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Pricing and Reliability Enhancements in the San Diego Activity-Based Travel Model

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TMIP Webinar Series

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Overview

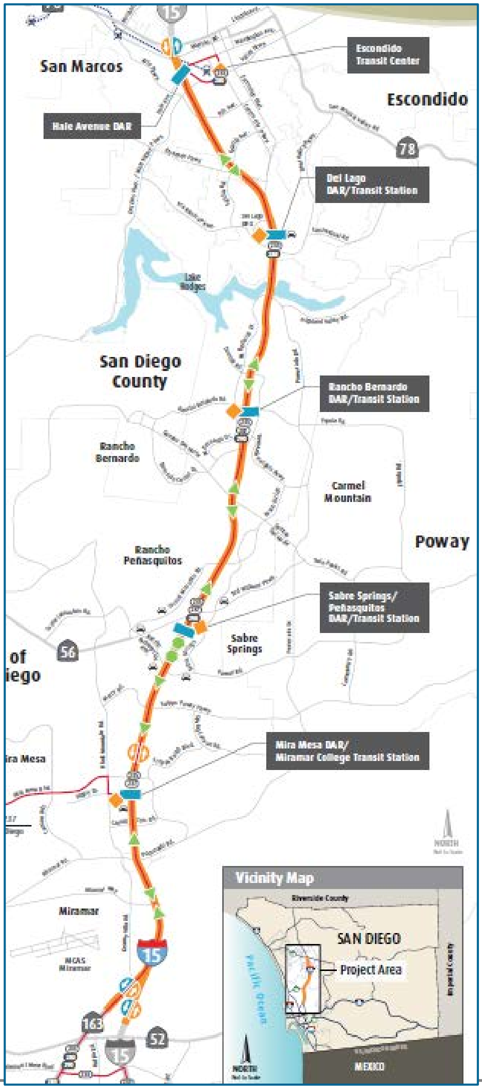
Objectives

- Modify San Diego Activity-Based Model to increase sensitivity to pricing alternatives
  - Travel time sensitivity heterogeneity
  - Value-of-time segmentation in skimming and assignment
- Add sensitivity to highway network reliability

Move research into practice

- SHRP Project C04: Improving Our Understanding of How Highway Congestion and Pricing Affect Travel Demand
- SHRP Project L04: Incorporating Reliability into Travel Models

Why is SANDAG interested in C04?



- Improved analysis tools for **San Diego Forward: The Regional Plan**
- Two existing toll facilities in San Diego (I-15 and SR-125)
- Additional ML facilities under consideration

What is an Activity-Based Model?

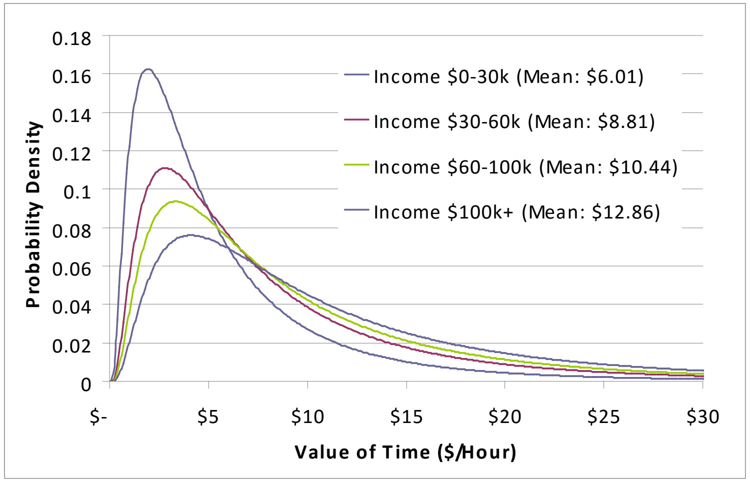
- Model travel by ***individuals***
  - Socio-economic characteristics are tracked explicitly
  - Decisions are simulated
- Model trips as part of ***tours***
  - A series of trips beginning and ending at home or work (anchor locations)
- Schedule activities consistently in ***time*** and ***space***
  - Activities occur in available time windows
  - No person can be in two places at the same time

Activity-Based Models: Micro-simulation

- A synthetic population is created that represents the actual population
- Travel is explicitly modeled for each person/household
- Monte Carlo simulation is used instead of fractional probability aggregation
- Results are aggregated and:
  - Assigned to transport networks
  - Compiled into reports

Examples of other AB Models with Pricing Enhancements

- San Francisco County Transportation Authority (SF-CHAMP)
  - Commuter value-of-time study used for random cost parameters
- Chicago Metropolitan Agency for Planning (CT-RAMP)
  - Eight time periods for skimming\assignment
- Sacramento Council of Governments (DaySim)
  - Distributed time sensitivity and continuous income as recommended by C04



C04 Highway Utility Function (implemented)

