categories)**
  1) Family; 2) Non-family
- **income (4 categories; included for 2008 synthesis only)**
  1) < $25,000; 2) $25,000 – $49,999; 3) $50,000 - $99,999; 4) > $99,999

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SCAG Population Synthesis: Attributes (continued)

Person attributes

140 person type constraints for 2003, 2008, 2035 Synthesis

- **age (10 categories)**
  1) Under 5 years; 2) 5 to 14 years; 3) 15 to 24 years; 4) 25 to 34 years; 5) 35 to 44 years; 6) 45 to 54 years; 7) 55 to 64 years; 8) 65 to 74 years; 9) 75 to 84 years; 10) 85 and more
- **gender (2 categories)**
  1) Male; 2) Female
- **race (7 categories)**
  1) White alone; 2) Black or African American alone; 3) American Indian and Alaska Native alone; 4) Asian alone; 5) Native Hawaiian and Other Pacific Islander alone; 6) Some other race alone; 7) Two or more races

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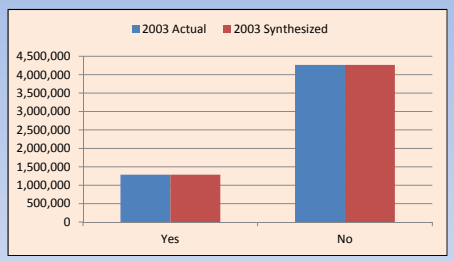
SCAG Population Synthesis: Summary

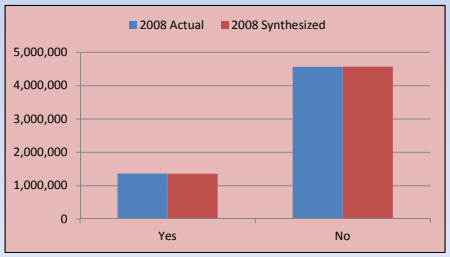
	2003 Synthesis			***2008 Synthesis***		
TAZ's Synthesized	4035 / 4109			4055 / 4109		
	Actual	*Synthesized*	*Percent Difference*	*Actual*	*Synthesized*	*Percent Difference*
Households	5,549,771	5,549,771	0.00%	5,925,576	5,925,576	0.00%
Groupquarters	172,143	172,143	0.00%	195,410	195,410	0.00%
Persons	17,595,729	17,363,222	-1.32%	18,904,466	18,451,705	-2.39%

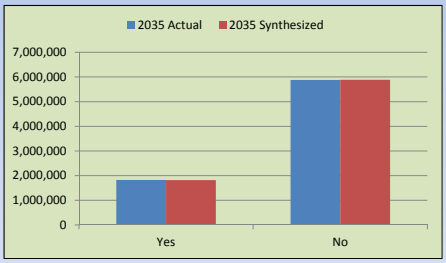
19

Household Attribute Distributions

Presence of children (*Controlled*)



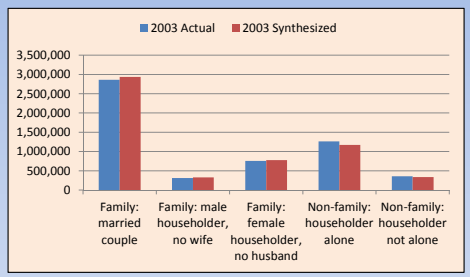


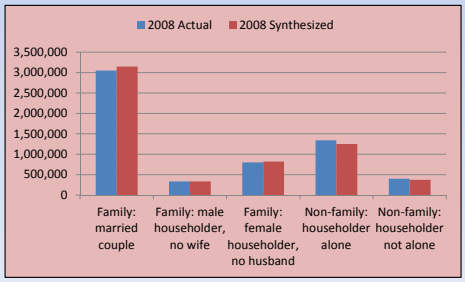


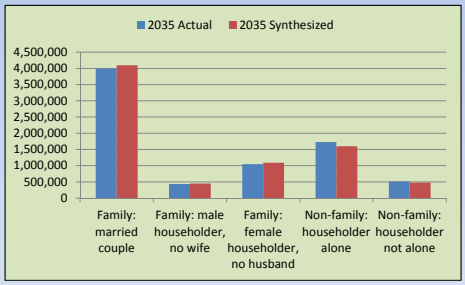
20

Household Attribute Distributions

Household type (*Controlled*)



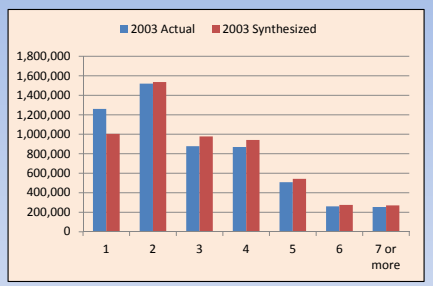


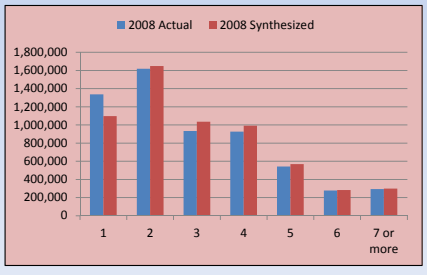


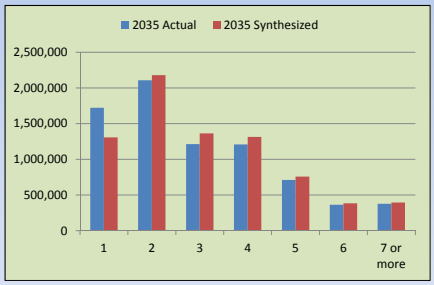
21

Household Attribute Distributions

Household size (*Controlled*)



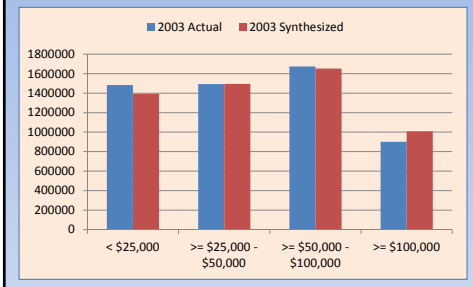


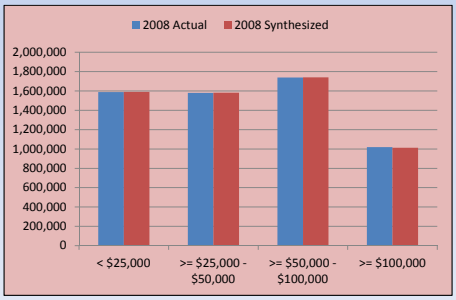


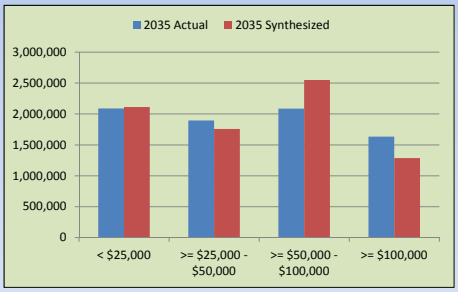
22

Household Attribute Distributions

Income (*2003, 2035 Uncontrolled; 2008 Controlled*)



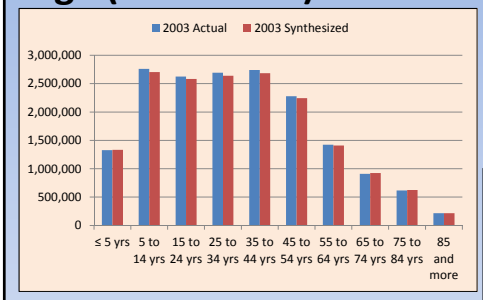


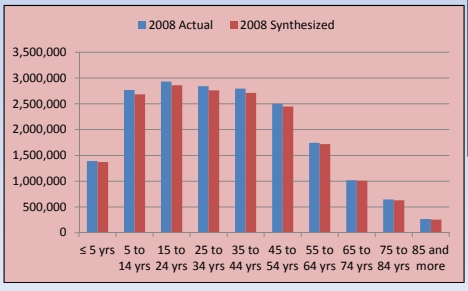


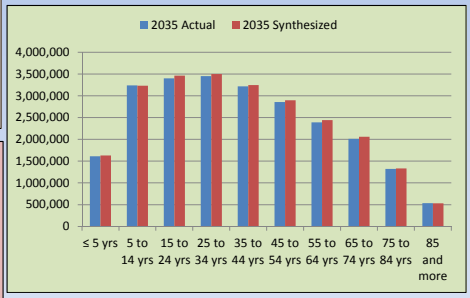
23

Person Attribute Distributions

Age (*Controlled*)







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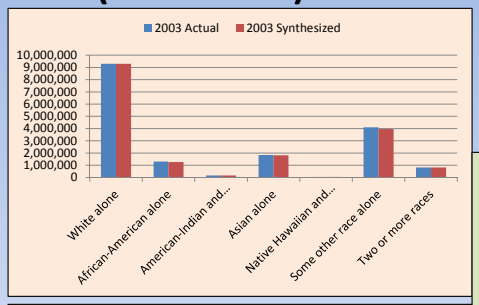
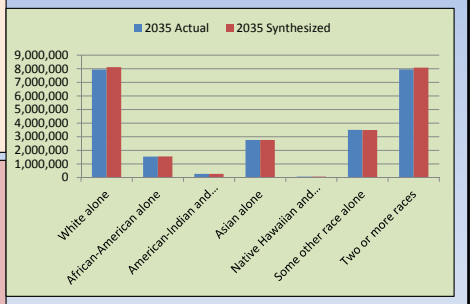
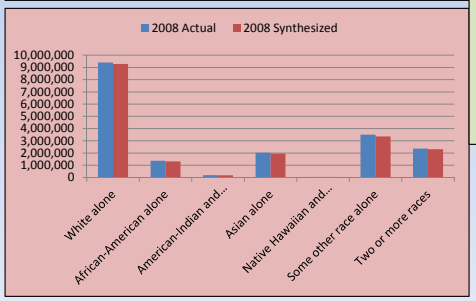
Person Attribute Distributions

Race (*Controlled*)







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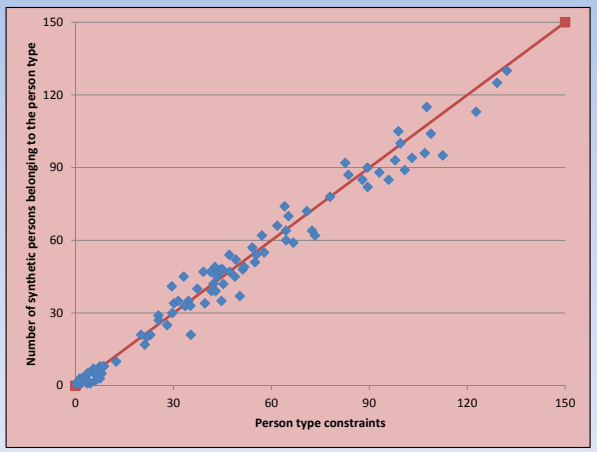
Match in Person Constraints

- Example TAZ 1 (for year 2035)

ID – 210410400

- ***Persons Actual – 4474***
- ***Persons Synthesized – 4365***
- ***AARD Value – 0.017***
- ***P-value – 0.9974***
- ***Inconsistencies:***
  None



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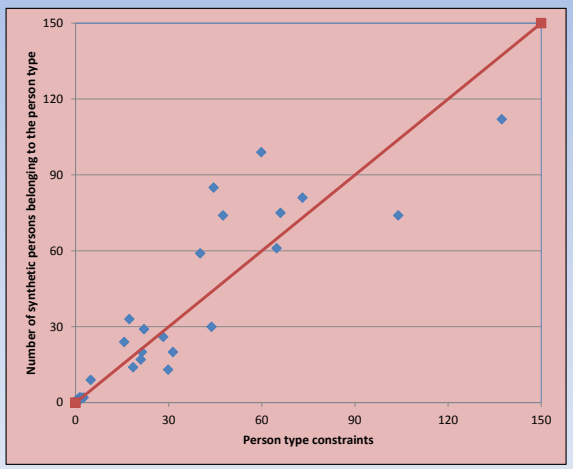
Match in Person Constraints

- Example TAZ 2 (for year 2035)

ID – 600010000

- ***Persons Actual – 908***
- ***Persons Synthesized – 965***
- ***AARD Value – 0.1603***
- ***P-value – 0.003***
- ***Inconsistencies:***
  - ***Person total inconsistency (person total implied from household size distribution is greater than given person total)***



27

AVAILABILITY OF OPPORTUNITIES BY TIME OF DAY – MICRO-ACCESSIBILITY MEASURES

28

The Many Ds in California Land Use & Transport Policy

- Density = (Population + Employment)/square mile
- Diversity = $1-\left|\frac{\mathrm{Re}.employment}{\mathrm{Re}.population}*\frac{(Loc.population-Loc.employment)}{(Loc.population+Loc.employment)}\right|$
- Design = a*street network density + b*sidewalk completeness+ c*route directness
- Destinations = from an origin zone i Sum over j of (attractions*impedance)
- Distance to transit

Local = depends on application; **street network density** = length of street in miles/area of neighborhood in square miles, **sidewalk completeness** = total sidewalk centerline distance/total street centerline distance, **route directness** = average airline distance to center/average roadway distance to center
INDEX 4D uses a=0.0195, b=1.18, and c=3.63

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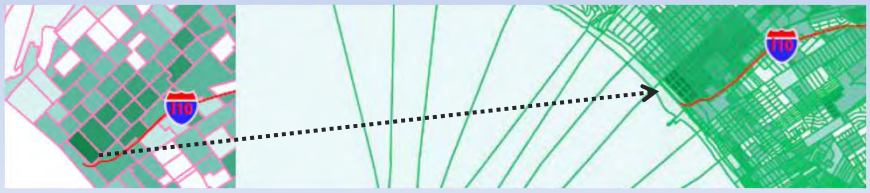
Data Used

- CTPP vintage 2000
- Dunn & Bradstreet post processed to provide summaries by block group (via a joint project with LANL & UCOP)
- US Census Block, block groups, TAZs, and Tracts
- SCAG network (highway and transit)
- Teleatlas California 2000
- InfoUSA (later vintage) just for comparison
- SCAG Post-Census Commute Arrival to Work and Departure from Work

30

Allocation from Block groups to Blocks

- Function of land area, population, amount of: freeways, arterials, collectors, ramps (negative and positive influence depends on industry type).



