The SHRP 2 Capacity Program
Background and Context for Advances in Travel Demand Modeling

Steve Andrle, Transportation Research Board
SHRP 2 Focus Areas

- **Safety**: fielding the largest-ever naturalistic driving study to reduce crashes and save lives through understanding driver behavior
- **Renewal**: making rapid, innovative construction possible for “ordinary” projects
- **Reliability**: Providing management and technical tools to reduce congestion through operations
- **Capacity**: Systematizing collaborative decision making to achieve better, faster project decisions
Capacity Background

- Charge from Congress: “Develop approaches and tools for systematically integrating environmental, economic, and community requirements into the analysis, planning, and design of new highway capacity.”
- Highway expansion projects were taking too long, were too often being delayed, or were not able to obtain the necessary approvals in the planning and environmental review process.
1. Compile lessons learned from case studies of successful delivery of 23 large and complex capacity expansion projects from across the United States

2. Develop methods to integrate transportation, environmental, community, and economic planning

3. Develop methods for addressing issues that were not being adequately addressed in the transportation planning and project development process
Issues with Travel Forecasting

- There was no feedback between the supply and demand side of forecasting models. What effect do network conditions have on route choice, time choice, mode choice, willingness to pay a toll, etc.
- It was difficult to deal with motorist reaction to pricing and congestion in planning models.
- Activity-based models offered promise but were slow to be adopted. What are the real costs and hurdles to overcome?
- It was not clear to what extent activity-based model structures could be successfully borrowed.
- There is no training guide for activity-based models.
- A quick-response model for estimating the travel effects of smart growth strategies was not available.
What SHRP 2 Did

• Modified existing travel demand and DTA models to operate in a feedback mode. The models were built and estimated for a 5-county region in the Jacksonville, Florida area and the SACOG area in Sacramento.
  – Daysim was linked to Transims in Jacksonville and a test network in Burlington VT.
  – Daysim was linked to DynusT in Sacramento and a transit simulation component was added (FastTrips)
  – Jacksonville demand model parameters were transferred to Tampa to test the feasibility of borrowing a model
• Estimated a series of equations from existing data sets for use in demand models (C04). The C04 results were used in the Jacksonville and Sacramento models
• Bullt SmartGap, a quick–response model based on prior work done by Oregon DOT, EPA, and FHWA. Estimates the travel demand effects of smart growth strategies.

• SHRP 2 is in the process of building a primer on activity-based models that shows linkages to land use models and DTA’s. The primer will become a part of TF (Travel Forecasting) Resources, a web-based resource being developed at TRB.
Status

• A “snapshot” of the Jacksonville and Burlington model sets is available. The report is in review and will be available shortly.

• The Sacramento work will be finished by the end of October 2013. The model sets will be available.

• SmartGap, a users guide, and *The Effect of Smart Growth Policies on Travel Demand* are available now on the SHRP 2 website

• *Improving our Understanding of How Congestion and Pricing Affect Travel Demand* (C04) is available on the SHRP 2 website

• The Primer is in progress and scheduled for completion in April 2014
Research Conducted on Other Issues

1. Collaborative Decision Making
2. Performance measurement
3. Analysis of economic benefits of projects
4. The relationship between operational improvements and the need for additional capacity
5. Joint transportation and environmental planning
6. Community visioning, smart growth, greenhouse gas emissions issues
7. Dealing with public-private partnership (P3) projects
8. Addressing freight issues
9. Means to the expedite planning and project delivery process
Direction of the Technical Coordinating Committee

- Document the decision points in a process that follows the steps used in successful capacity expansion projects
- Organize information on lessons learned from these successful projects around the decision points in the process and make all this information available via a web portal
- The web portal was named “Transportation for Communities - Advancing Projects through Partnerships,” and is referred to as “TCAPP.”
Conclusions of Research

1. Collaborative decision-making is a key to success, supported by an effective strategy for enhancing the environment, improving economic vitality, and achieving community goals.

2. The transportation planning and project development process as practiced and as defined in federal statutes and regulations is an elaborate and complex process that involves a series of decision points.

3. Improved forecasting tools can better represent the effects of operational improvements and aid decision making.

4. Decisions need to be agreed to by key decision makers at each point in the process and not revisited.

5. Many of the key decisions that enable a project to be approved should be made before the NEPA process begins.
Effective Collaborative Decision Making

Effective Strategies for Environmental, Economic, and Community Goals
SHRP2 Project C04: Improving Our Understanding of How Congestion & Pricing Affect Travel Demand

Advances in Travel Demand Forecasting
TRB Webinar October 1, 2013
Research Team

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- Principal Investigators
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  - Kara Kockelman, UT-Austin
  - Tom Adler, John Bowman, RSG
  - Jean Wolf, GeoStats (Westat)
Primary Objectives and Focus

- Select and thoroughly analyze travel behavior data in order to formulate approaches to better model impacts of congestion and pricing on travelers and transportation systems … primarily within an Activity-Based Modeling (ABM) framework