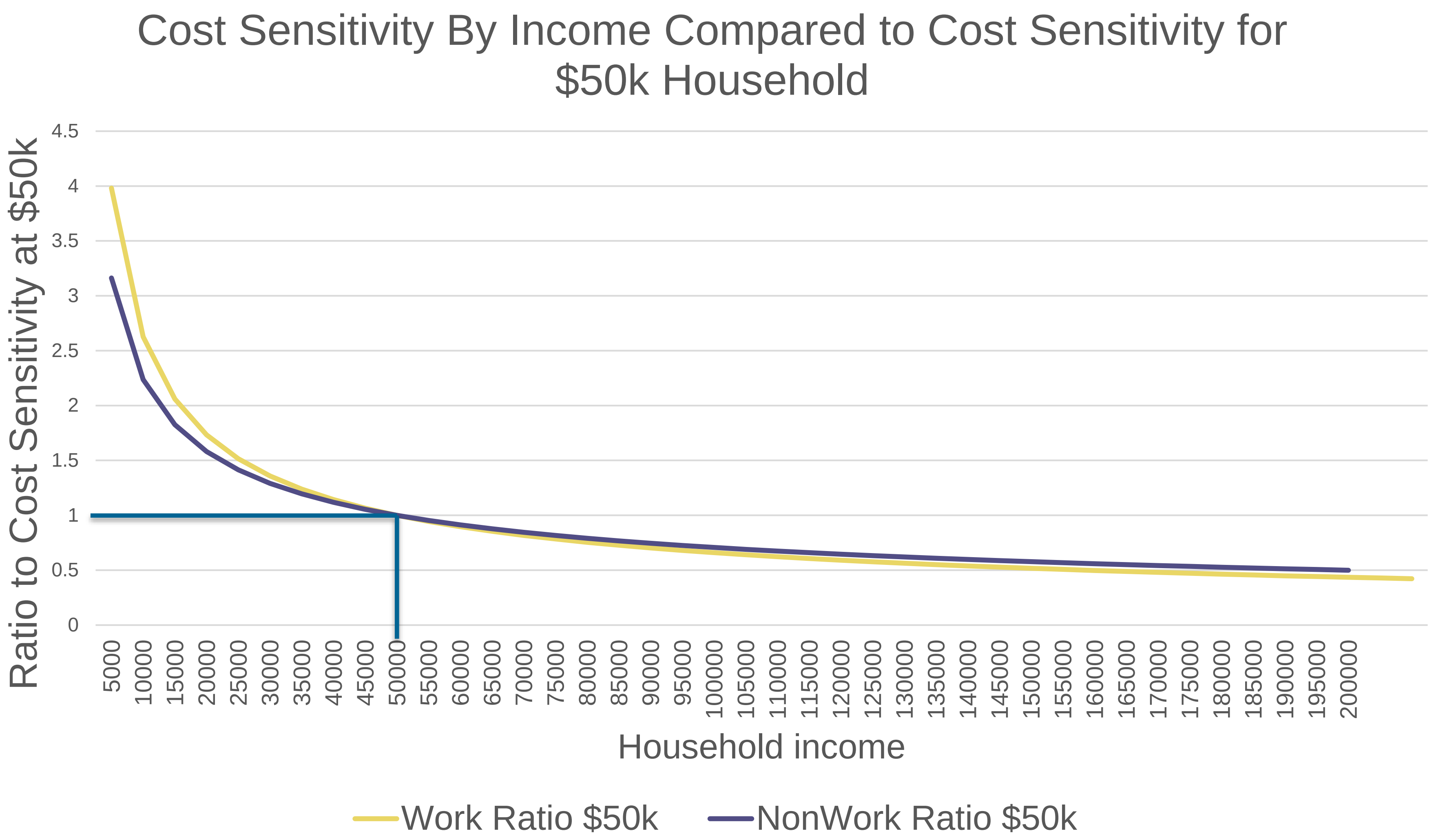
$$Utility_{ij} =$$
$$\alpha \times Time_{ij} + \beta \times \left[Cost_{ij} / \left(I^e \times O^f\right)\right] + \gamma \times \frac{STD}{Distance_{ij}} + \delta$$

where:

α *is a log-normally distributed random parameter representing unobserved user heterogeneity with respect to travel time sensitivity*
β *is the travel cost coefficient*
γ *is the reliability coefficient*
δ *is an alternative-specific constant for toll usage*

I^e *captures the effect of income (I) on travel cost sensitivity*
O^f *captures the effect of auto occupancy on travel cost sensitivity*
STD/Distance is the standard deviation of travel time per mile