Block Groups

Blocks

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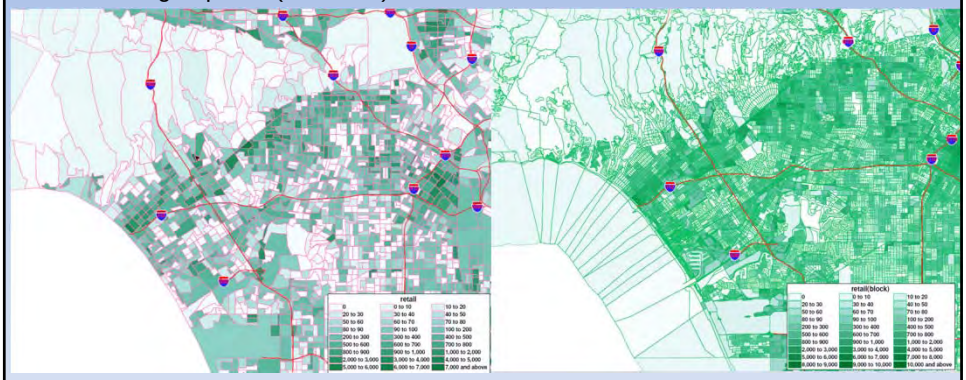
Retail Density

Block group level(observed)

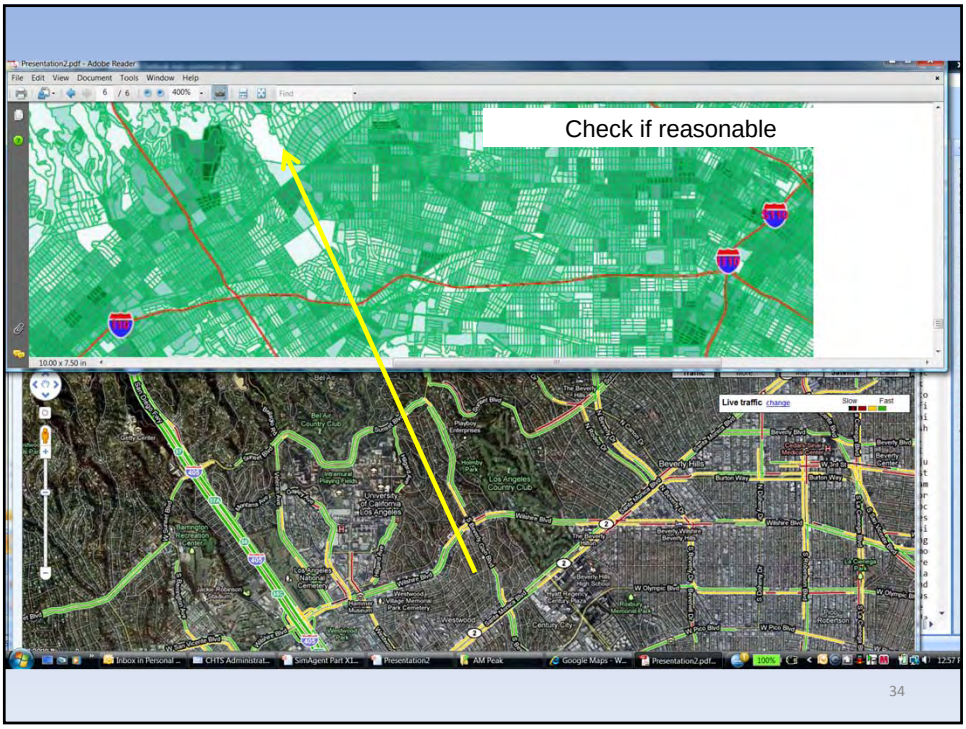
Block level(predicted from model)



Education & Health Density

Block group level(observed)

Block level(predicted from model)



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Time of Day Variation

- Travel time on the network → use travel speed from calibrated four step model that has four wide time periods (AM Peak - 6AM to 9AM, Midday - 9AM to 3PM, PM Peak - 3PM to 7PM, Night - 7PM to 6AM)
- Opening-closing times for businesses → use arrival and departure time of workers in post Census survey (16k hhs)
- To account for the "wide" periods of the network times we use MIN and MAX for the number of employees by industry that can be reached within a temporal buffer of 10, 20, and 50 minutes
- The buffers 10 vs 50 resemble local vs regional accessibility
- Shortest path computed using aprox. 200,000 by 200,000 origin destination matrix using TRANSCAD.

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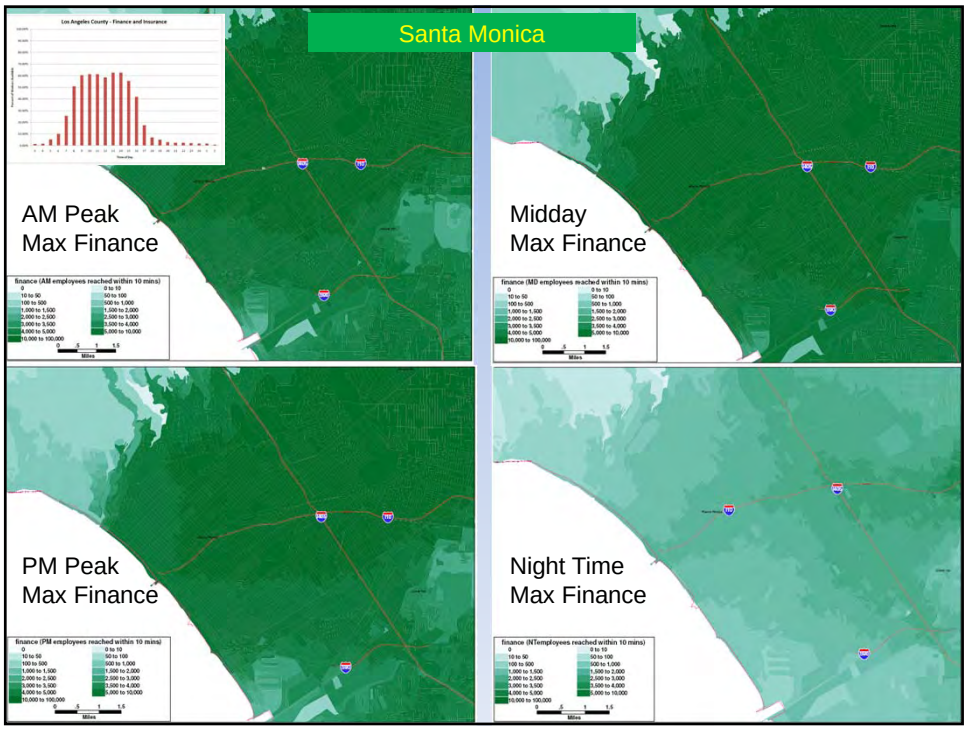
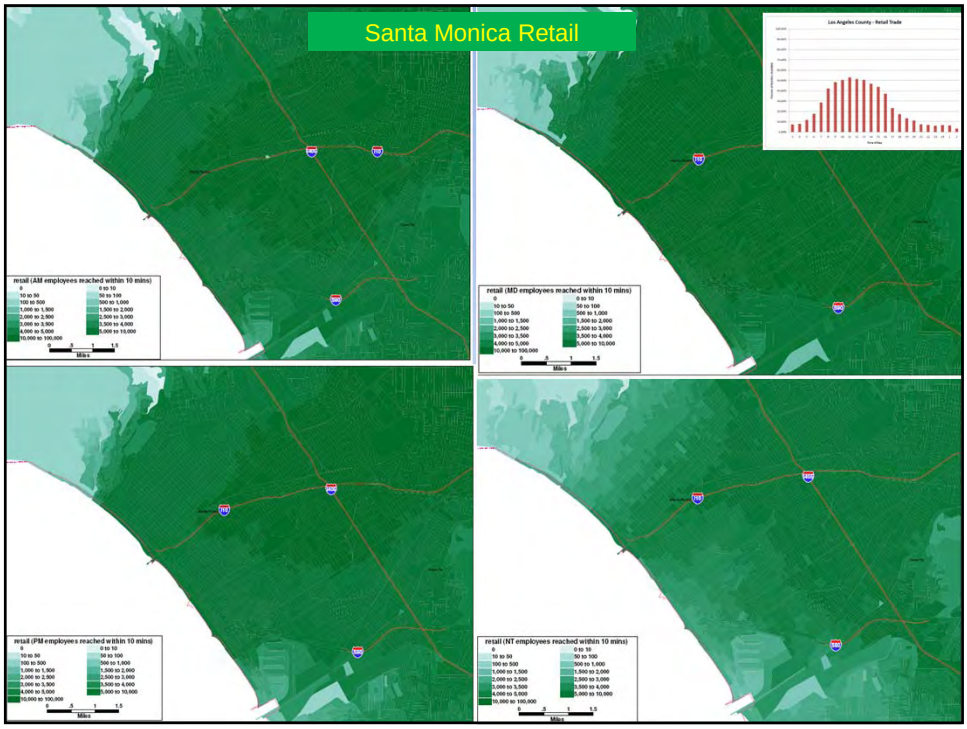
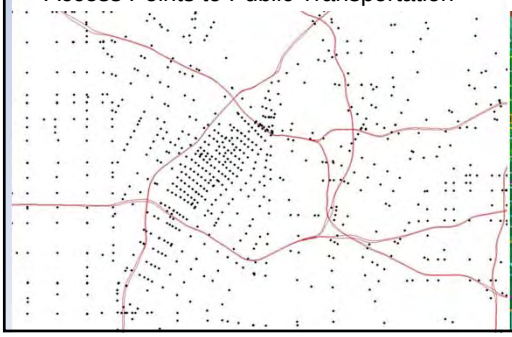




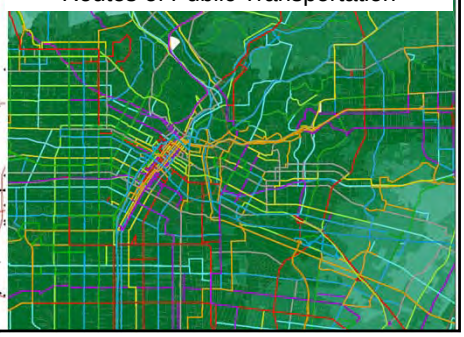
Transit Accessibility

- 60 meters / min walking speed
- 6 min penalty for switching transit lines
- Max time set at 3 hours
- Sparse distance matrix in output
  - Do not report if > 3 hours