- Focus on key challenging modeling issues:
  - Generalized cost formulation – assessment of delays /time in congestion
  - Variation in traveler preferences w/r to travel time, costs, VOT
  - (Un)Reliability of travel

- Site specific testing - estimation of new relationships with validation of findings and testing for cross sites / transferability

- Synthesis of findings and general recommendations for model developers, with an emphasis on model structure needed to accommodate the developed functions
C04 Data Sources

- Principal Sites: Integrated regional data and implementation testing:
  - Seattle (PSRC)
  - New York (NYMTC, MTA, NYCDOT, PANYNJ)

- Supporting Sites: Project site specific analysis / transferability testing:
  - San Francisco (SFCTA, MTC)
  - Minneapolis: I-394 MnPASS HOT (MnDOT)
  - Chicago (CMAP)
  - San Diego: I-15 ML (SANDAG)
  - Orange County: SR-91 (OCTA)
  - Baltimore Region: DYNASMART-P
  - NY BPM Region: Mode and Route choice demand model implementation with DYNASMART-P
Model Estimation Approach

Progressive testing of increasingly more complicated model specifications

1. Basic model – estimate parameters for time and cost only in linear function,
2. Explore non-linear and distance effects
3. Perception of travel time by congestion levels and facility type
4. Impact of income
5. Impact of car occupancy
6. Impact of gender, age, and other person characteristics
7. Incorporation of reliability measures
8. Toll-averse bias
9. Situational variability (unobserved heterogeneity) in traveler preferences
Specification of an Extended Auto Utility Function in Travel Choice Models
Basic Generalized Cost Function (Starting)

- $U = b \times Time + c \times Cost$
  - $b =$ travel time coefficient
  - $c =$ travel cost coefficient
  - VOT = $b/c$ (constant)

- Most of research and nearly all of models in practice use this simple function for auto utilities

- This function is simplistic and masks many important effects of congestion and pricing
Perceived Time by Congestion Levels

- $U = b \times \text{Time} + c \times \text{Cost}$
- $U = b_1 \times \text{FFTTime} + b_2 \times \text{Delay} + c \times \text{Cost}$
- $b_2 / b_1 \approx 1.5 - 2.0$

Every minute spend in congestion conditions is perceived as 1.5-2.0 min of free driving!

May serve as a proxy for travel time unreliability:
- Loses significance if reliability is incorporated directly
- Useful for simple models that cannot incorporate reliability directly
Incorporation of Reliability

- \( U = b \times Time + c \times Cost \)
- \( U_s = b \times Time + c \times Cost + d \times STD/Dist \)
  - \( d \) = coefficient for reliability measure
  - \( VOR = (d/c)/Dist \)
  - \( VOR/VOT = (d/b)/Dist \) (Reliability Ratio ≈ 0.5-1.5)
  - Typical VOR range:

<table>
<thead>
<tr>
<th>Trip purpose</th>
<th>Distance</th>
<th>VOR</th>
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</thead>
<tbody>
<tr>
<td>Work</td>
<td>5 miles</td>
<td>$54.9/hour</td>
</tr>
<tr>
<td></td>
<td>10 miles</td>
<td>$27.5/hour</td>
</tr>
<tr>
<td></td>
<td>20 miles</td>
<td>$13.8/hour</td>
</tr>
<tr>
<td>Non-work</td>
<td>5 miles</td>
<td>$40.8/hour</td>
</tr>
<tr>
<td></td>
<td>10 miles</td>
<td>$20.4/hour</td>
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<tr>
<td></td>
<td>20 miles</td>
<td>$10.2/hour</td>
</tr>
</tbody>
</table>
Toll-Averse Bias

- $U = b \times Time + c \times Cost$
- $U_t = a + b \times Time_t + c \times Cost_t$ (for toll routes)
- $U_{nt} = b \times Time_{nt} + c \times Cost_{nt}$ (for non-toll routes)
  - $a =$ toll bias (toll-averse bias if negative)
- Toll bias represents psychological perception beyond time-cost tradeoffs:
  - Significant toll-averse bias equivalent of 15-20 min even in NY where tolling has long history
Impact of Car Occupancy

- \( U = b \times \text{Time} + c \times \text{Cost} \)
- \( U = b \times \text{Time} + c \times \left( \frac{\text{Cost}}{\text{Occ}_f} \right) \)
  - \( f \approx 0.6-0.8 \)

VOT grows with occupancy but not linearly:
- Less cost sharing for intra-household carpools
- Almost proportional cost sharing for inter-household carpools

Typical cost sharing:
- SOV=1.00
- HOV2=0.57
- HOV3=0.41
Situational / Unobserved Heterogeneity

- \( U = b \times \text{Time} + c \times \text{Cost} \)
- \( U = \int (b \times \text{Time} + c \times \text{Cost}) \times g(b) \, db \)
  - \( b \) = randomly distributed with density \( g(b) \)
  - VOT = \( b/c \) (becomes randomly distributed)