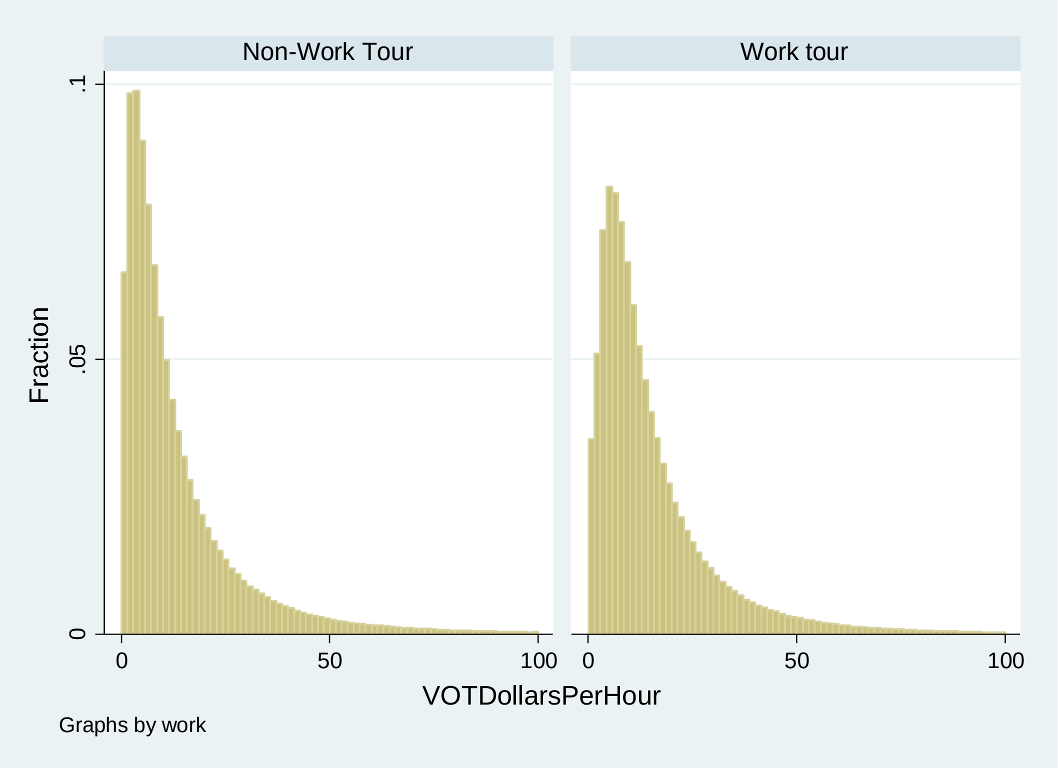
Cost Sensitivity By Household Income



Travel Time Sensitivity

- Report recommends average travel time parameters but does not recommend specific location and scale parameters for distributed time sensitivity
- Our approach was to multiply estimated travel time coefficient by $\ln N\ (\mu, \sigma^2)$ with (non-log) mean = 1.0 and standard deviation calibrated to match other recent SP VOT studies
- Separate draws for each person for both work and non-work
  - Time sensitivity for joint tours set to oldest tour member

Resulting Value of Time Distributions



Statistic	Work	Non-Work
Mean	$ 16.24	$ 14.78
Std. Dev	$ 18.35	$ 20.16
Minimum	$ 0.04	$ 0.03
Maximum	$ 955.18	$ 1,317.83

Percentiles	Work	Non-Work
1%	$ 0.51	$ 0.46
5%	$ 1.96	$ 1.21
10%	$ 3.19	$ 1.99
25%	$ 5.93	$ 4.15
50%	$ 10.95	$ 8.75
75%	$ 19.92	$ 17.79
90%	$ 34.24	$ 33.23
95%	$ 47.53	$ 48.04
99%	$ 88.43	$ 95.32

All trips:
33rd percentile VOT = $6.00/hour
66th percentile VOT = $14.30/hour

SHRP Project C04 Key Recommendations: Reliability

- Incorporation of reliability
  - C04 suggests perceived travel time by congestion as proxy for reliability
  - Requires travel time skims by LOS (D, E, F, F+?)
  - Would not affect path (problem)

Travel time conditions	Weight
Free Flow	1.00
Busy	1.05
Light Congestion	1.10
Heavy Congestion	1.20
Stop Start	1.40
Gridlock	1.80

INRIX Travel Time Data

October 2012. Weekdays. Joined to network. 1400 centerline miles.

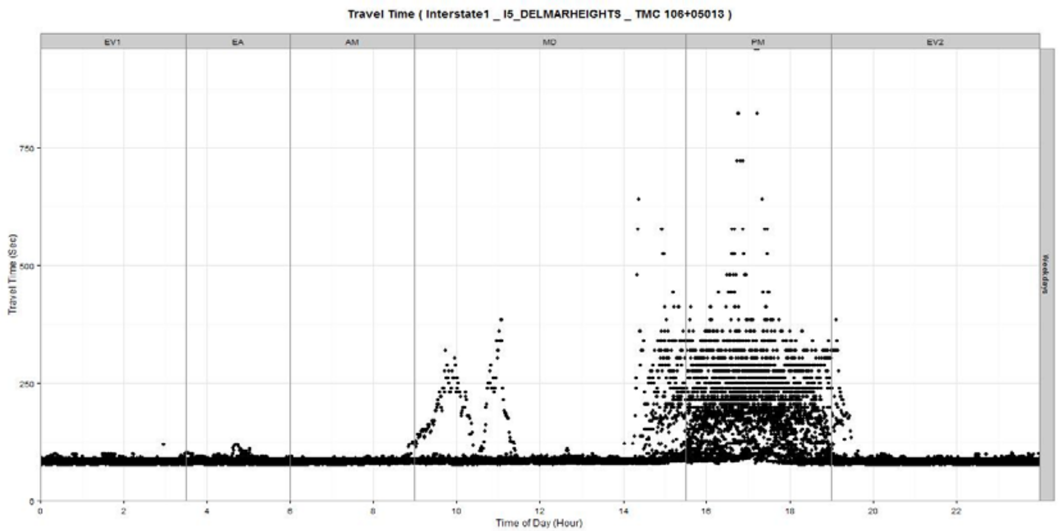
Facility Type	Data Size (number of segments)	Est. Sample Size – 80% (number of segments)
Freeways	1,020	816
Arterials	1,482	1,185
Ramps	130	104
Others (collectors and local roads)	355	284
Total	**2,987**	**2,389**