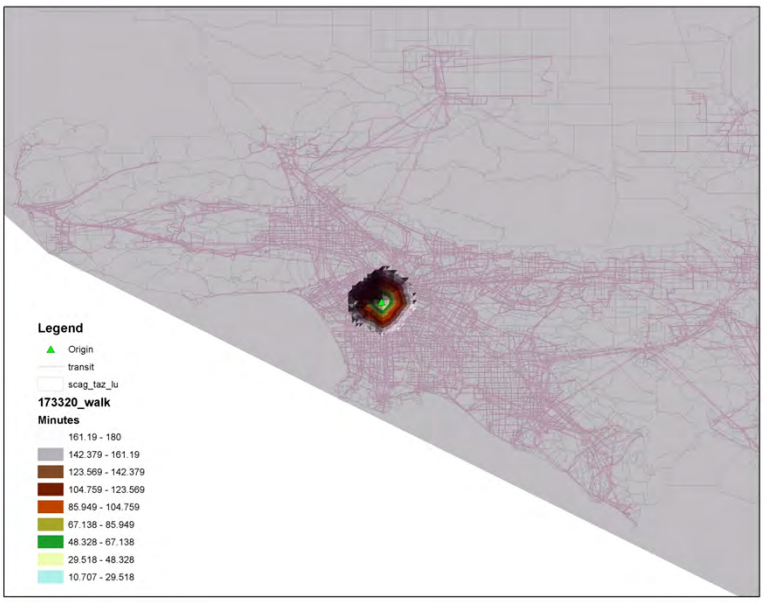
Access Points to Public Transportation



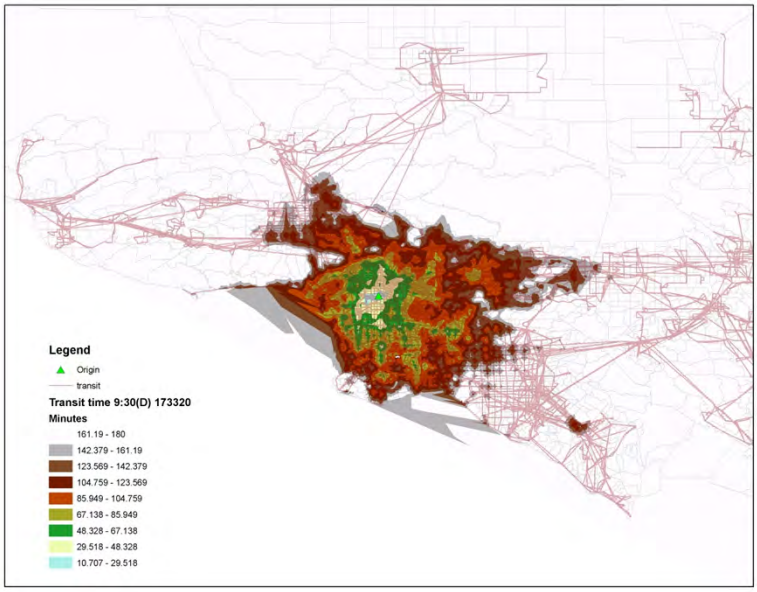
Routes of Public Transportation



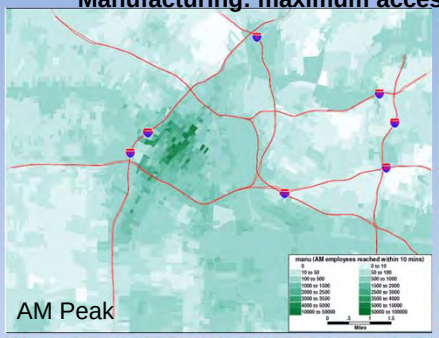
Walk Time Isochrones Example

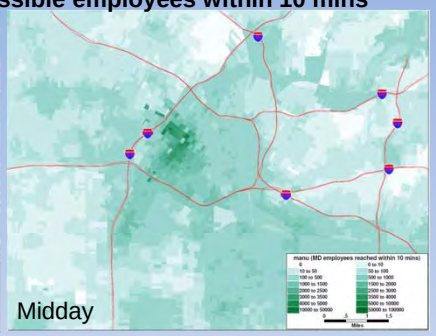


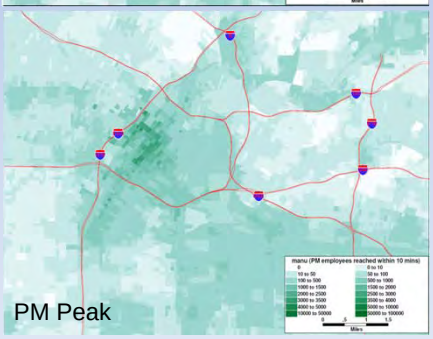
Transit Travel Time Isochrones Example

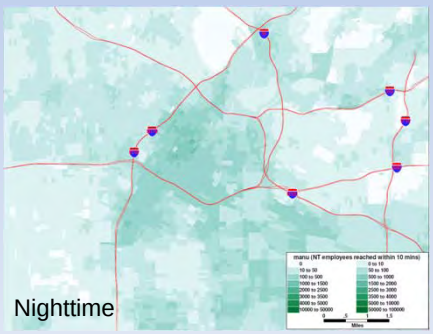


Manufacturing: maximum accessible employees within 10 mins

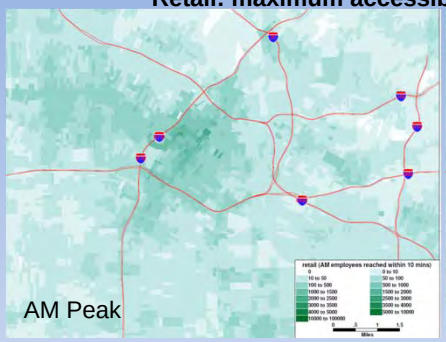


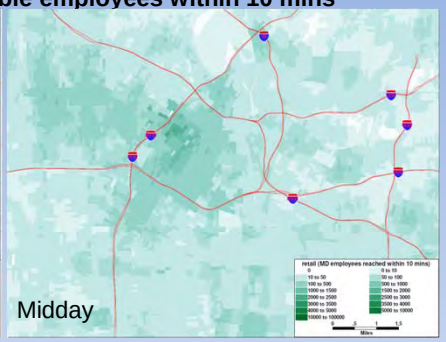


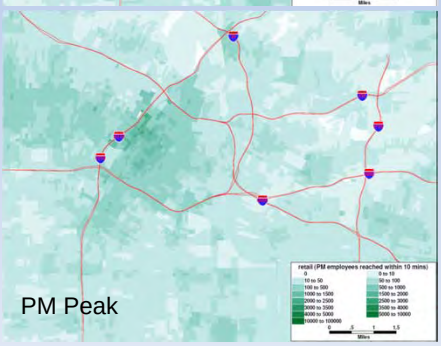


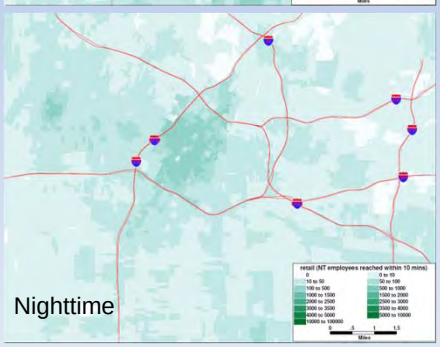


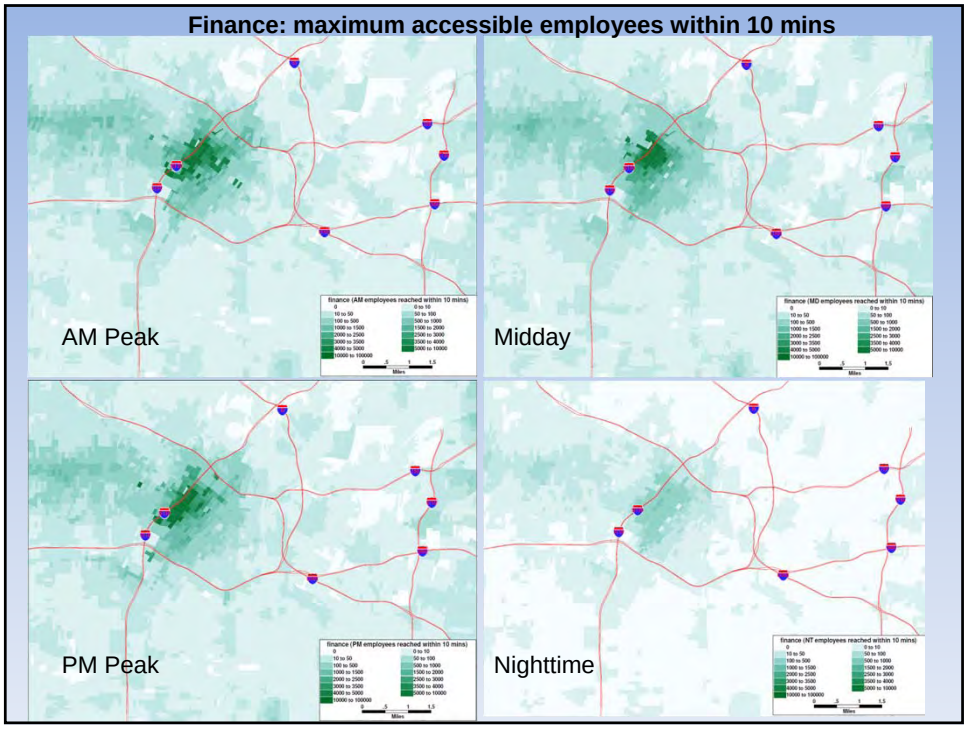
Retail: maximum accessible employees within 10 mins

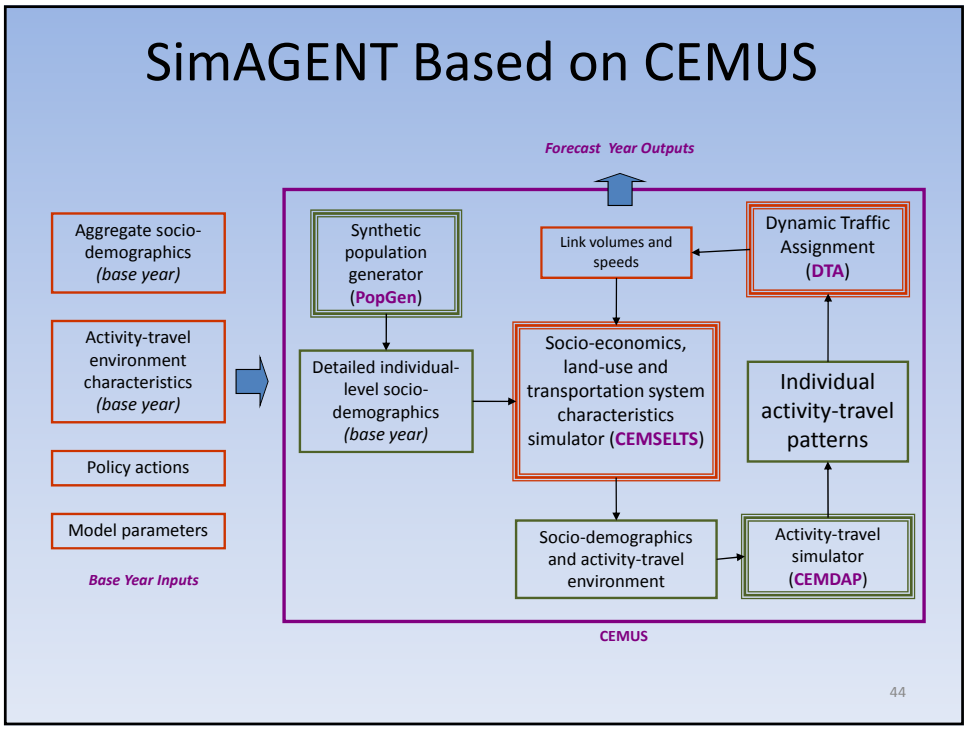






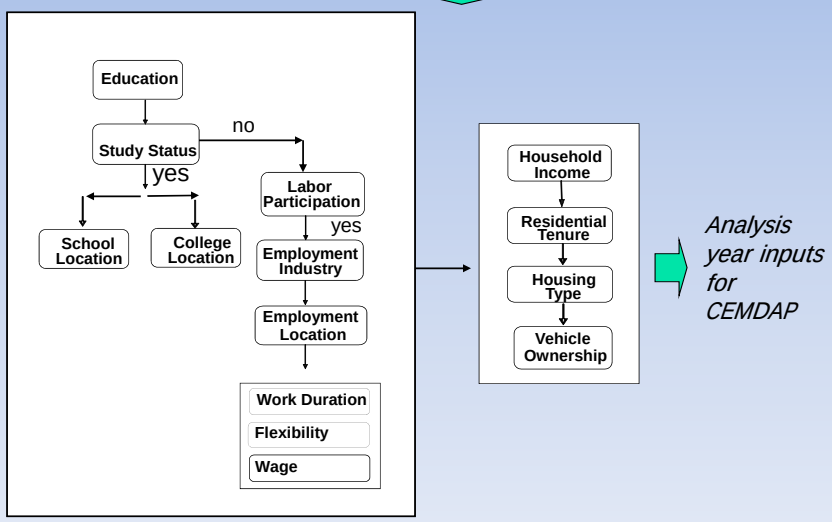



Finance: maximum accessible employees within 10 mins
AM Peak
Midday
PM Peak
Nighttime


SimAGENT Based on CEMUS
Forecast Year Outputs
Aggregate socio-demographics (base year)
Activity-travel environment characteristics (base year)
Policy actions
Model parameters
Base Year Inputs
Synthetic population generator (PopGen)
Detailed individual-level socio-demographics (base year)
Link volumes and speeds
Dynamic Traffic Assignment (DTA)
Socio-economics, land-use and transportation system characteristics simulator (CEMSELTS)
Individual activity-travel patterns
Socio-demographics and activity-travel environment
Activity-travel simulator (CEMDAP)
CEMUS
44

CEMSELTS: Modeling Framework

Analysis year PopGen outputs



Person Models

Model name	Econometric Structure / Rule Based and Independent Variables	Choice Alternatives/Comments
Schooling		
For children aged < 5 years	Rule based model – all children under the age of 5 are considered as not going to school	Schooling or no schooling
For children between 5 to 12 years	Rule based model – all children between 5-12 years are assumed to attend school, and their grade is based on age	Grades K through 7
If age between 13 and 18 years	Rate-based probability model depending on age, race, and gender	Continue school, drop-out, or complete schooling. If drops out, grade is set to the grade at which drop-out occurs
If age > 18 years	Rate-based probability model for education level based on race.	Associate degree, bachelors, Masters, Ph.D.
School location of children	Deterministic Model: Closest zone which contains a school	List of zones with a school