- Unobserved heterogeneity is significant:
  - VOT is subject to many additional unknown parameters (for example, person taste and psychological type)
  - VOT is subject to situational variability for the same person and trip (trip to important meeting vs. routine trip to work)
  - VOR variance was difficult to explore; the result are inconclusive, better data on travel time variation is needed
Improved Final Generalized Cost Function

- $U = b \times Time + c \times Cost$

**Deterministic version:**

- $U_s = a_s + (b_{1s} + b_{2s} \times Dist + b_{3s} \times Dist^2) \times Time + c_s \times Cost/(Inc^e_s \times Occ^f_s) + d_s \times STD/Dist$

- Applicable with any model that generates STD reliability measure
- If STD reliability measure cannot be produced perceived highway time can be used as a proxy

**Probabilistic version:**

- $U_s = \int [a_s + (b_{1s} + b_{2s} \times Dist + b_{3s} \times Dist^2) \times Time + c_s \times Cost/(Inc^e_s \times Occ^f_s) + d_s \times STD/Dist] \times g(b_{1s}) \, db_{1s}$

- Applicable only with advanced microsimulation model
Where,

**VARIABLES**

- **TIME** = average travel time
- **DIST** = travel distance
- **STD** = day-to-day standard deviation of the travel time
- **COST** = monetary cost including tolls, parking, and fuel
- **INC** = (household) income of the traveler
- **OCC** = vehicle occupancy

**PARAMETERS**

- **$a_{1s}$** = alternative-specific “bias” constant for tolled facilities
- **$b_{1s}$** = basic travel time coefficient, ideally estimated as a random coefficient to capture unobserved user heterogeneity
- **$b_{2s}, b_{3s}, ...$** = coefficients reflecting the impact of travel distance on the perception of travel time
- **$c_s$** = auto cost coefficient
- **$e,f$** = coefficients reflecting the impact of income and occupancy on the perception of cost
- **$d_s$** = coefficients reflecting the impact of travel time (un)reliability
SHRP2 C04 – Incorporation of Issues and Findings in C10 and in emerging modeling Practice
Route Choice: Toll versus Free

Traveler-specific coefficients applied in calculation of route utilities

Incorporated a binary path type Toll / Non-Toll choice model in DaySim+CUBE

Continuous Income function

Vertical integration with mode & destination choice models

Functional form and magnitude for:
- Toll bias
- Income and Occupancy effect on cost coefficient
- Travel time coefficient – drawn from log-normal distribution (mean 1.0; Std 0.8 work, 1.0 non-work)
- Scale parameter for higher level choices (inverse of path type choice logsums)
SHRP 2 C04 Issues and Findings in C10B

- Variable VOT specifications in Mode Choice
  - Segmentation of by income group
  - SACOG RP survey data did not yield usable locally estimated models of segmented VOT
  - Adopted VOT distributions by from recent SFCTA SP analysis analyzed in C04
  - VOT = Applied to InVehicleTime (IVT)

- Incorporated travel time (Un)reliability
  - Applied with DynusT simulation
  - Concept of “extra impedance”
    - TTI = FF / actual speed
    - TTE = Mean Time + a * (80th TT – 50th TT, where
    - a = value of unreliability relative to mean travel time (a value of 0.8 proposed)
<table>
<thead>
<tr>
<th>Finding</th>
<th>Applied</th>
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<tbody>
<tr>
<td>Impact of commuting distance on VOT</td>
<td>CMAP ABM</td>
</tr>
<tr>
<td>Impact of income on VOT</td>
<td>CMAP ABM, MAG ABM, JTMT ABM, MORPC ABM, NOACA ABM, OKI ABM, Ottawa Trans Tour-Based model, SACOG, PRSC, Tampa, Jacksonville</td>
</tr>
<tr>
<td>Impact of car occupancy on VOT</td>
<td>CMAP ABM, MAG ABM, JTMT ABM, MORPC ABM, NOACA ABM, OKI ABM, SACOG, PRSC, Tampa, Jacksonville</td>
</tr>
<tr>
<td>Incorporation of travel time reliability in mode and route choice</td>
<td>Ottawa Trans Tour-Based model, SHRP 2 L04</td>
</tr>
<tr>
<td>Randomized VOT</td>
<td>CMAP ABM, MAG ABM, JTMT ABM, SACOG, PRSC, Tampa, Jacksonville</td>
</tr>
<tr>
<td>New methods of ABM-DTA integration</td>
<td>SHRP 2 L04, CMAP ABM-DTA integration</td>
</tr>
</tbody>
</table>
Highlighting
a Few Statistically-Based Findings
and their Policy Implications
1. **VOT and Willingness to Pay** have a wide range from $5/hour through $50/hour across income groups and major travel purposes. There is a significant situational variation (unobserved heterogeneity) on the top of it with the “tail” of the distribution going beyond $100/hour.

**Policy Implications:**

Prices have to be at significant levels to influence congestion. Variability by time of day, vehicle occupancy, and frequency of travel allows prices to have more effect.
2. In parallel with relatively high VOT (Willingness to Pay for Travel Time Savings) there is a significant negative toll bias ("threshold" effect equivalent to 15-20 min). This is generally found in both Revealed Preference and Stated Preference data, and supported by research in behavioral economics.