- Low sample size for ramps and others

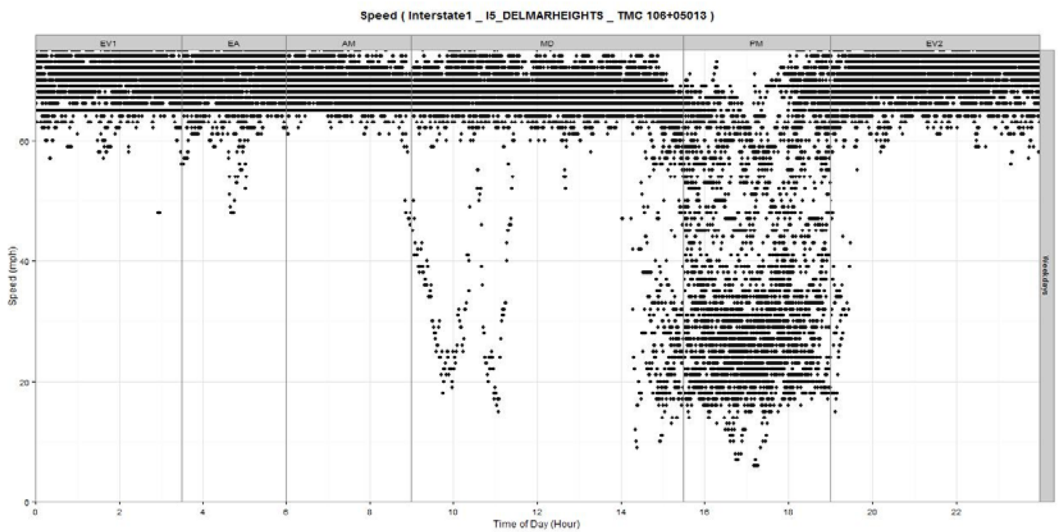
Estimations for freeway and arterial facility types

Interstate (I5) – Del Mar Heights (TMC 106+05013)