Person Models

Model name	Econometric Structure / Rule Based and Independent Variables	Choice Alternatives/Comments
Employment/Drivers License Models		
Labor participation model	Binary Logit model; independent variables include age, gender, race, education, presence of children	Employed, Not employed (Applied for individuals over 16 years of age and not studying)
Employment industry model	Multinomial logit model; ; independent variables include age, race, gender and education level	Construction and Manufacturing, Trade and Transportation, Professional businesses, Government, Retail and Repair, Other (relevant for employed individuals)
College Location	Spatial location choice model; independent variables include whether TAZ is a major /minor college TAZ, distance, race of person, accessibility measures of the TAZ	TAZs of SCAG area with Colleges
Employment location model	Spatial location choice model; independent variables include employment density, transportation level of service, accessibility to population and employment, and zones in central business district	TAZs of SCAG area
Weekly work duration model	Grouped response model; independent variables include gender, education level and industry	< 35 hours, 35-45 hours, and > 45 hours (the results are post processed to estimate a continuous "work hours" variable for each employed individual)
Work flexibility model	Ordered probit model; independent variables include gender, race , education level, employment industry, and hours worked.	No flexibility, Low flexibility, Medium flexibility, High flexibility (flexibility level definition is based on individual response in the survey)
License Model	Binary Logit model; independent variables include age, gender, and race	Has a valid license versus no valid license

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Household Models

Model Name	Econometric Structure and Independent Variables	Choice Alternatives
Household Income model	Grouped Response Model, Independent variables include race, presence of elderly individuals, education level of members of households, employment industry of workers in household	0-$10,000; $10,000-$24,999, $25,000-$34,999, $35000-$49,999, $50,000-$74,999,$75,000-$99,999,$100,000-$149,999, >$150,000; Later converted into Continuous income
Residential tenure model	Binary logit model; independent variables include household income, household size, number of employed people, number of children, race, presence of elderly people, single-adult household and presence of unrelated people	Own or rent house
Housing type model	Multinomial logit model; independent variables include household income, race, presence of elderly people, single-adult household, presence of unrelated people and highest education level in the household	Single-family detached, Single-family attached, Apartment, and Mobile home or trailer

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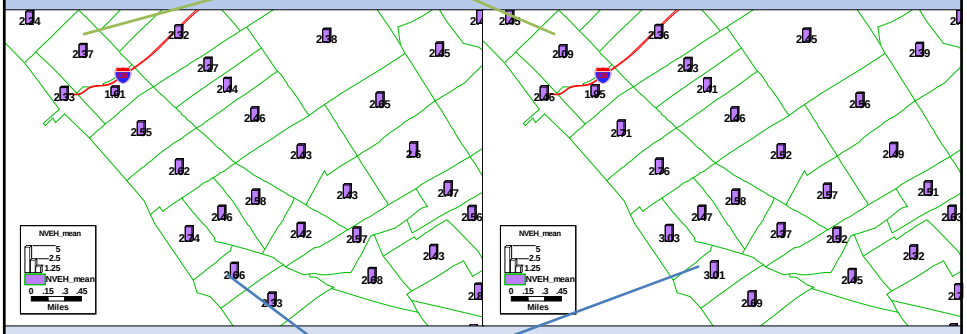
Average Vehicles Per Household

2003 2035

Decrease in average cars per household is -0.28=2.09-2.37



Increase in average cars per household is 0.35=3.01-2.66

Phase 1 Version

- Auto Ownership model → Simple MNL with 4 categories
- Implemented as part of CEMSELTS
- Limitations:
  - No vehicle fleet composition information
  - No modeling of make of each vehicle
  - No allocation of vehicles to household members
  - No allocation of vehicles to different trips

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Key Changes for Phase 2 & 3

- Vehicle Type Choice Model → MDCEV
- Vehicle Make Model
- Primary Driver Model
- Allocation of a household vehicle to each independent tour
- Explicit vehicle type choice model for joint trips of the household
- Integration of all these models within SimAGENT

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Vehicle Type Choice Model

- Vehicle type choice determines vehicle fleet mix; critical to energy and emissions analysis
- Bhat's Multiple Discrete-Continuous Extreme Value (MDCEV) – and its mixed variants – is capable of modeling multiple vehicle holdings, body types, fuel types, age, and use (miles) simultaneously

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Vehicle Type Choice Model

- Log-Regression model to predict annual household mileage
- Vehicle Fleet Composition → MDCEV
- 54 Alternatives: Combination of 9 body types and 6 vintage categories
  - Body type: Sub-compact car, Compact car, Medium car, Large Car, Sports car, Medium SUV, Large SUV, Van, Pickup
  - Vintage: New or 1 year, 2-3 years, 4-5 years, 6-9 years, 10 to 12 years, >12 years
  - Plus One non-motorized mileage alternative

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Vehicle Make Model

- For each body type and vintage combination predicted by MDCEV → Vehicle Make determined using MNL model
- Vehicle Make information obtained using Wards Automotive year books from 2008, 2006, 2004, 2002, 1999,1996 and Green Vehicle Guide from EPA
- Variables in the model:
  - Dimensions of the vehicle, Horse Power, Engine Capacity, Type of wheel drive, Curb weight, Green House Gas Rating, Annual Fuel Cost, Purchase Price, Vehicle Make (Honda, Toyota, BMW *etc*)
  - Interactions with Household Characteristics like Size and income

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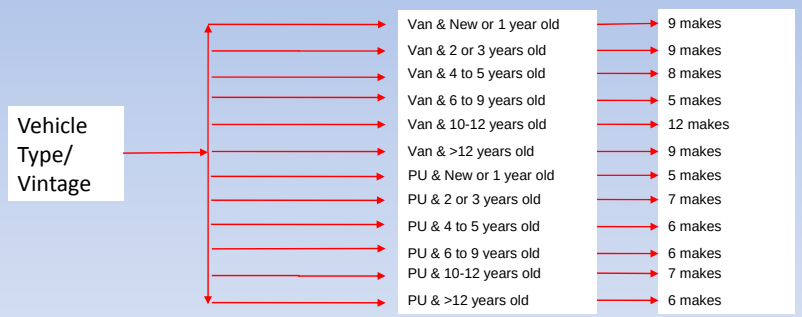
Vehicle Make Alternatives

A total of 759 Makes across all vehicle type and vintage combinations



55

Primary Driver Model

- Multinomial Logit model → allocates each vehicle to a person (primary driver)
- Number of alternatives = Number of licensed individuals in household
- Independent variables → Interaction of several person specific variables like gender, education, employment with vehicle characteristics

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Allocation of Vehicles to Tours

- Any independent vehicle tour made by a household member is assumed to be made using the individual's primary vehicle
- The vehicle used for joint tours in a household is determined using an MNL model
- Alternatives: Primary vehicles of all members participating in the joint activity
- Variables: Vehicle characteristics (Engine CC, Horse Power, vehicle body type) and their interaction with joint activity characteristics (such as number of participating people in the joint activity, distance to joint activity location, etc.)

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Vehicle Type Choice Model Results

Body Type	Survey Data	CEMDAP
Sub-compact Car	3.5	2.7
Compact Car	18.2	23.9
Medium Car	22.3	23.9
Large Car	5.7	3.3
Sports Car	5.6	4.1
Medium SUV	9.5	9.9
Large SUV	11.0	8.9
Van	7.0	5.9
Pickup	17.2	17.3

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Vehicle Type Choice Model Results

Vintage Category	Survey Data	CEMDAP
New or one year	13.4	11.4
2 to 3 years old	15.9	13.5
4 to 5 years old	15.1	12.5
6 to 9 years old	26.4	27.7
10 to 12 years old	11.2	12.2
> 12 years	18.0	22.7

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Ongoing and Future Work

- Enhance vehicle type choice model → Inclusion of built environment variables (micro-accessibility measures) in the vehicle type choice model
- Inclusion of Evolution component (Vehicle Disposal, Replacement & Addition Models) within SimAGENT
- Examine a much more extensive set of land-use and transportation policies, including those that can affect vehicle fleet evolution over time and GHG emissions

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CEMSELTS 2003 Household Level Modules

Household Socio-demographics	Model Component		Percentage Values					
		SCAG 2003	ACS 2003	Census 2000	Predicted	Difference in Percentage (SCAG 2003)	Difference in Percentage (ACS)	Difference in Percentage (Census)
Type of Household								
Family	PopGen	70.82	69.52	70.47	72.74	1.92	3.22	2.27
Non- Family		29.18	30.48	29.53	27.26	-1.92	-3.22	-2.27
Family Household Structure								
Married Couples	PopGen	72.82	71.05	72.76	72.70	-0.12	1.65	-0.06
Male Householder, no wife		7.96	8.65	7.98	8.10	0.14	-0.56	0.12
Female Householder, no husband		19.21	20.30	19.26	19.21	0	-1.09	-0.05
Presence of Children								
Households with children	PopGen	23.16	36.92	38.32	35.11	11.95	-1.81	-3.21
Households without children		76.84	63.08	61.68	64.89	-11.95	1.81	3.21
Number of Persons								
1 person	PopGen	22.72	23.72	22.73	18.15	-4.57	-5.57	-4.58
2 persons		27.38	28.33	27.41	27.70	0.32	-0.63	0.29
3 persons		15.82	16.13	15.97	17.61	1.79	1.49	1.64
4 persons		15.67	15.56	15.40	16.95	1.28	1.39	1.55
5 persons		9.15	8.87	8.99	9.75	0.6	0.88	0.76
6 persons		4.69	4.21	4.60	4.95	0.26	0.74	0.35
7 or more persons		4.58	3.18	4.90	4.89	0.31	1.71	-0.01

CEMSELTS 2003 Household Level Modules

Household Socio-demographics	Model Component	Percentage Values				
		ACS 2003	Census 2000	Predicted	Difference in Percentage (ACS 2003)	Difference in Percentage (Census)
Number of Vehicles						
Households with no vehicles	CEMSELTS	8.29	10.07	7.27	-1.02	-2.79
Households with 1 vehicle		33.34	34.85	31.32	-2.02	-3.55
Households with 2 vehicles		37.48	37.16	34.71	-2.77	-2.44
Households with 3 vehicles		14.10	12.59	15.17	1.07	2.59
Households with 4 or more vehicles		6.79	5.33	11.52	4.74	6.19
Number of Workers						
Households with no workers	CEMSELTS	12.21	11.31	16.84	4.63	5.54
Households with 1 worker		34.23	32.98	36.80	2.58	3.81
Households with 2 or more worker		53.57	55.71	46.36	-7.21	-9.35
Household Income						
$0- $9999	CEMSELTS	8.08	8.98	8.09	0.01	-0.90
$10,000-$24,999		17.72	17.86	26.93	9.21	9.07
$25,000-$34,999		11.13	11.70	13.52	2.39	1.82
$35,000-$49,999		15.05	15.24	14.47	-0.58	-0.77
$50,000-$74,999		18.53	18.89	13.58	-4.95	-5.31
$75,000-$99,999		11.27	11.16	7.54	-3.73	-3.62
$100,000-$149,999		11.08	9.78	7.28	-3.80	-2.49
$150,000 or more		7.14	6.38	8.58	1.44	2.20
Household Tenure						
Owner	CEMSELTS	55.74	54.78	61.05	5.30	6.25
Renter		44.26	45.22	38.95	-5.30	-6.25

CEMSELTS 2003 Individual Level Modules

Individual Socio-demographics	Model Component	Percentage Values						
		SCAG 2003	ACS 2003	Census 2000	Predicted	Difference in Percentage (SCAG 2003)	Difference in Percentage (ACS)	Difference in Percentage (Census)
Gender								
Male	PopGen	49.55	49.51	49.61	49.69	0.14	0.18	0.08
Female		50.45	50.49	50.39	50.31	-0.14	-0.18	-0.08
Race								
Caucasian	PopGen	52.85	37.35	38.85	41.59	-11.26	4.24	2.74
African American		7.42	6.89	7.30	7.12	-0.3	0.23	-0.18
Hispanic		--	42.56	40.57	36.90	--	-5.66	-3.67
Asian or Pacific Islander		10.74	11.20	10.44	3.15	-7.59	-8.05	-7.29
Other		28.99	1.99	2.84	11.24	-17.75	9.25	8.4
Age								
0-4	PopGen	7.55	7.57	7.78	7.67	0.12	0.10	-0.11
5-14		15.69	16.08	16.39	15.55	-0.14	-0.54	-0.84
15-24		14.92	14.11	14.37	14.85	-0.07	0.74	0.48
25-34		15.31	15.30	15.87	15.22	-0.09	-0.08	-0.65
35-44		15.59	15.83	16.10	15.48	-0.11	-0.35	-0.62
45-54		12.94	13.05	12.16	12.95	0.01	-0.10	0.79
55-64		8.09	8.32	7.40	8.12	0.03	-0.20	0.72
65 and up		9.91	9.74	9.94	10.17	0.26	0.43	0.23

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CEMSELTS 2003 Individual Level Modules