**Policy Implications:**

Pricing makes sense if it is associated with significant travel time savings and reliability improvements to overcome a psychological bias against any tolls.
Behavioral Insights for Policy

3. Traveler’s responses to congestion and pricing are dependent on the range of available options. They generally follow the sequence:

- Primary: route/lane type change, small shifts in departure time (up to ±60 min),
- Secondary: switch to transit (in transit-rich areas), carpooling
- Tertiary: principal rescheduling of trips & activities by time-of-day periods
- Longer term changes in home, work, other locations.

Policy Implications:

Impact of peak period pricing on congestion level may be minor if the peak period is already spread over 2-3 hours and transit service is limited.
Improvements in *travel time reliability* are as important as improvements in average travel time. Reliability Ratio (cost of 1 minute of standard deviation versus cost of 1 minute of average time) is in the range of 0.5-1.5

**Policy Implications:**

Dynamic pricing, traffic accident management and other strategies that specifically guarantee stable travel times (and avoid non-recurrent congestion) are highly valued by travelers.
5. *Income* has a strong although not linear effect on VOT and Willingness to Pay. To account for income effect Cost/Toll variables in travel models should be scaled by Income powered by 0.6-0.8.

**Policy Implications:**

Pricing studies need to explicitly consider income distributions and future income growth in each region, corridor, and area. In the absence of locally calibrated models, model parameters from the other region have to be scaled by income differences.
Principal Conclusions

- Policy implications may be quite significant for:
  - More accurate forecast of response and performance levels
  - Capture of additional benefits associated with tolled roads and managed lanes, particularly with guaranteed reliability

- Universal fully transferable model:
  - Impossible, due to regional specifics, data / model limitations
  - Seed conceptual structures are becoming clear

- Complete operational models incorporating extended behavioral sensitivities
  - Definitely yes!
  - Reliability is extremely important and statistically significant
  - Mostly requires ABM platform
  - Integrated ABM+DTA framework is the best
SHRP 2 C05
UNDERSTANDING THE CONTRIBUTION OF OPERATIONS, TECHNOLOGY, AND DESIGN TO MEETING HIGHWAY CAPACITY NEEDS

Presented by:
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Kittelson & Associates, Inc.
Project Team

• Kittelson & Associates, Inc.
  – Wayne Kittelson, PE and Brandon Nevers, PE

• Institute of Transportation Research and Education
  – Nagui Rouphail, PhD

• University of Utah
  – Xuesong Zhou, PdD (now with Arizona State University)

• Ruhr University
  – Werner Brilon, PhD
Project Scope and Objectives

• Objectives:
  – Quantify capacity benefits of improvements at the network level
  – Provide information and tools to analyze operational improvements as an alternative to traditional construction
  – Develop guidelines for “sustainable service rates” to be used in planning networks

• Limits of project scope:
  – Automobile mode focus, not transit or non-motorized travel
  – Capacity focus, not demand management
Categories of Potential Strategies

• Operations-based, such as
  – Signal coordination
  – Ramp metering

• Design-based, such as
  – Narrow lanes
  – Alternative left turn treatments

• Technology-based (ATIS, Advanced Traveler Information System), such as
  – Pre-trip information
  – In-vehicle information

• Strategies to improve freeway performance, arterial performance, or both
## 25 Non-Lane Widening Strategies to Improve Capacity Selected for Evaluation

<table>
<thead>
<tr>
<th>Freeway</th>
<th>Arterial</th>
<th>Both</th>
</tr>
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<tbody>
<tr>
<td>HOV Lanes</td>
<td>Signal Retiming</td>
<td>Narrow Lanes</td>
</tr>
<tr>
<td>Ramp Metering</td>
<td>Signal Coordination</td>
<td>Reversible Lanes</td>
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<tr>
<td>Ramp Closures</td>
<td>Adaptive Signals</td>
<td>Variable Lanes</td>
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<tr>
<td>Congestion Pricing</td>
<td>Queue Management</td>
<td>Truck Only Lanes</td>
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<tr>
<td>Pricing by Distance</td>
<td>Raised Medians</td>
<td>Truck Restrictions</td>
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<tr>
<td>HOT Lanes</td>
<td>Access Points</td>
<td>Pre-Trip Information</td>
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<tr>
<td>Weaving Section</td>
<td>Right/Left Turn Channelization</td>
<td>In-Vehicle Info</td>
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<tr>
<td>Frontage Road</td>
<td>Alt LT/RT Treatments</td>
<td>VMS/DMS</td>
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<tr>
<td>Interchange Modifications</td>
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Insights on Strategy Effectiveness

• Effectiveness needs to be tested in network context
  – Requires the use of a travel demand/dynamic traffic assignment (DTA) model
  – Cannot be done with static look-up tables or simple spreadsheets

• Impacts most pronounced at the link and corridor levels, and often difficult to see at the network level
  – Demand-side issues are best viewed from an O-D perspective
  – Supply-side issues are best viewed at the link and corridor level