Travel Time



Speed

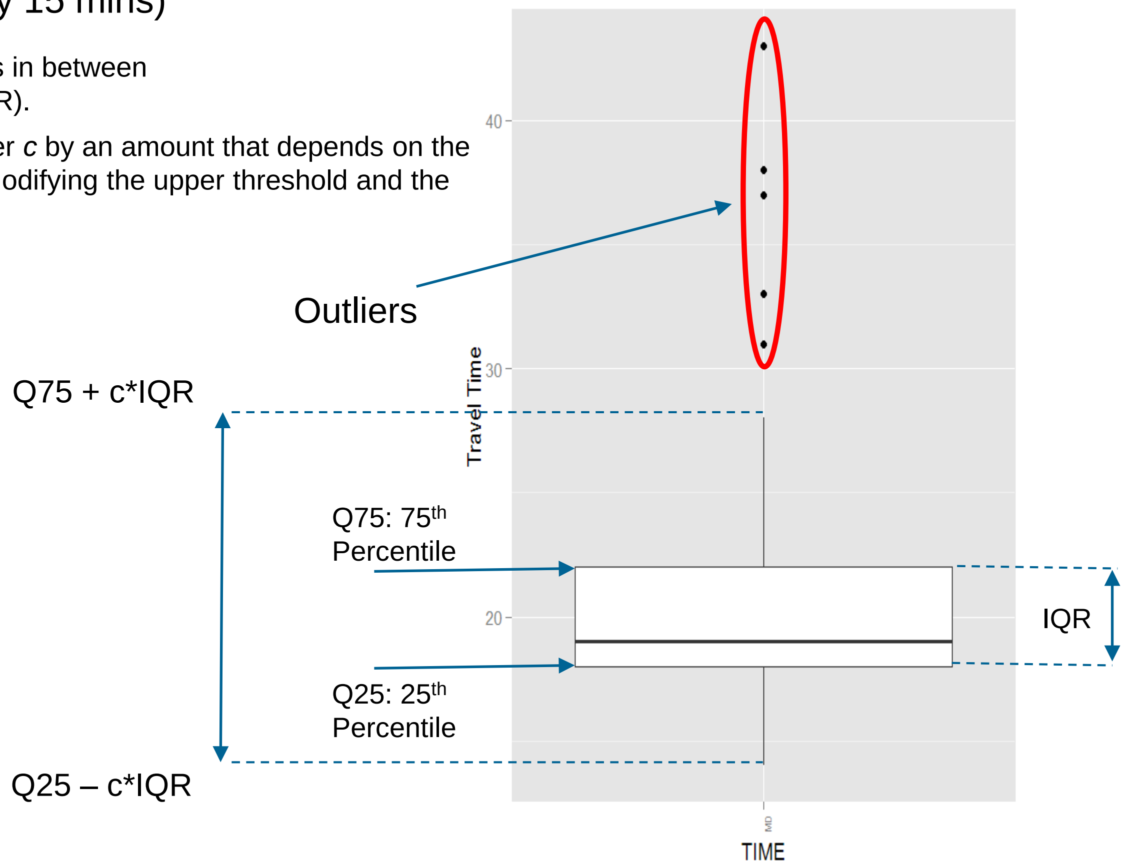


Outlier Detection

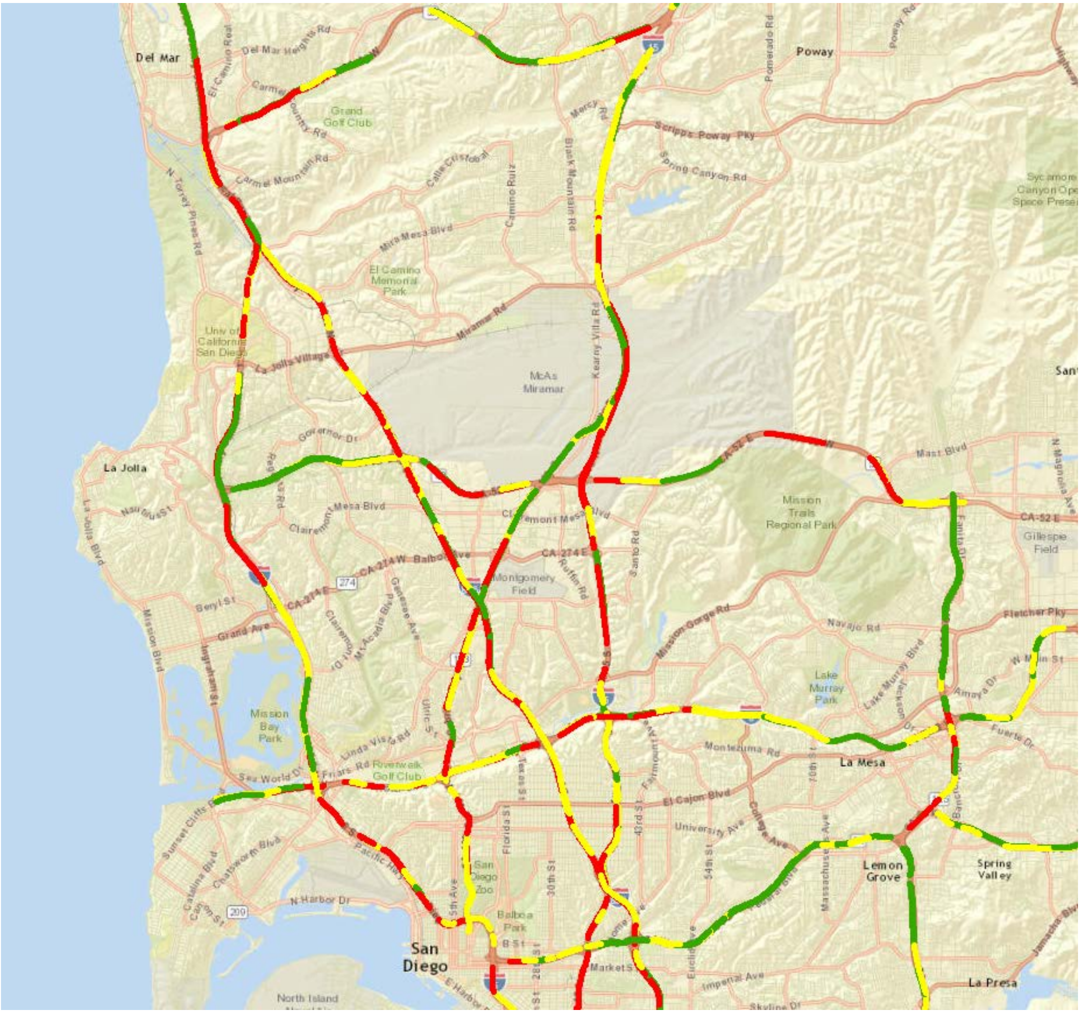
Adjusted Box Plot (every 15 mins)

Data is considered valid if it falls in between (Q25 – c*IQR) and (Q75 + c*IQR).

Modifies the threshold parameter *c* by an amount that depends on the asymmetry of the distribution, modifying the upper threshold and the lower threshold differently.



Speed Variability (Freeways)



5:30 pm – 5:45 pm
(PM peak period)

Speed Standard Deviation (mph)

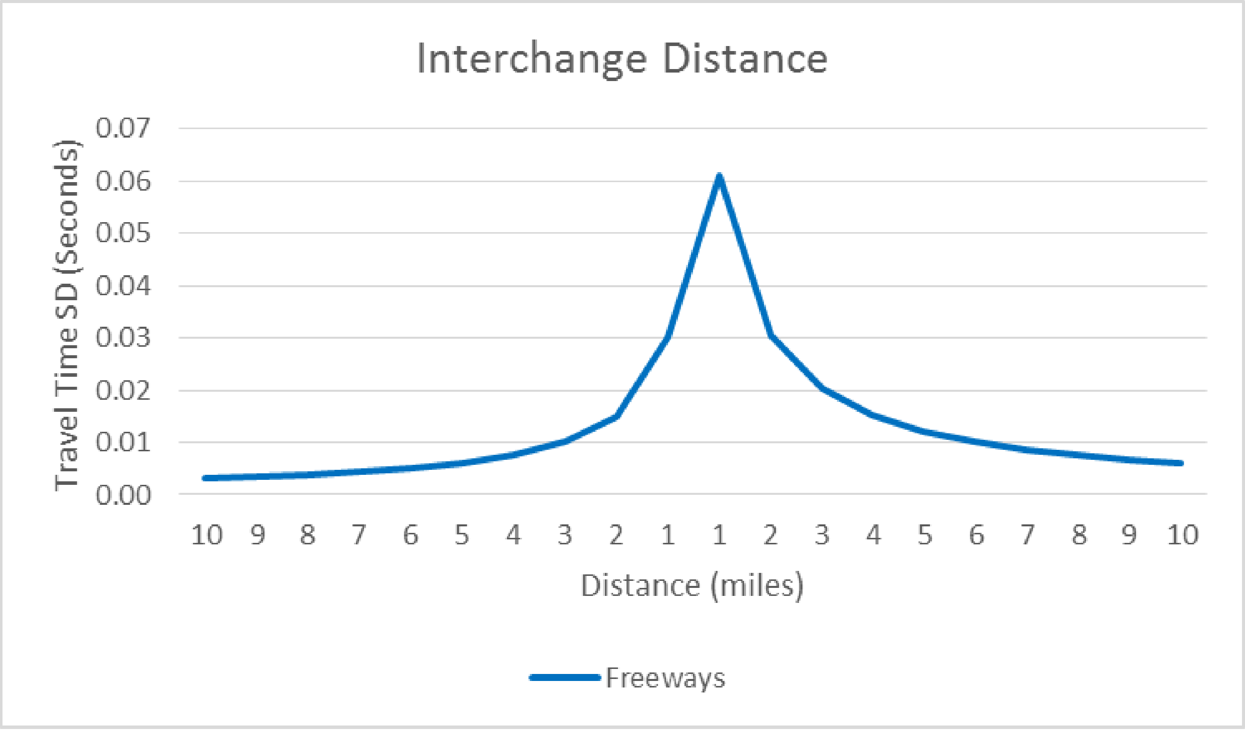
- 0.000000 - 3.000000
- 3.000001 - 7.000000
- 7.000001 - 25.692287