Individual Socio-demographics	Model Component	Percentage Values				
		ACS 2003	Census 2000	Predicted	Difference in Percentage (ACS 2003)	Difference in Percentage (Census 2000)
Enrollment of Children *(aged 3 to 17 years)*	CEMSELTS					
Preschool - Grade 3		37.07	41.17	44.59	7.52	3.42
Grade 4 - Grade 8		41.64	38.76	42.16	0.52	3.4
Grade 9 - Grade 11		21.29	20.07	13.25	-8.04	-6.82
Educational Attainment *(18 years and above)*	CEMSELTS					
Less than Grade 9		11.58	13.14	2.23	-9.35	-10.91
Grade 9 - Grade 12 (no diploma)		12.05	14.71	8.28	-3.77	-6.43
Completed High School		45.70	44.00	58.48	12.78	14.48
Associate or Bachelors		22.55	20.77	22.95	0.4	2.18
Graduate Degree (Masters or Ph.D)		8.12	7.37	8.06	-0.06	0.69
Labor Participation	CEMSELTS					
Employed		59.47	56.81	59.07	-0.40	2.26
Unemployed		40.53	43.19	40.93	0.40	-2.26
Employment Industry	CEMSELTS					
Construction and Manufacturing		19.92	20.67	14.46	-5.46	-6.21
Trade and Transportation		4.94	4.86	7.32	2.38	2.46
Personal, Professional and Financial		50.63	49.34	49.42	-1.21	0.08
Public and Military		3.94	4.04	5.07	1.13	1.03
Retail Trade		15.29	15.60	10.77	-4.52	-4.83
Other		5.28	5.49	12.96	7.68	7.47

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CEMSELTS Work Flow Distribution by Destination County

Origin County	Destination County													
	Census 2000 Work Flows (in %)							CEMSELTS 2003 Work Flows (in %)						
	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total	Imperial	Los Angeles	Orange	Riverside	San Bernardino	Ventura	Total
Imperial	0.60	0.00	0.00	0.01	0.00	0.00	0.61	0.76	0.00	0.00	0.02	0.00	0.00	0.78
Los Angeles	0.01	53.32	2.39	0.14	0.61	0.48	56.94	0.00	52.21	3.23	0.31	1.19	0.53	57.46
Orange	0.00	2.76	16.26	0.17	0.14	0.01	19.35	0.00	2.80	14.17	0.35	0.28	0.00	17.60
Riverside	0.01	0.55	0.77	6.22	0.90	0.00	8.45	0.00	0.23	0.21	7.59	1.39	0.00	9.43
San Bernardino	0.00	1.66	0.43	0.78	6.81	0.01	9.69	0.00	1.03	0.22	1.33	7.52	0.00	10.10
Ventura	0.00	1.02	0.01	0.00	0.00	3.93	4.97	0.00	0.99	0.00	0.00	0.00	3.64	4.63
Total	0.62	59.31	19.86	7.32	8.47	4.43	100.00	0.77	57.26	17.83	9.59	10.38	4.18	100.00

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SimAGENT
Activity Scheduling Framework

CEMDAP

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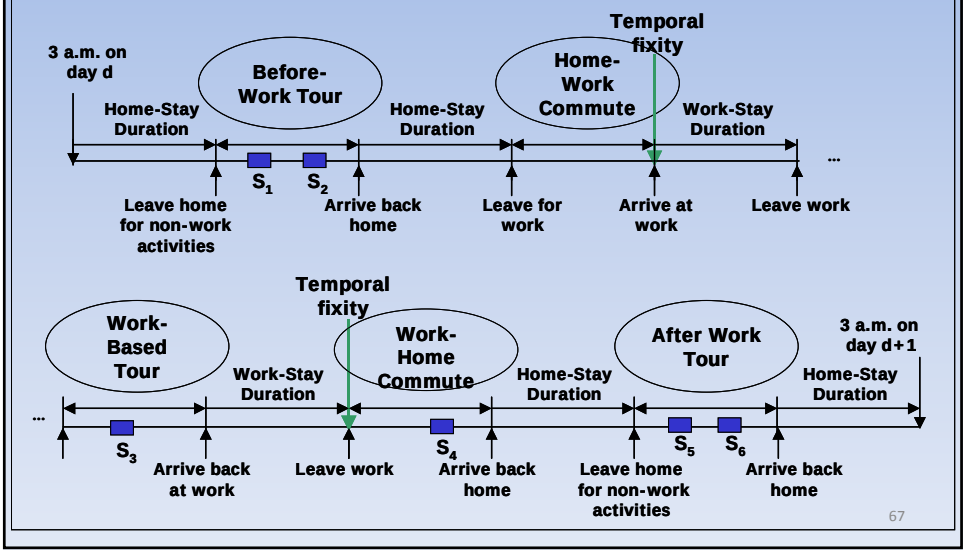
Representation for a worker's daily activity-travel pattern



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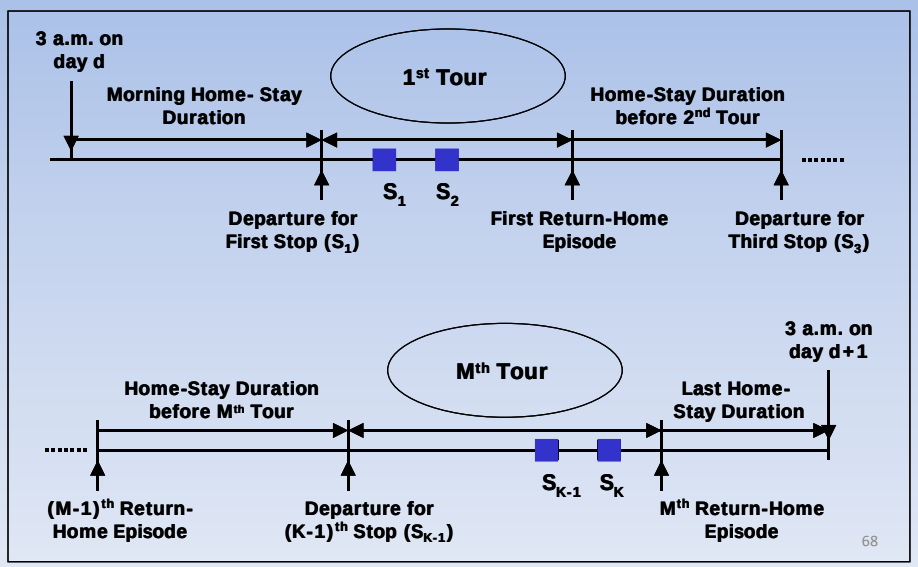
Representation for a nonworker's daily activity-travel pattern



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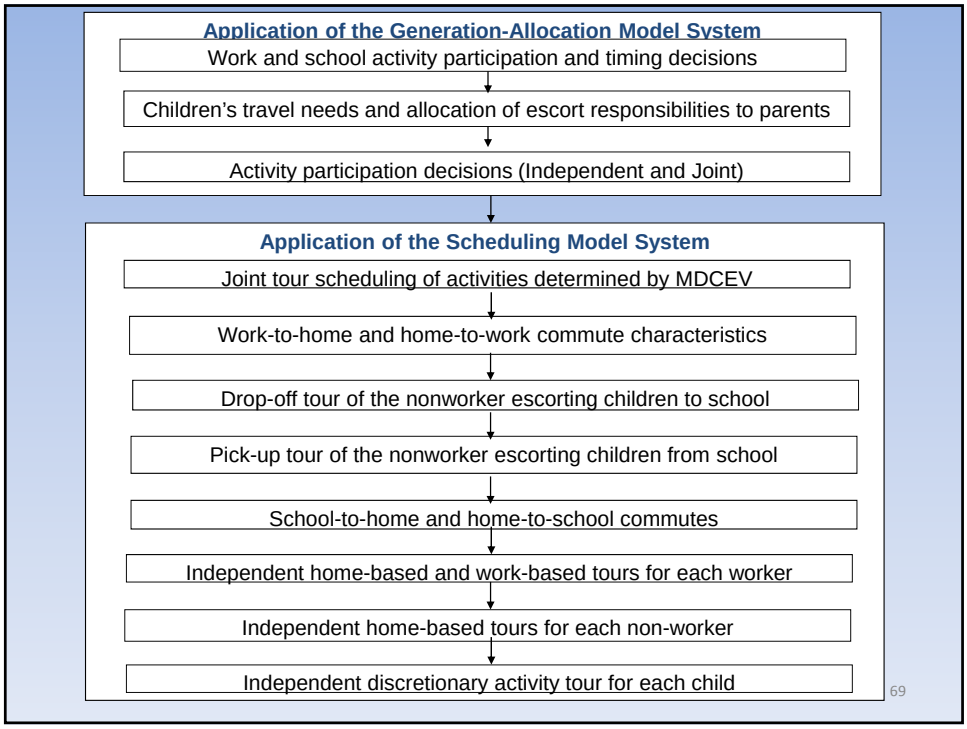
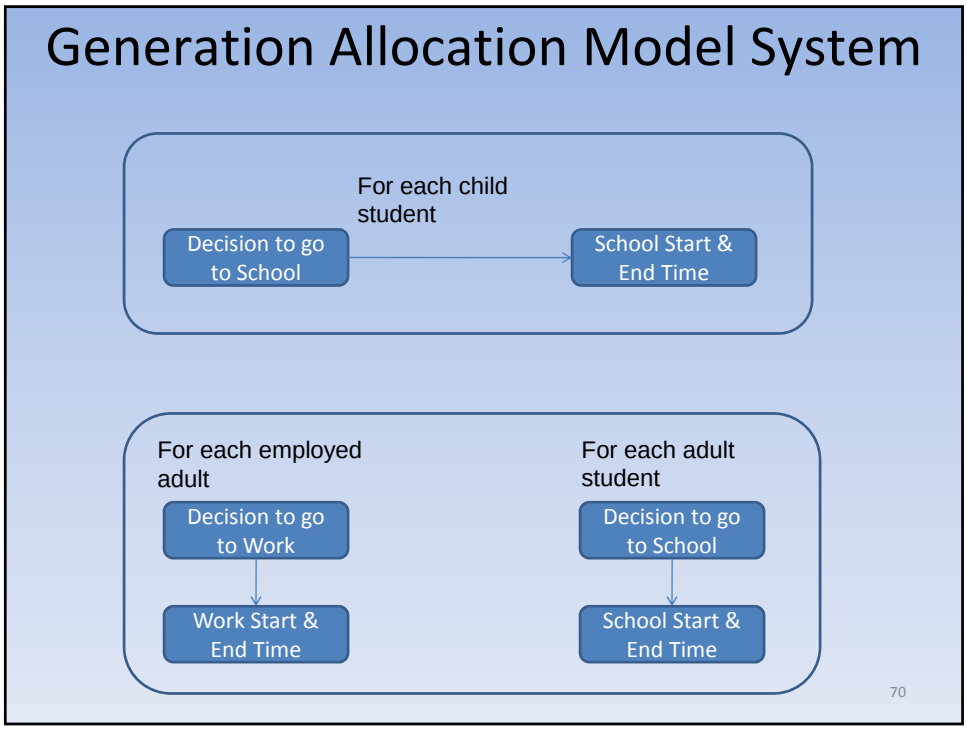
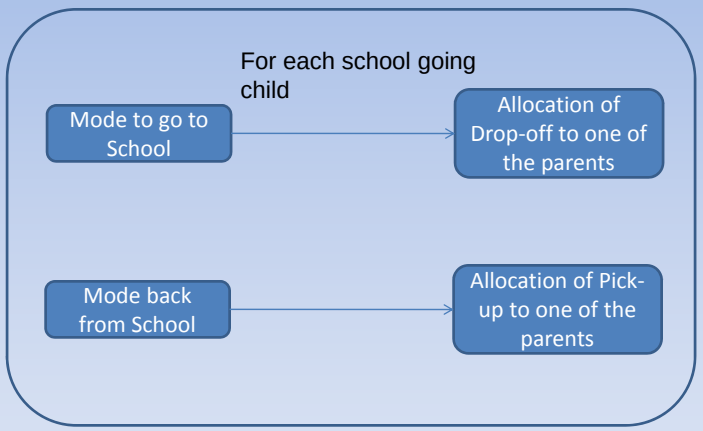

Application of the Generation-Allocation Model System
Work and school activity participation and timing decisions
Children's travel needs and allocation of escort responsibilities to parents
Activity participation decisions (Independent and Joint)
Application of the Scheduling Model System
Joint tour scheduling of activities determined by MDCEV
Work-to-home and home-to-work commute characteristics
Drop-off tour of the nonworker escorting children to school
Pick-up tour of the nonworker escorting children from school
School-to-home and home-to-school commutes
Independent home-based and work-based tours for each worker
Independent home-based tours for each non-worker
Independent discretionary activity tour for each child
69


Generation Allocation Model System
For each child student
Decision to go to School
School Start & End Time
For each employed adult
Decision to go to Work
Work Start & End Time
For each adult student
Decision to go to School
School Start & End Time
70

Generation allocation model system



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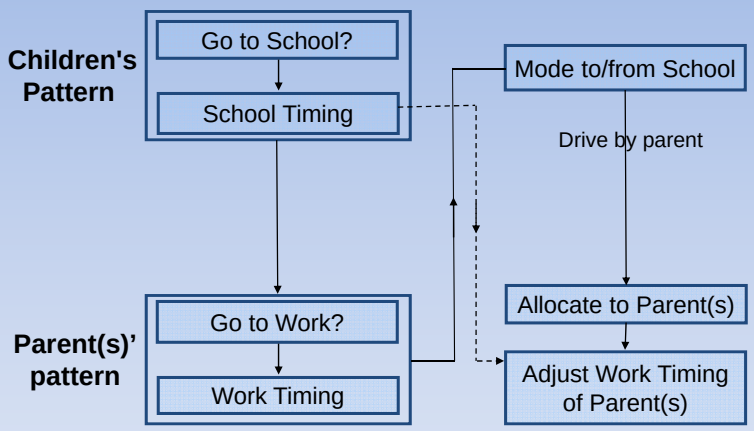
Interleaved Approach