• Pre-trip information can reduce buffer time and improve reliability

• En-route information may create instabilities
Dynamic Traffic Assignment (DTA) Modeling

- Estimate travel patterns and driver behavior (route choice) in “real time” across a network
- Serves as a “bridge” between high-level travel forecasting models and detailed microsimulation models
Multi-Resolution Modeling

**Macro**
- Regional Travel Demand Model
  - Converter
    - Network
    - OD Data

**Meso**
- Preliminary Regional DTA Model
  - Refine DTA Model:
    - Links
    - Lanes
    - Traffic Control
    - Signal Timing
  - Calibration/Validation
  - Final Regional DTA Model

**Micro**
- Detailed Operations Analysis
  - Network Alternatives
  - Converter
    - Create Sub-Area Model
    - Fine Tune

Field Data
- Link Speeds
- Link Volumes
- Link Density

Regional Operations Analysis
Modeling Enhancements Made in C05

1. Stochastic capacity
2. Driver learning
3. Short lane effects on arterials
4. Performance measurement
1. Stochastic Capacity

*Resulting Pre-Breakdown Headway Distribution*

- Shows that single headway value not appropriate for defining breakdown conditions
- Probability of breakdown increases with increasing flow rate
- Stochastic capacity for arterials also developed
2. Day-to-Day Driver Learning

– Traveler’s route choice is based on experiences remembered from the past two weeks

– Limits applied to number of travelers who will adjust their trip each day

– Important in the evaluation of non-recurring congestion
3. Method for Estimating Lane Blockage Effects

SSR = Sustainable Service Rate
4. Performance Measurement

• Performance Measures
  – Volume, capacity, delay, density, travel time, queue, breakdown count

• Spatial Level
  – Node, Link, corridor, O-D pair, subarea, and whole network

• Temporal Level
  – 15-min, 1 hour, multiple hours, whole day, time periods across multiple days (reliability)

Green = enhancements to conventional practice
Overview of Strategy Testing Plan

• Two networks tested:
  – Freeway corridor with parallel arterials (Dallas-Fort Worth, Texas)
  – More complex and realistic subarea network (Portland, Oregon)
Overview of Strategy Testing Plan (cont.)

• Test Protocol
  – I: Baseline stabilization
  – II: Strategy stabilization
  – III: 20-day results comparison period

![Network-Wide Simulation Results](image-url)
20-Day Average Results for the Primary SB O-D Ft. Worth, TX Subarea

* Effects in peak direction with lane addition for one hour
20-Day Average Results (cont.)

- **Buffer Index** = \((95^{th} \text{ %ile TT} - \text{Mean TT})/\text{Mean TT}\)
Conclusions

• Dynamic Traffic Assignment (DTA) models can be effective in assessing lower-cost strategies

• New modeling capabilities are available that can be extended to a variety of DTA models

• Capacity and reliability can be tied together with travel time reliability

• Further enhancements to include non-recurring congestion will create additional value for practitioners and decision makers
Key Products

• Traffic Model Enhancements
• Diagnostic Tools
  – Visualization Capabilities (DTALite)
  – Spreadsheet-Based Models
• Strategy Evaluation Approach
• Final Report
• Guidebook
Advances in Travel Demand Forecasting

Considerations for Implementing New Technologies and Methods
(SHRP2 Capacity C10)

Brian Gardner, FHWA
Matt Hardy, AASHTO
Planning, Programming, Project Development

- Continuing emphasis on management and operations
- Strategic reconfiguration scenarios
- Congestion, tolling, and pricing
- Support other, higher fidelity analyses

*Need better representation of dynamic systems in planning models*
Current Technologies

- **Activity-Based Demand Models**
  - Time-space constraints
  - Scheduling

- **Dynamic Network Models**
  - Times and costs change over time

*FHWA 2013*
Implementation

- Activity-Based Models
  - Increasing number of regional planning agency deployments
- Dynamic Network Models
  - Subarea, project, and corridor level deployments
- Joint Interaction & Application
Translating SHRP2 Methods & Lessons into Practice

- **Data**
  - Users, Networks, Controls, Validation
- **Methods & Software**
  - Interaction, Interpretation
- **People**
  - Public Agencies, Consultants, Developers
• In 2012, the AASHTO Board of Directors approved funding the implementation of SHRP2 products
  – Funding came from State Planning and Research money
  – AASHTO is committed to the successful implementation of SHRP2
• The AASHTO Standing Committee on Planning (SCOP) and FHWA are developing a SHRP2 Capacity Strategic Implementation Plan
  – Five “bundles” of projects:
    • Freight Modeling
    • Analytical Tools
    • Economic Analysis Tools
    • Process
    • TCAPP
  – All of the products discussed here are part of the Analytical Tools bundle
What’s Next

• Implementation Planning Workshop in CY 2014 Q1
• Implementation Assistance Program
• For more information:
  www.fhwa.dot.gov/goshrp2/
  www.fhwa.dot.gov/planning/tmip/
  http://shrp2.transportation.org/Pages/default.aspx
SHRP 2 C10A
Partnership to Develop and Integrated Advanced Travel Demand Model with a Fine-Grained, Sensitive Network Model