Travel Time Reliability Regression Model

$$\frac{\sigma_{min\ per\ mile}}{\mu_{\mathrm{min}\ per\ mile}} = f\ (speed, lanes, control\ type, distance\ to\ freeway, time\ period, volume/capacity)$$

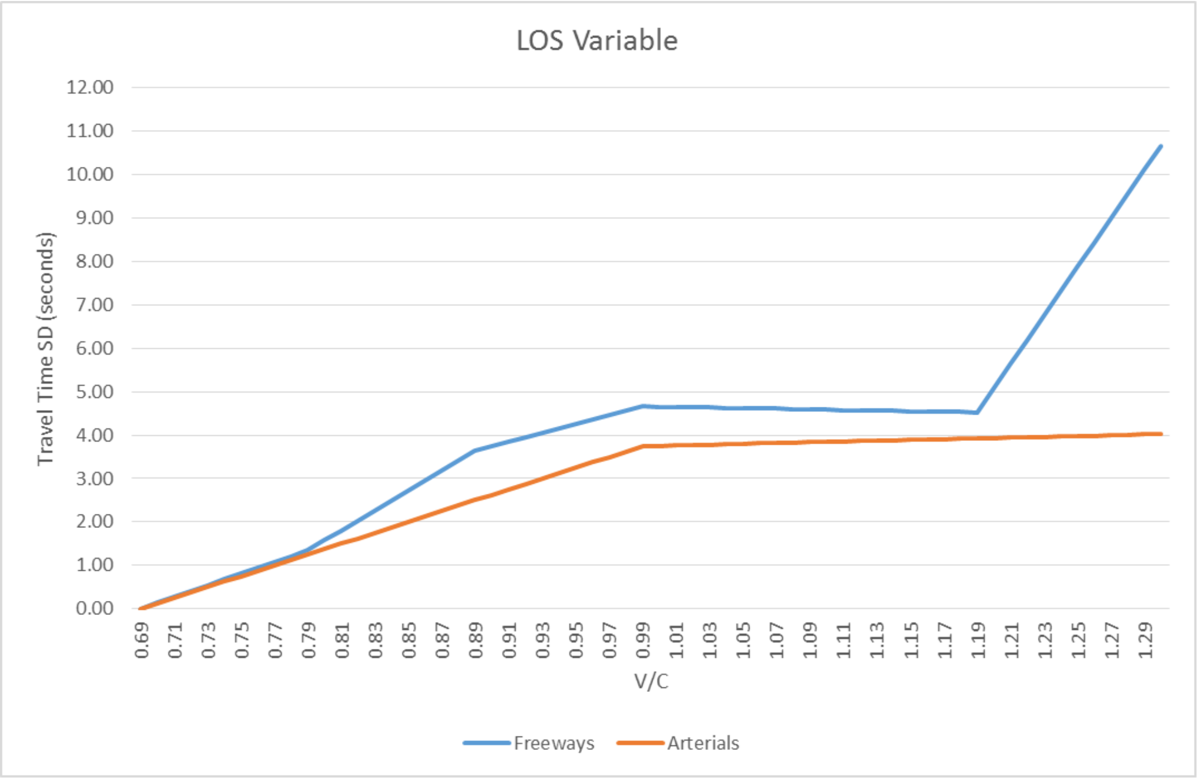
- Dependent variable formulated so that it can be implemented in volume-delay function
- Posted speed represents facility type variations for arterials
- (Inverse of) Distance to major freeway captures potential weaving conflicts: upstream (past) versus downstream (to)
- Control type - signalized, stop-controlled, metered, rr-xing, none)
- Time period captures time-of-day effects within broad periods
- V/C ratio captures congestion effects