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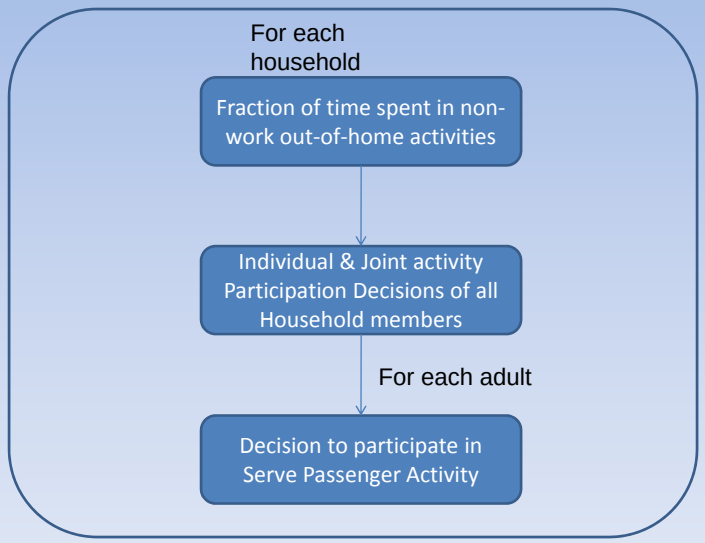
Generation allocation model system



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Joint Activities and Interactions

- In conventional discrete choice frameworks, the need to generate mutually exclusive alternatives results in an explosion in the number of alternatives
- MDCEV allows us to tackle the problem by considering activity participation as a household decision.
- MDCEV offers substantial computational and behavioral advantages

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Explosion of Choice Alternatives

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Each box represents an alternative

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MDCEV Model

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

\+ **None**

Each box represents an alternative

Total 7 alternatives versus 64 in traditional case

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MDCEV Model

Total choice set size comparison for 3 activity purposes

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

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

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MDCEV Alternatives

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

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MDCEV Alternatives

- Joint activities modeled only for households of size <=5
  - Constitute 97% of households in survey data
  - 95% of the joint activities undertaken by households <=5
- Two MDCEVs
  - *MDCEV1*: For Households of size <= 5 (allowing joint activity participation)
  - *MDCEV2:* For Households of size > 5 (only independent activities)
- *MDCEV1:*Maximum number of alternatives = 253 (8*(2^5 – 1) + 5)
- MDCEV2:Maximum number of alternatives = 10**N* (N = Household Size)

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Time Budget for MDCEV

- Total time budget needed for predicting activity participation durations in MDCEV determined using Fractional Split Model (FSM)
- FSM→ Three alternatives
  - Fraction of Total Household in-Home activity participation duration (f1)
  - Fraction of Total time spent traveling (f2)
  - Fraction of Total household out-of-home non-work activity participation duration (f3)
- Budget for MDCEV = f3**N**(1440 – work/school duration of individual *i*)
  - *N* = Number of people in household
- MDCEV Output: Total activity participation duration throughout the day in each of the activity alternatives

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Scheduling Model System: Joint Tours

- Number of episodes of joint participation of each activity type = 1 in almost all households in the survey data
- For each joint activity generated using MDCEV, Run→
  - Joint Travel or Separate Travel model
  - Joint Activity Start Time model
    - Number of minutes from the constraint time
    - Constraint time determined by Work/School End Time of participating members, School start time of kid if adult making drop –off is participating member of joint activity, & previous joint activity end time
    - People making pick-up did not participate in joint activity in the data
  - Travel time to joint activity model
  - Joint activity location model
  - Joint tour vehicle model for joint travel

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Scheduling Model System: Joint Tours

- Joint activities of workers scheduled in work-to-home commute or After-work period
  - Determined by the Joint Activity Start Time
- For non-workers participating in joint activities
  - Decision to undertake independent tour before pick-up or joint tour
  - Decision to undertake independent tour after pick-up or joint tour

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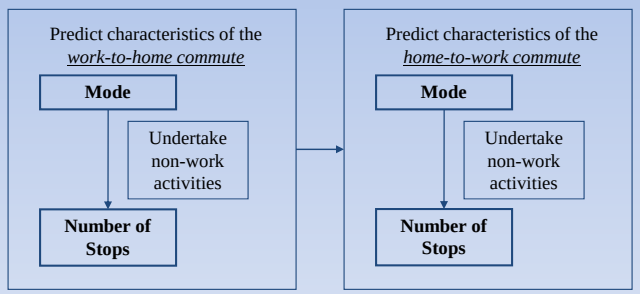
Modeling the Commute Characteristics of Workers



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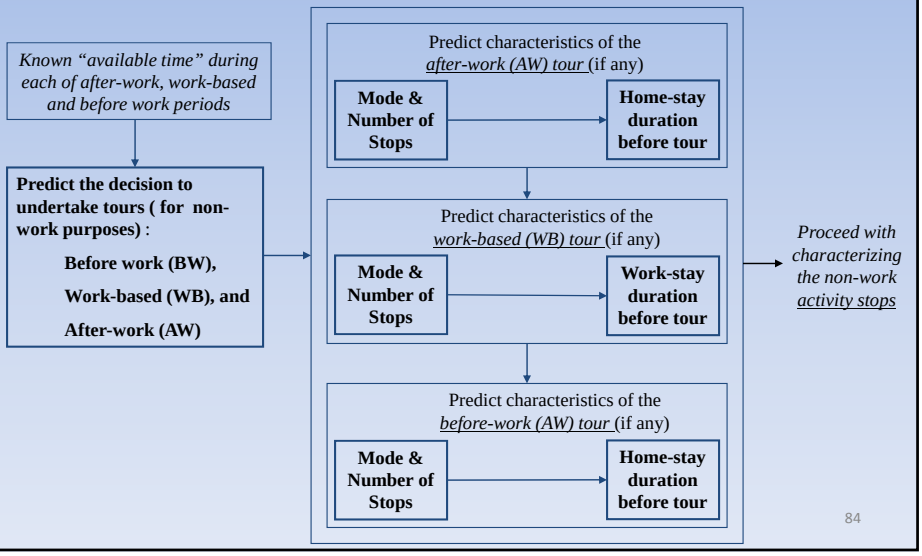
Modeling Non-work Activity Scheduling of Workers: Characterizing Tours



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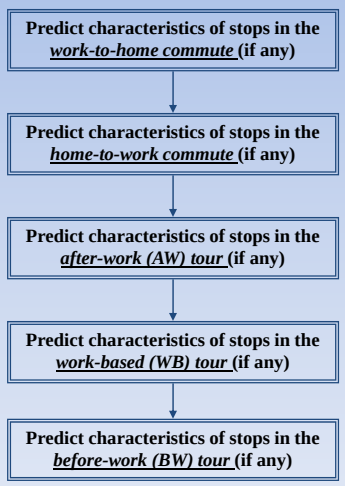
Modeling Non-work Activity Scheduling of Workers: Characterizing Stops



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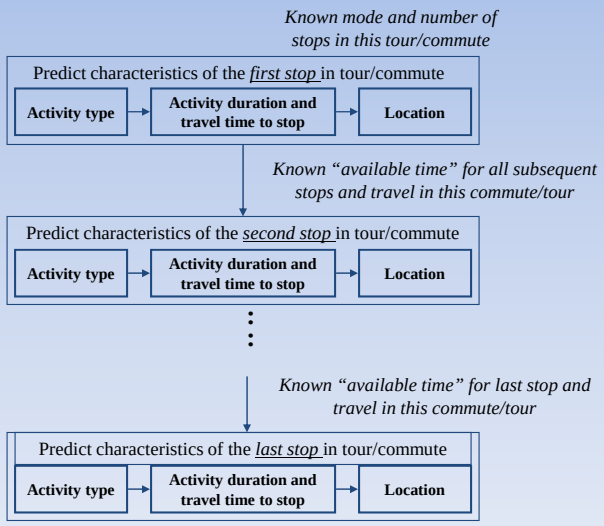

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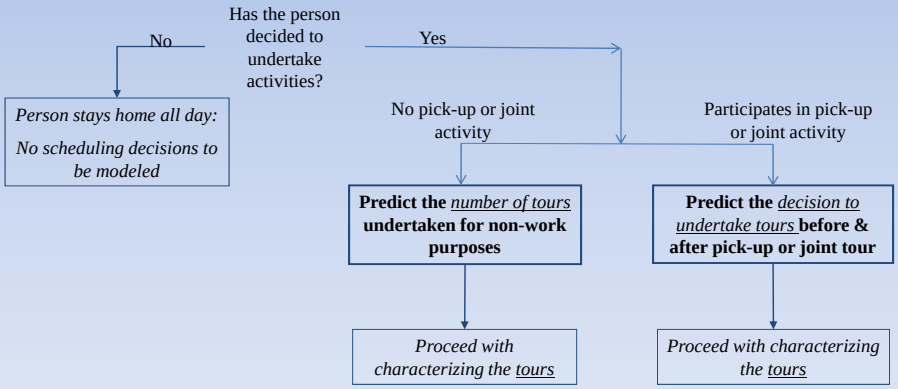
Modeling Number of Independent Tours for Non Workers



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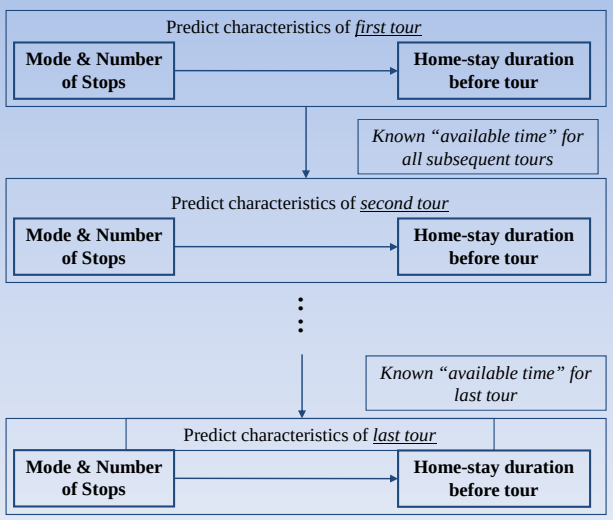
Modeling Activity Scheduling of Non-Workers: Characterizing Tours



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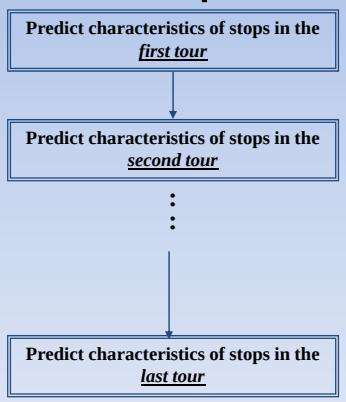
Modeling Activity Scheduling of Non-Workers: Characterizing Stops



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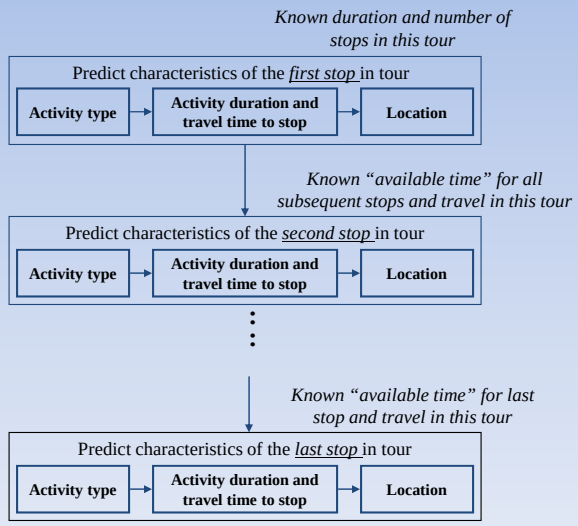
Modeling Activity Scheduling of Non-Workers: Characterizing Stops



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SimAGENT: Simulation Outputs

- SimAGENT produces as output the complete activity-travel patterns for a day for every individual in the population of interest.
- There are nine output files:
  - Adults: decisions to undertake activities of different types for adults
  - Children: decisions to undertake activities of different types for children
  - Workers: pattern-level attributes of the workers' (including adult students)
  - Students: pattern-level attributes of the child students
  - Non-workers: pattern-level attributes of non-workers
  - Tours: tour-level attributes
  - Stops: stop-level attributes
  - No Travel: list of people who did not undertake travel
  - Vehicles: vehicle fleet characteristics of the household