SHRP 2 C46
Activity-Based Model Primer & Integrated Model Model Considerations

Joe Castiglione, RSG
C10A Project Team

- RSG
- AECOM
- Dr. John Bowman
- Dr. Travis Waller, UNSW
- Dr. Mohammed Hadi, FIU
- Dr. Ram Pendyala, ASU
- Dr. Chandra Bhat, UT Austin
- NFTPO
C10A Objectives

- Develop an operational “integrated” model
  - Advanced demand model
  - Time-dependent network supply model

- Demonstrate value of model
  - Validation / calibration
  - Sensitivity tests

- Implement in a framework that is easily transferable to the local jurisdictions for policy analysis

- Incorporate findings from other SHRP 2 efforts
What is an integrated model?

- A model system in which different models exchange information in a systematic and mutually dependent manner
  - AB info to DTA
  - DTA network impedances to ABM

- C10A model components
  - Daysim “activity-based” model
  - TRANSIMS network simulation model
  - MOVES

- C10A integrated model system implemented in both Jacksonville, FL and Burlington, VT
Why develop an integrated model?

- Current models are limited
  - Not sufficiently sensitive to travel behavior and network conditions
  - Unable to represent the effects of policies such as variable road pricing and TDM

- Integrated model systems represent demand changes and network performance better
  - Peak spreading, mode choices, destination choices
  - Capacity and operational improvements such as signal coordination, freeway management and variable tolls
How can an integrated model be used?

- Freeway Tolling
  - Vary tolls by detailed time of day and facility
  - Demonstrate shifts by time of day and purpose

- Travel Demand Management
  - “Flexible Schedule” scenario
  - Demonstrate that fewer work activities results in more non-work activities

- Operations
  - Corridor signal progression
  - Challenging to code and interpret results
C10 Lessons Learned

- Data development
  - Simulation network sensitivity
  - Detailed alternative scenario assumptions
- Transferability
- Calibration / Validation
- Configuration
  - Convergence
  - Consistency
- Application
Integrated model system
  - is more sensitive to a wider range of policies
  - produces a wider range of statistics of interest to decision-makers

Level of effort required to effectively test different types of improvements varied widely

Debugging the model system, and individual scenarios was the greatest challenge

Must have willingness to investigate and experiment
C46 Objectives

- Develop Primer on activity-based (AB) travel demand models
  - Practical, how-to guide for practitioners and managers
  - Explain concepts and implementation
  - Consider linkages between AB models and dynamic network models and land use models
- Develop Implementation Considerations Report
Three primary sections

Moving to AB Models
  - For agency managers
  - Capabilities, sensitivities

Technical roadmap
  - For modeling managers
  - Component selection, linkages, data and resource requirements

AB concepts and algorithms
  - For practitioners
  - Design, components, development tasks
Examine benefits, barriers, practical issues agencies face in migrating from “traditional” to “advanced” approaches using SHRP2 products

Identify challenges and strategies for overcoming

Inform implementation
SHRP C10B
Partnership to Develop an Integrated Advanced Travel Demand Model with Fine-Grained, Time-Sensitive Networks

Thomas Rossi, Cambridge Systematics, Inc.
SHRP C10B Team

• Cambridge Systematics, Inc.
• Sacramento Area Council of Governments
• University of Arizona
• University of Illinois, Chicago
• Sonoma Technology, Inc.
• Fehr and Peers
Integrated Modeling Approach

Long-Range Planning Mode

SACSIM
- Long-Term Model (Location, Auto Ownership, etc.)
- Daily Activity Pattern Generation and Scheduling

MOVES
- Parcel-to-Parcel Travel Time, Cost, Accessibility, and Reliability Measures

DynusT
- Multimodal, Multiresolution Traffic Simulation
- Multimodal, Dynamic Traffic-Transit Assignment

Initial Skim
- Transit Network
- Transit Schedule
- Other Trip Attributes
- Truck OD Policies
SHRP C10B

- Integration of SACSIM with DynusT
- Implemented in Sacramento, California
- Uses original DaySim model estimated in Sacramento
- Incorporates new transit simulation process (FAST-TrIPS)
- Integration with MOVES
- Testing using policy alternatives in Sacramento
Model Features

• Integrated model components
  – DaySim (tours/trips) ⇒ DynusT/FAST-TrIPS (auto/transit simulation)
  – Exogenous trips ⇒ DynusT (auto simulation)
  – DynusT ⇒ MOVES

• User interface
  – Enables users to create, run, manage scenarios

• Run times for Sacramento regional model – about one day per feedback loop
  – 10 iterations of DynusT assignment per loop
MOVES Integration
Main components

1. DynusT processing to prepare network and activity data for MOVES
2. MOVES input files set-up using other data sources
3. MOVES CO$_2$ emissions modeling
   - Running exhaust (related to roadway links)
   - Start exhaust (related to traffic analysis zones)
Other Model Features

- DaySim revised to incorporate variable value of time (for road pricing analysis)
- Travel time reliability incorporated into DynusT
- Feedback process for using travel times from DynusT as inputs to SACSIM
- Conversion of shared ride person tours to vehicle tours
Policies/Projects Tested

• Scenarios compared between the original SACSIM model and the new C10B integrated model
  – Operations-Oriented Interchange Project
  – New Transit Line
  – Freeway Bottleneck Analysis

• Scenarios tested using only the new C10B integrated model
  – ITS/Arterial Signal Coordination
  – Transit Schedule Coverage Change
  – HOT Lane project
Some Interesting Results...