Major Interchange Distance



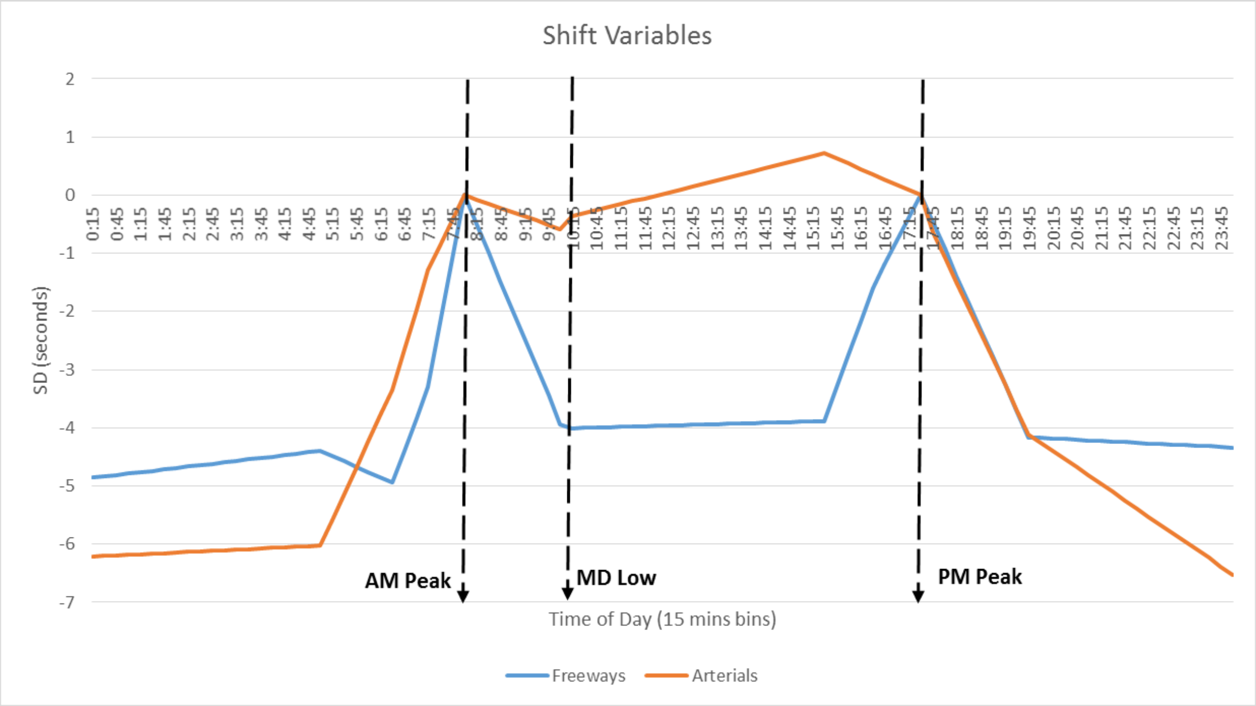
Facility	Avg. Speed (mph)	Mean TT (secs)
Freeway	65	55

Level of Service (LOS)



Facility	Avg. Speed (mph)	Mean TT (secs)
Freeway	65	55
Arterial	45	80

Shift Variables



Facility	Avg. Speed (mph)	Mean TT (secs)
Freeway	65	55
Arterial	45	80

Estimation Results

- Two estimations – one with time-of-day effects and one without
- Significant time-of-day effects capturing within period variability
- Distance to/from major interchanges significant for freeways
- Reasonable LOS effects
  - Flatter for arterials than freeways
- Adjusted r^2
  - 0.18 for freeways
  - 0.37 for arterials

Reliability Implementation

Original VDF Model Form

Uncongested Signal Delay

$$T_f = T_0 * \left[1 + \alpha_l * \left(\frac{V}{C_s}\right)^{\beta_l}\right] + P * \frac{c}{2} * \left(1 - \frac{g}{c}\right)^2 * \left[1 + \alpha_i * \left(\frac{V}{C_i}\right)^{\beta_i}\right]$$

$$C_i = S * \frac{g}{c}$$

Mid-link BPR function

Intersection congestion adjustment

Modified VDF Model Form

$$T_{f+r} = T_f + T_f \; * [\sum_{t=1,n} (\gamma_t * \frac{v}{c} - t + 0.01) + R]$$

Where:

T_{f+r} = Travel time with (un)reliability

T_f = Travel time without (un)reliability

t = v/c thresholds (C, D, E, F-low, F-high)