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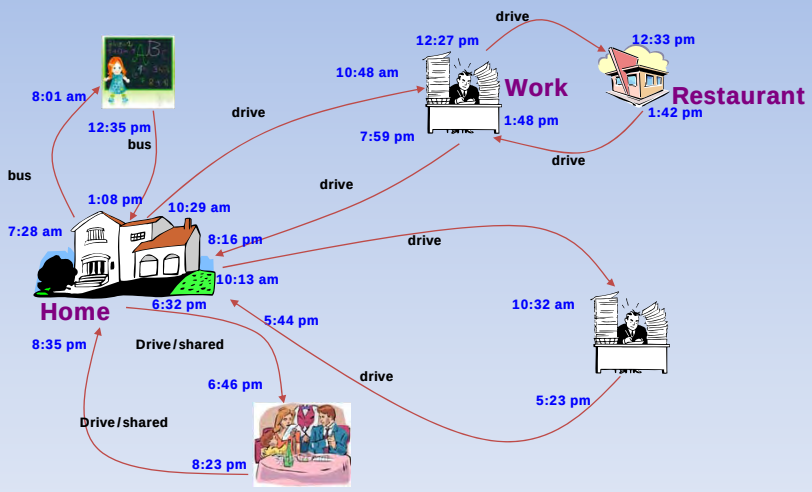
Sample SimAGENT Output: Daily activity-travel undertaken by a household



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SimAGENT Output: Adults

ADULTS.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Adult goes to work on the day
4	Adult undertakes work-related activity
5	Adult drops-off children at school
6	Adult picks-up children from school
7	Adult undertakes joint discretionary activities with children
8	Adult undertakes shopping activity
9	Adult undertakes HH/personal business activity
10	Adult undertakes social/recreational activity
11	Adult undertakes eat-out activity
12	Adult undertakes other serve passenger activity

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SimAGENT Output: Children

CHILDREN.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Child goes to school on the day
4	Child undertakes joint discretionary activities with parent
5	Child undertakes independent discretionary activities

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SimAGENT Output: Workers

WORKERS.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Work/school start time
4	Work/school end time
5	Number of before-work tours
6	Number of work-based tours
7	Number of after-work tours

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SimAGENT Output: Students

CHILDSTU.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	School start time
4	School end time
5	Child gets dropped off at school by parent
6	Child gets picked up from school by parent

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SimAGENT Output: Non-workers

NONWORKERS.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Total number of tours made

97

SimAGENT Output: Tours

TOURS.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Tour identification number
4	Home/work stay duration before tour
5	Tour mode
6	Tour duration
7	Number of stops in tour
8	Joint Tour Identification number
9	Joint travel or separate travel
10	Vehicle used for the tour

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SimAGENT Output: Stops

STOPS.OUT	
Column No.	**Description**
1	Household identification number
2	Person identification number
3	Tour identification number
4	Stop identification number
5	Activity type
6	Start time of travel to the stop
7	Travel time to stop
8	Stop duration
9	Stop location (zone) ID
10	Origin zone ID
11	Trip distance (zone to zone)
12	Activity type at the previous stop

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SimAGENT Validation

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Average Number of Trips per Household

Type of Trips	SimAGENT	Survey	SimAGENT (85% Work Scenario)	SimAGENT (95% Work Scenario)
Home Based Work	1.27	1.33	1.68	1.97
Home Based Other	5.13	4.90	4.94	4.88
Non-home based	2.31	2.59	2.69	2.93
Total	8.71	8.82	9.30	9.79

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Number of Worker Tours
SCAG Survey *vs.* SimAGENT

Number of Tours	BW		WB		AW	
	Survey	SimAGENT	Survey	SimAGENT	Survey	SimAGENT
0	94.26	96.69	81.03	76.67	79.48	81.36
1	5.74	3.31	16.59	18.01	17.86	17.17
2	--	--	2.38	5.32	2.66	1.47

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Number of Non-Worker Tours
SCAG Survey *vs.* SimAGENT

Number of Tours	Survey	SimAGENT
1	58.81	55.51
2	27.54	24.79
3	9.49	12.55
4	4.17	7.15

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Number of Stops
SCAG Survey *vs.* SimAGENT

	Survey	SimAGENT
Avg. no. of stops in WB tour	1.37	1.36
Avg. no. of stops in BW tour	1.41	1.34
Avg. no. of stops in AW tour	1.40	1.36
Avg. no. of stops in WH commute	0.40	0.35
Avg. no. of stops in HW commute	0.26	0.18
Avg. no. of stops in non-worker tour	1.78	1.66

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Tour Mode Shares: SimAGENT *vs.* Survey

	WH Commute		WB Tour		BW Tour		AW Tour		NW	
	SimAGENT	Survey	SimAGENT	Survey	SimAGENT	Survey	SimAGENT	Survey	SimAGENT	Survey
DA	77.7	78.2	64.2	69.3	56.5	44.0	55.0	56.2	51.9	39.8
DR_PAX	8.9	9.8	15.9	13.8	26.2	39.1	35.3	31.7	28.8	36.7
SR	8.1	6.6	6.0	6.3	4.0	2.5	3.9	5.1	12.2	14.1
W/B	2.7	2.9	13.7	10.1	12.7	14.0	4.9	6.3	5.7	7.5
TR	2.6	2.5	0.2	0.5	0.6	0.5	0.9	0.7	1.4	1.9

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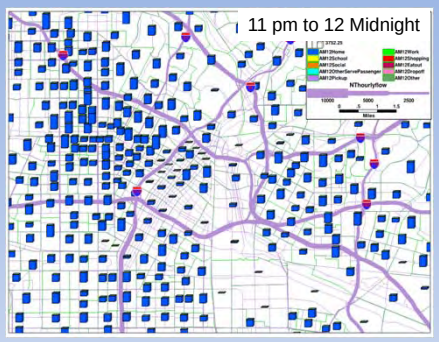

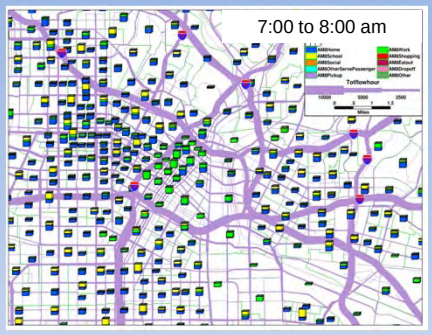

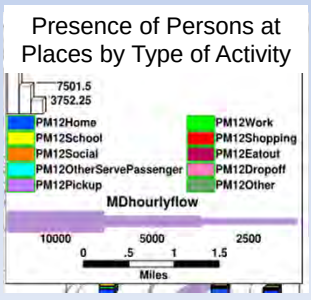

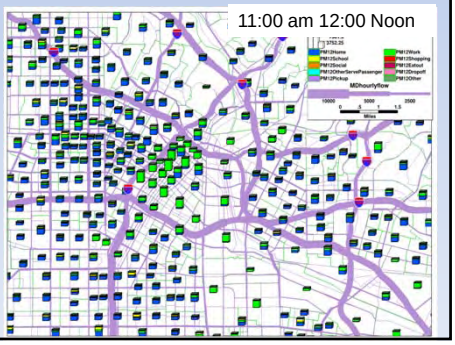

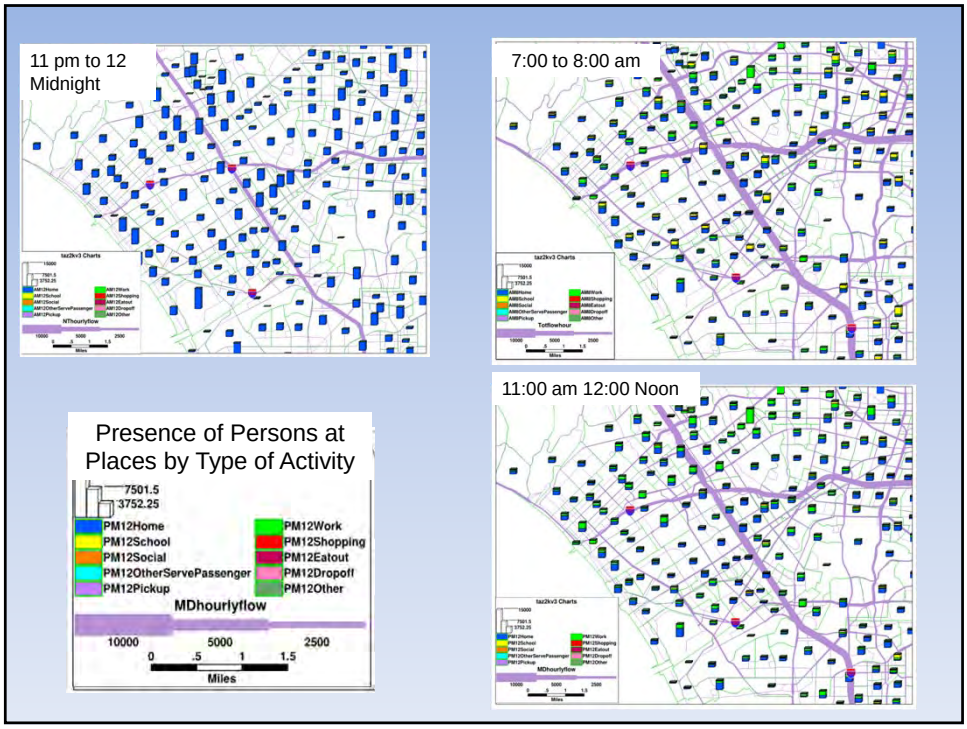

Comparison with 2008 4-step model

Emissions and Fuel Consumption	4-Step Model*	SimAGENT Baseline*
Organic Gases (g/mile)	0.943	0.926
CO (g/mile)	9.498	9.348
NOx (g/mile)	1.929	1.955
CO2 (g/mile)	561.340	543.545
Gasoline (gallons/mile)	0.051	0.050
Gasoline (mile/ gallons)	19.377	20.203
Diesel (gallons/mile)	0.102	0.101
Diesel (mile /gallons)	9.833	9.893
Organic Gases (g/person-day)	22.291	21.333
CO (g/person-day)	224.553	215.388
NOx (g/person-day)	45.606	45.050
CO2 (g/person-day)	13271.790	12524.452
Vehicle Miles Travel/person-day	23.643	23.042

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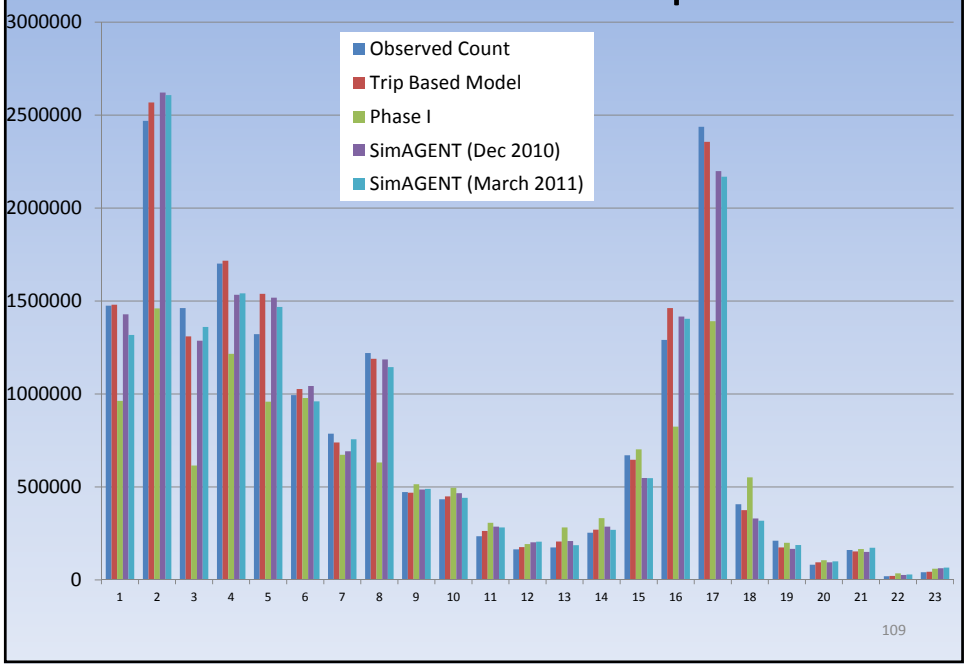
Verification is ongoing!

Screenline Counts Comparison



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Ongoing Work

- Completed model calibration and tests; conducting sensitivity tests for SB 375 policy scenarios (cost, time, growth, spatial land use distribution)
- Ongoing/planned efforts:
  1) Re-calibrate model with new data SCAG has developed for 2012 RTP
  2) Undertake extensive technology transfer and training; SCAG staff being trained in model operation, analysis, theory, and model estimation
  3) Build interface with PECAS land use model

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More Plans

1) Re-estimate the model based on new travel survey/Census,
2) Use finer TAZ system (12000+ zone system)
3) Develop DTA capability (DynusT, MATSIM)
4) Perform emissions analysis with link between DTA and MOVES
5) Add links and feedback loops to PECAS land use model
6) Integrate with household and vehicle evolution models
7) Enhance model of vehicle ownership, body type, make and model as well as vehicle allocation model

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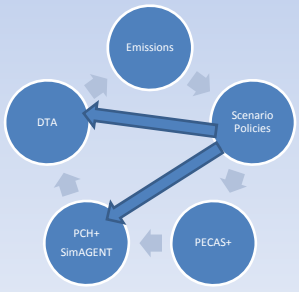
Joint Team and SCAG Staff Vision

- By end of the project, SCAG will have an integrated model system with PECAS land use model - dynamic demographic simulation (PopGen-CEMSELTS-HH evolution model - PCH) to CEMDAP (daily activity pattern) to DTA to MOVES



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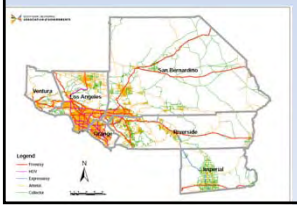
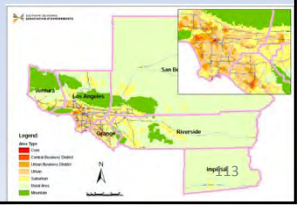
THANK YOU!