• Removal of freeway bottleneck (still analyzing)
  – Logical changes in vicinity
  – Some changes away from project
  – Due to simulation noise?

• Doubling frequency on transit route
  – Static model shows large ridership increase, reductions on nearby routes
  – C10 model shows almost no change in ridership
  – May be due to bus bunching resulting in unchanged wait times
Comparison of Static And Dynamic Skim Times

pm static vs dynamic skim tts
Comparison of Static and Dynamic Skim Times

distribution of the differences between static and dynamic tts in the am peak

mean=-0.2
std=6.0
Project Status – Final Tasks

- Documentation of policy/project testing
- Final project documentation
- Finalization of integrated model and software
For Further Information…

- Thomas Rossi, Cambridge Systematics
  - trossi@camsys.com
- www.dynust.net
Smart Growth Area Planning Tool (SmartGAP)

The Effect of Smart Growth Policies on Travel Demand

Maren Outwater
RSG

October 1, 2013
Overview

Purpose

- Provide tools, methods, and resources to evaluate smart growth policies on travel demand

Objectives

- Understand critical decision points in the transportation planning process and how smart growth approaches affect demand for capacity
- Research the dynamics and inter-relationships of smart growth strategies with the performance of a transportation investment
- Identify range of features and capabilities that new tools need to represent
- Facilitate improved communication, interaction and partnerships between decision-makers and planners in transportation and land use arenas
Decision Points for Smart Growth in the Planning Process

Process maps for State DOTs and MPOs

Areas where smart growth levers can be used
- Policy Studies
- Planning studies
- Programming
- Implementation
Based on interviews with planning officials

Most agencies are interested in scenario planning as a strategy for evaluating smart growth

- Develop a regional scenario planning tool

Many agencies need coordination, cooperation, and communication with local governments on land use policy, since land use regulations are governed by local governments

- Develop a tool that can be used by land use and transportation planners to provide opportunities for interaction on common goals

Agencies also want to understand

- Induced demand, TDM and urban form
- Congestion reduction
- Outcomes and performance
# Background Research

<table>
<thead>
<tr>
<th>Topic</th>
<th>Well-established Relationships</th>
<th>Gaps in Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built environment impact on peak auto demand</td>
<td>Impact on daily travel</td>
<td>Impact by time of day</td>
</tr>
<tr>
<td>Mobility by mode and purpose</td>
<td>Impact on daily travel</td>
<td>Impact by trip purpose</td>
</tr>
<tr>
<td>Induced traffic and induced growth</td>
<td>Capacity expansion on an expanded facility</td>
<td>Route shifts, time of day shifts, mode shifts, induced trips, new destinations, growth shifts on the network; effects of operational improvements, land use plans</td>
</tr>
<tr>
<td>Relationship between smart growth and congestion</td>
<td>Localized effects</td>
<td>Macro-level or regional effects</td>
</tr>
<tr>
<td>Smart growth and freight</td>
<td>Freight is necessary for population centers</td>
<td>Impacts of loading docks, truck routing, full-cost pricing, freight facilities and crossings, inter-firm cooperation, stakeholder communication</td>
</tr>
</tbody>
</table>
Developed for regional decision-makers of transportation and land use policies

Evaluates regional scenarios

- Built environment
- Travel demand
- Transportation supply
- Policies

Considers households and firms individually

Easy to use and freely distributed

### PLACE TYPES

<table>
<thead>
<tr>
<th>Development Type</th>
<th>Urban Core</th>
<th>Close in Community</th>
<th>Suburban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Employment</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Mixed-Use</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Transit Oriented Development</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rural/Greenfield</th>
</tr>
</thead>
</table>
Evaluates transportation impacts of smart growth strategies
Graphical User Interface

“Model Flow” showing model components

Drop down menus for project and scenario management and help

Run button executes complete model

“Inputs”, “Outputs”, and “Reports” tabs

Individual inputs that can be selected, edited and commented
Input Data
Performance Metrics

Community Impacts
- Accident Rates
- Job Accessibility by Income Group
- Walking Percentage Increase

Direct Travel Impacts
- Daily Transit Trips
- Daily Vehicle Miles Traveled
- Daily Vehicle Trips
- Peak Travel Speeds by Vehicle Type
- Vehicle Hours of Delay
- Vehicle Hours of Travel

Environment and Energy Impacts
- Fuel Consumption
- Greenhouse Gas Emissions

Financial and Economic Impacts
- Annual Transit Operating Cost
- Annual Traveler Cost (Fuel and Charges)
- Regional Infrastructure Costs for Highway
- Regional Infrastructure Costs for Transit