SOUTHERN CALIFORNIA
ASSOCIATION of GOVERNMENTS





Appendix M: Presentation – Land Use Forecasting Model: PECAS Progress Report

Peer Review Meeting – June 28, 2011

SOUTHERN CALIFORNIA
ASSOCIATION of GOVERNMENTS

PECAS PROGRESS REPORT

Presented by John Abraham, Ph.D. (HBA Specto)

SCAG Validation Peer Review
6/28/2011

SOUTHERN CALIFORNIA
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6/28/2011

Contents

- Objectives
- Team
- Model description
- Status
  - Tasks
  - Data
  - Scenarios
- Next steps

Project Objectives

- A working land use model for coming SCS/RTP process
  - Provide overall & region-wide land use pattern by scenarios
- Support demand for comprehensive impact analysis
  - Mainly scenario test tool for region-wide impacts from policy variables
- Establish in-house knowledge base on model and data

Project Team

- Consultants
  - UC Davis (ULTRANS)
    - Mr. Mike McCoy. Project Manager
    - Dr. Sheng-yi Gao (statewide model)
    - Mr. Eric Lehmer (Database / software)
  - HBA Specto Inc.
    - Prof. John Douglas Hunt
    - Dr. John Abraham
    - Dimantha De Silva, Abdel-Rahman Muhsen
- Staff
  - Sungbin Cho, Program Manager
  - Cheol-Ho Lee, Data/GIS

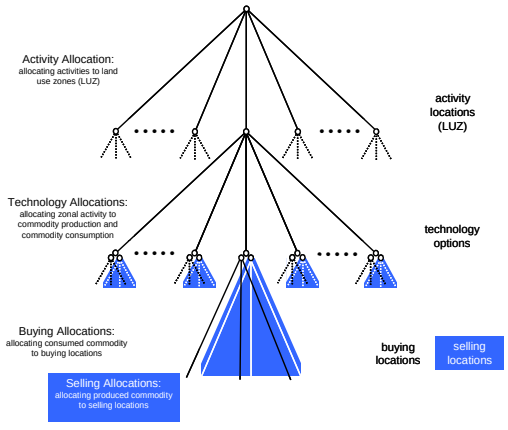
Integrated Land Use Model

- PECAS = Production – Exchange – Consumption Allocation System
  - Activity Allocation (AA) Module allocates economic activities to Land use zone (LUZ)
    - Series of Choices
    - Short term equilibrium, searching for market-clearing prices in each type of interchange
  - Space Development (SD) Module forecasts land use change of each land parcel
    - By given transition probability, rent (at LUZ level) and local rent/cost modification factors

Integrated Land Use Model

- AA Module
  - Buy/Sell location
  - Technology
  - Activity location
  - Activity Flow

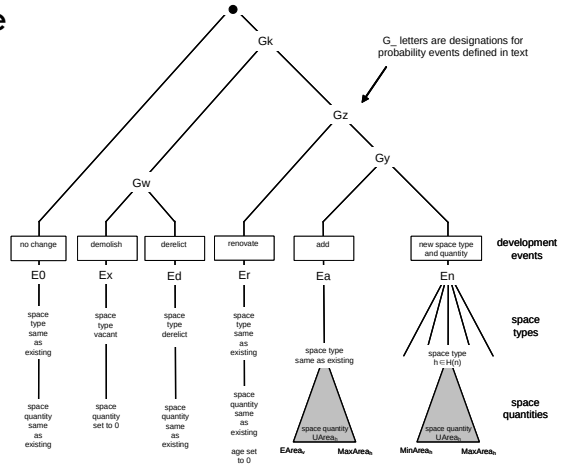
LUZ spatial treatment



Integrated Land Use Model

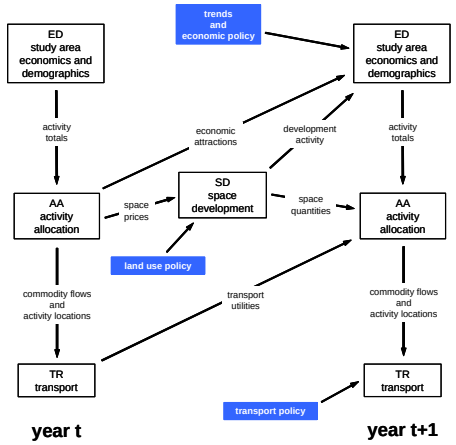
- SD Module

Parcel Microsimulation Treatment



Integrated Land Use Model

- Model System



Status

- Tasks
  - Design Knowledge Transfer Framework …done
  - Design SCAG PECAS Model … done
  - Statewide PECAS Model Transfer … done
  - Knowledge Transfer … on going
    - Based on the Statewide Mode and Data
    - Staff follows the Model Development Process
    - Workshops and weekly conference
    - Model runs by staff, review with consultant
  - Calibration and Scenario Test … on going

Status – Model Development

- Yr 2009
  - 10 Workshops over 28 days at SCAG or UCD
  - Covered Topics are
    - Model structure, Source Code, Data Structure
    - Synthesizing Missing Information
    - Model Runs and Scenario Development
    - Calibration Strategy and Method
- Yr 2010
    - Weekly Conference Calls
    - Major thrust in Data Development
    - Currently, Scenario Test and Calibration stage

Status – Model Development

- 29 Model Development Process

Not started	Statewide Model	Initiated	Completed

Establish Space Rents and Rent Modifier Equations	Develop Commodity Production Zonal Level Targets
Establish Space Transition Cost System	Develop Commodity Consumption Zonal Level Targets
Establish Space Maintenance Cost Equations	Develop Commodity Spatial Flow Targets
Establish Base Year Parcel Database	Develop Imports and Exports Targets by External Zone
Establish Base Year Space Quantities by Zone	Establish Imports and Exports Equation Parameters
Establish All-Year Parcel Inputs for Calibration Period	Develop Skim Matrices From Transport Model
Establish Pseudo-Parcel Settings and Space Transition Constants	Establish X-Vector Attribute Values
Establish Transport Utility Equations	Establish Buying and Selling Utility Equation Parameters
Establish Floor Space Short-Run Supply Curves	Establish Size Terms for Import and Exports Commodities
Identify Household Technology Option Points	Establish Technology Allocation Utility Equation Parameters
Identify Industrial Technology Option Points	Establish Location Allocation Utility Sensitivity Parameters
Identify Accounts Categories Technology Option Points	Establish Location Allocation Utility Equation Zone Constants
Develop Labor Production Zonal Level Targets	Develop Transport Model Inputs From PECAS Outputs
Develop Labor Consumption Zonal Level Targets	Conduct Semi-Automated Stage 3 Calibration
Develop Labor Spatial Flow Targets	

Status - Data

- Parcel-based land use DB
  - Minimum spatial modeling unit
  - Basis of individual business (employment), commercial building and household data
- Attributes
  - 2008 polygon, 2007 attributes. 4.8 million records
  - ID(APN), Location, County-identified Use, Property Size and Value
  - Existing Land use and General Plan from cities and counties

Status - Data

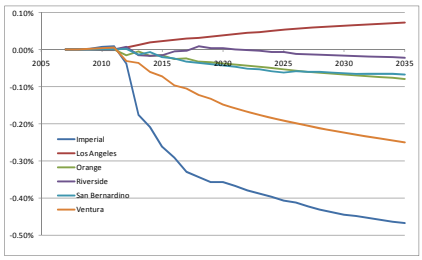
- Business Database
  - Individual business with location, industrial code, employment
- Building Inventory
  - 'All' buildings in rent market with historical rent
- Others
  - Regional Input-Output (IMPLAN & REMI)
  - Freight data
  - ACS Census Micro data

Initial Scenario Tests

- Compares to official forecast (Aug 2010 version)
  - Calibrated with separate space supply (transition) for each county to prevent even growth distribution
- Model showed significant travel impedance sensitivity to VMT Pricing, yet limited sensitivity to household and job reallocation
- Showed limited sensitivity to Maximum Density in the General Plan (for TOD)
- Variation in wage and commodity price spatially as well as temporally as proper imports and exports are introduced
- Limited sensitivity of development capacity to household and job reallocation

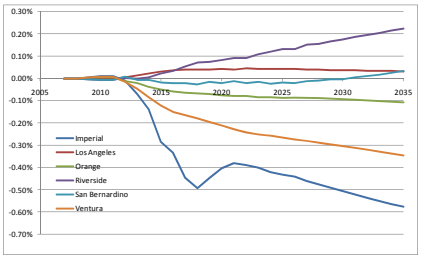
TOD Scenario impact

- TOD Scenario: allow 50% more density within 0.5 mile to transit stops

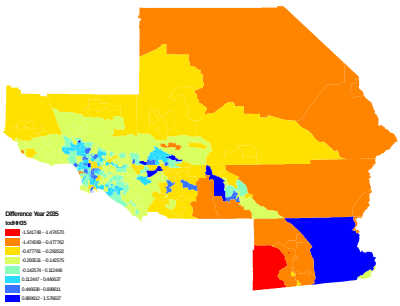


Households (Δ to Base, %)

Jobs (Δ to Base, %)

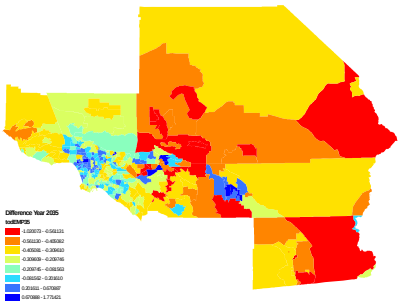


TOD Scenario Impact

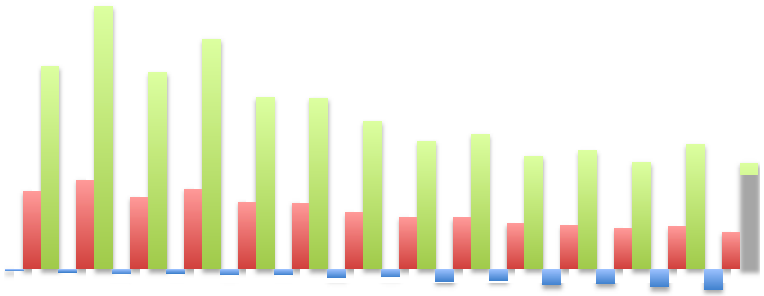


Households (Δ to Base, %)
(Yr 2035)

Jobs (Δ to Base, %)
(Yr 2035)



Household Benefit Measures



Further calibration

- Prioritized model improvements
- Location sensitivity parameters
  - Were borrowed from uncalibrated statewide model
- Import/Export function sizes
  - Were set large to ensure convergence in situations of data inconsistency

Larger and more complex changes

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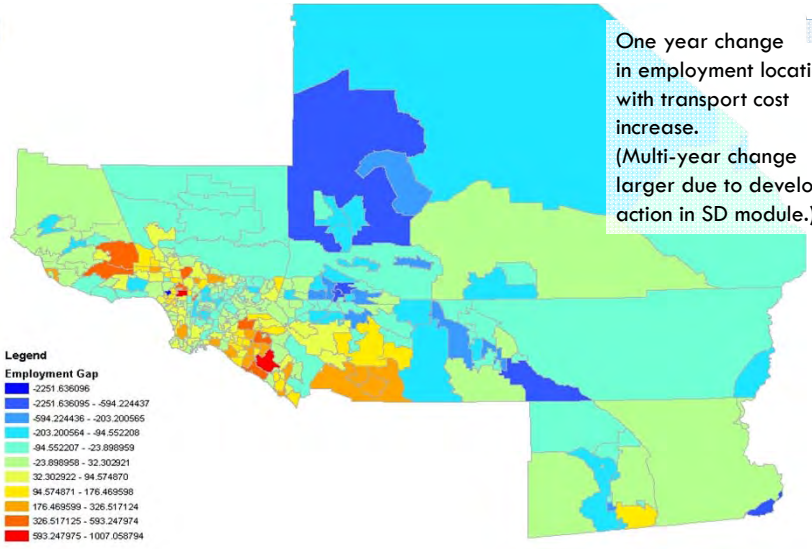

One year change in employment location with transport cost increase. (Multi-year change larger due to developer action in SD module.)

Integrated Land Use Model

- A Scenario Analysis Tool
  - Aggregated spatial economic representation
  - Detailed economic categories
  - Sensitive to global parameters, such as gas price, and allowing Floor-Area ratio
- Can support further spatial disaggregation
  - Other models need SED in small area
  - Parcel microsimulation supports spatial detail

Action Items – Mid Term

- Model Validation
  - With multi-year parcel databases, sub-county validation (TAZ, LUZ, other aggregations)
- Further Scenario Tests
  - Re-run scenarios that have been previously setup, compare results between scenarios.
- Peer Review Fall of 2011
- Outreach
  - Start planning within SCAG for model use in currently relevant policy analysis
  - Member agency and other stakeholders

Q/A

- Question ?