Location Impacts
- Regional Accessibility
Distribution and Use of SmartGAP

Available on SHRP 2 Web Site


SmartGAP Installation

- Install by simple unzipping to a location on your computer’s hard drive, e.g. c:\SmartGAP
- Consists of text file scripts, csv file input files, and .Rdata binary files holding containing models

R is an open source statistical software platform

- SmartGAP runs in R so R must be installed on the computer
- SmartGAP uses several add in packages to R which it will download automatically the first time it is run
- R is available at: [http://cran.r-project.org/](http://cran.r-project.org/)
Congestion Impacts

Accounts for recurring and nonrecurring congestion on local streets, arterials and freeways
Predicts the change in VMT for each household due to changes in urban form and the short and long term induced demand effects of increases in transportation supply.

<table>
<thead>
<tr>
<th>Category</th>
<th>Urban Form Description</th>
<th>Elasticity for Change in VMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>Household/Population Density</td>
<td>-0.04</td>
</tr>
<tr>
<td>Diversity</td>
<td>Land Use Mix (entropy)</td>
<td>-0.09</td>
</tr>
<tr>
<td>Design</td>
<td>Intersection/Street Density</td>
<td>-0.12</td>
</tr>
<tr>
<td>Distance to Transit</td>
<td>Distance to Nearest Transit Stop</td>
<td>-0.05</td>
</tr>
</tbody>
</table>
Transportation Policies

Predicts the Change in VMT for each Household due to Transportation Policies

**Pricing Policies**
- VMT charges
- Parking pricing

**ITS strategies**
- Freeways
- Arterials

**Travel Demand Management Strategies**
- Ridesharing
- Transit Passes
- Telecommuting
- Vanpool Programs
Pilot Tests: Objectives for each Region

- Atlanta Regional Commission (ARC)
  - Large MPO setting
  - Test success of scaling to large area (e.g. run time issues)
  - Plan to compare with detailed land use scenario test results (INDEX)

- Thurston Regional Planning Commission (TRPC)
  - Smaller/medium MPO setting
  - Test network installation for multi-user access

- Maryland DOT (MDOT)
  - DOT setting
  - Test larger urban/suburban county and smaller rural county
  - Plan to compare with regional travel demand model results

- RSG Test Bed for Portland Metro Region
  - Used for debugging purposes and reasonableness testing of the model components and the performance metrics
  - Results generated for the 8 standard scenarios, plus pricing scenarios
## Test Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Land Use</th>
<th>Transportation</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>Baseline</td>
<td>Baseline</td>
<td>Baseline</td>
</tr>
<tr>
<td>#2</td>
<td>Baseline</td>
<td>+ 20% in Transit Supply</td>
<td>Baseline</td>
</tr>
<tr>
<td>#3</td>
<td>Baseline</td>
<td>+ 20% in Roadway Supply</td>
<td>Baseline</td>
</tr>
<tr>
<td>#4</td>
<td>Baseline</td>
<td>Baseline</td>
<td>+20% in Lane Miles with ITS</td>
</tr>
<tr>
<td>#5</td>
<td>Shift 10% of Population and Employment to Close in Community and 10% to Urban Core. Proportional reduction from Suburban Area</td>
<td>Baseline</td>
<td>Baseline</td>
</tr>
<tr>
<td>#6</td>
<td>Shift 20% of Population and Employment to Close in Community and 20% to Urban Core. Proportional reduction from Suburban Area</td>
<td>Baseline</td>
<td>Baseline</td>
</tr>
<tr>
<td>#7</td>
<td>Shift 30% of Population and Employment to Close in Community and 30% to Urban Core. Proportional reduction from Suburban Area</td>
<td>Baseline</td>
<td>Baseline</td>
</tr>
<tr>
<td>#8</td>
<td>Shift 30% of Population and Employment to Close in Community and 30% to Urban Core. Proportional reduction from Suburban Area</td>
<td>+20% in Transit Supply</td>
<td>+20% in Lane Miles with ITS</td>
</tr>
</tbody>
</table>
Changes in Vehicle Hours of Delay in Atlanta
Delay decreases most with additional lane miles and ITS to reduce congestion.

Transit Trips in Olympia
The transit trip metric is based on land use effects only.
Pilot Test Summary

- Performance metrics were consistent with expectations
- Installation and input file preparation were easy
- Regional policy scenario testing is useful for
  - Smaller MPOs, local jurisdictions without advanced travel demand models
  - Bigger MPOs, state agencies to pre-screen policy scenarios before undertaking extensive travel demand modeling exercises that are resource intensive
- Run times are reasonable
SmartGAP Summary

Use

- SmartGAP can evaluate smart growth policies on travel demand

Features

- Represents critical decision points in the transportation planning process and how smart growth approaches affect demand for capacity
- Includes the dynamics and inter-relationships of smart growth strategies with the performance of a transportation investment
- Facilitates improved communication, interaction and partnerships between decision-makers and planners in transportation and land use arenas
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