γ_t = Coefficients for v\c thresholds

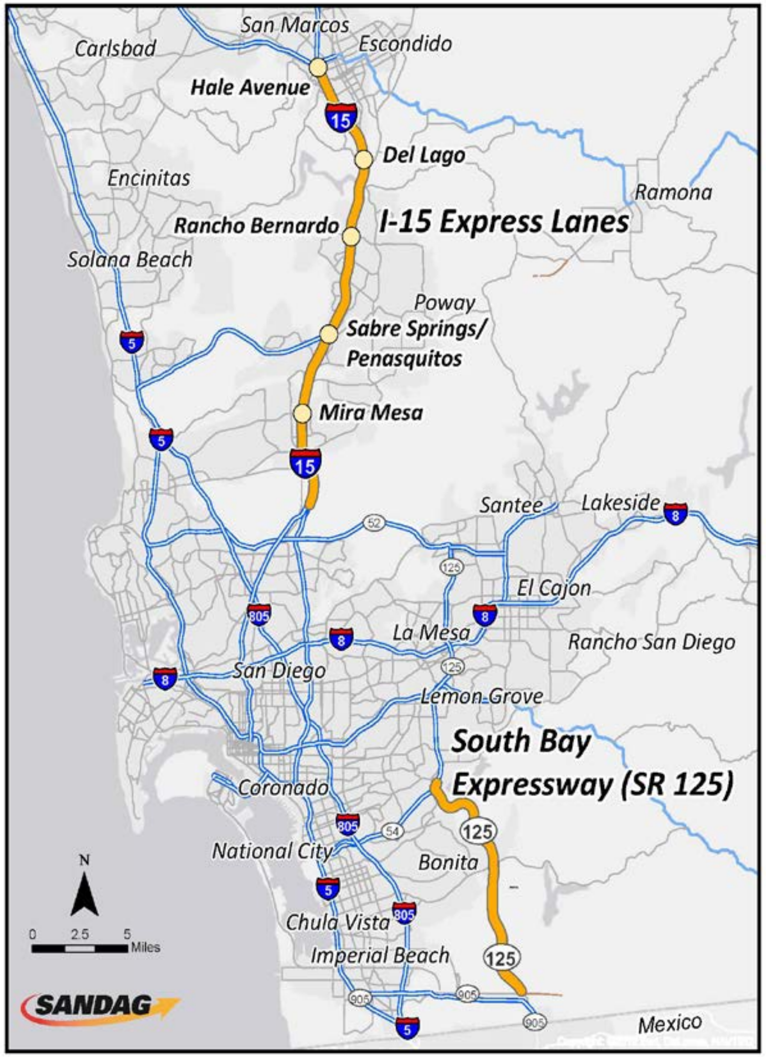
R = non-v\c link (un) reliability

Skimming

Problem: Standard deviation is not additive but variance is

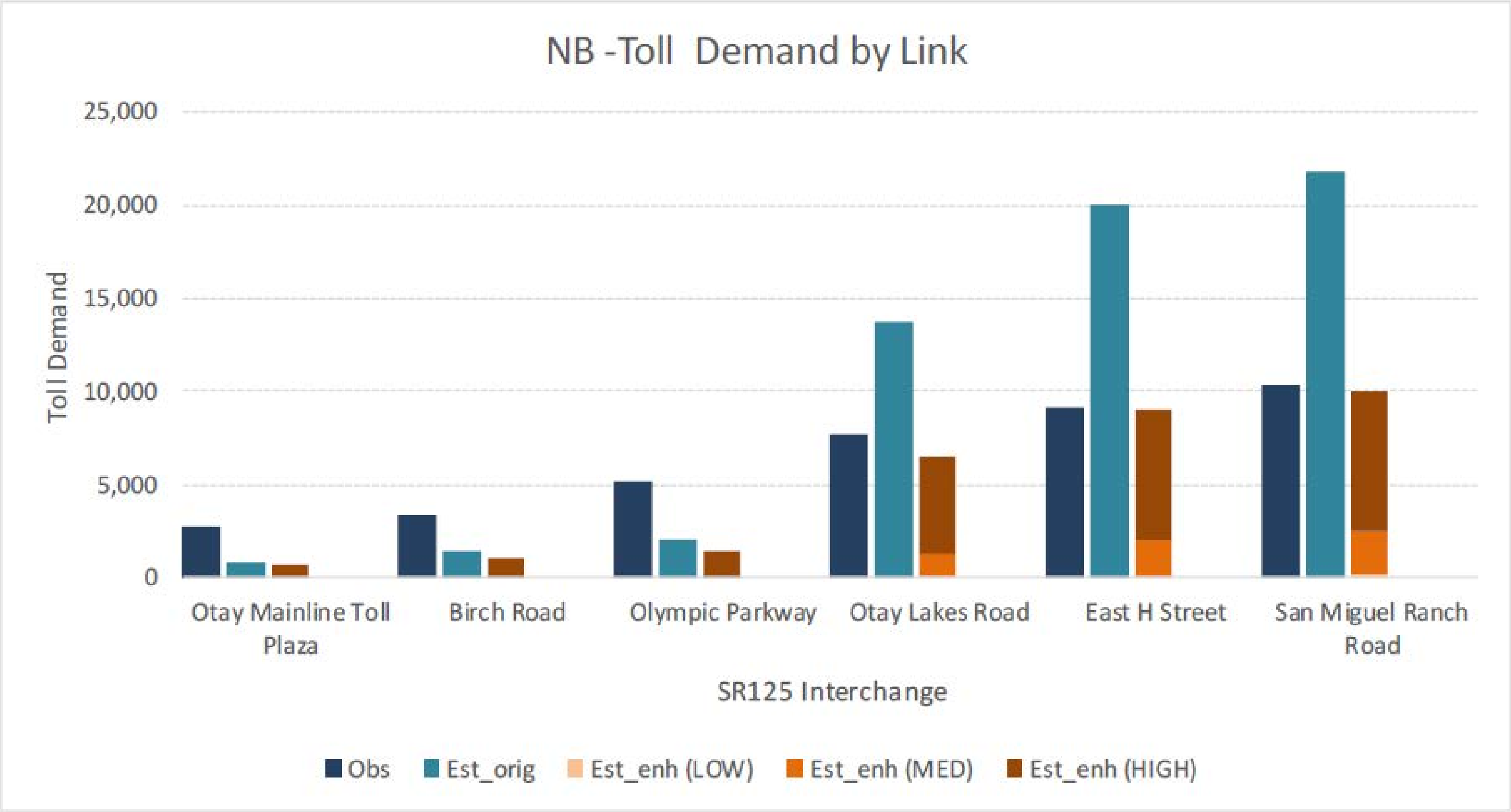
- Path reliability calculation is not theoretically consistent
- To compensate, we square the unreliability portion of the cost for each link and skim
- Final skims are square root of the skimmed value

Validation Results



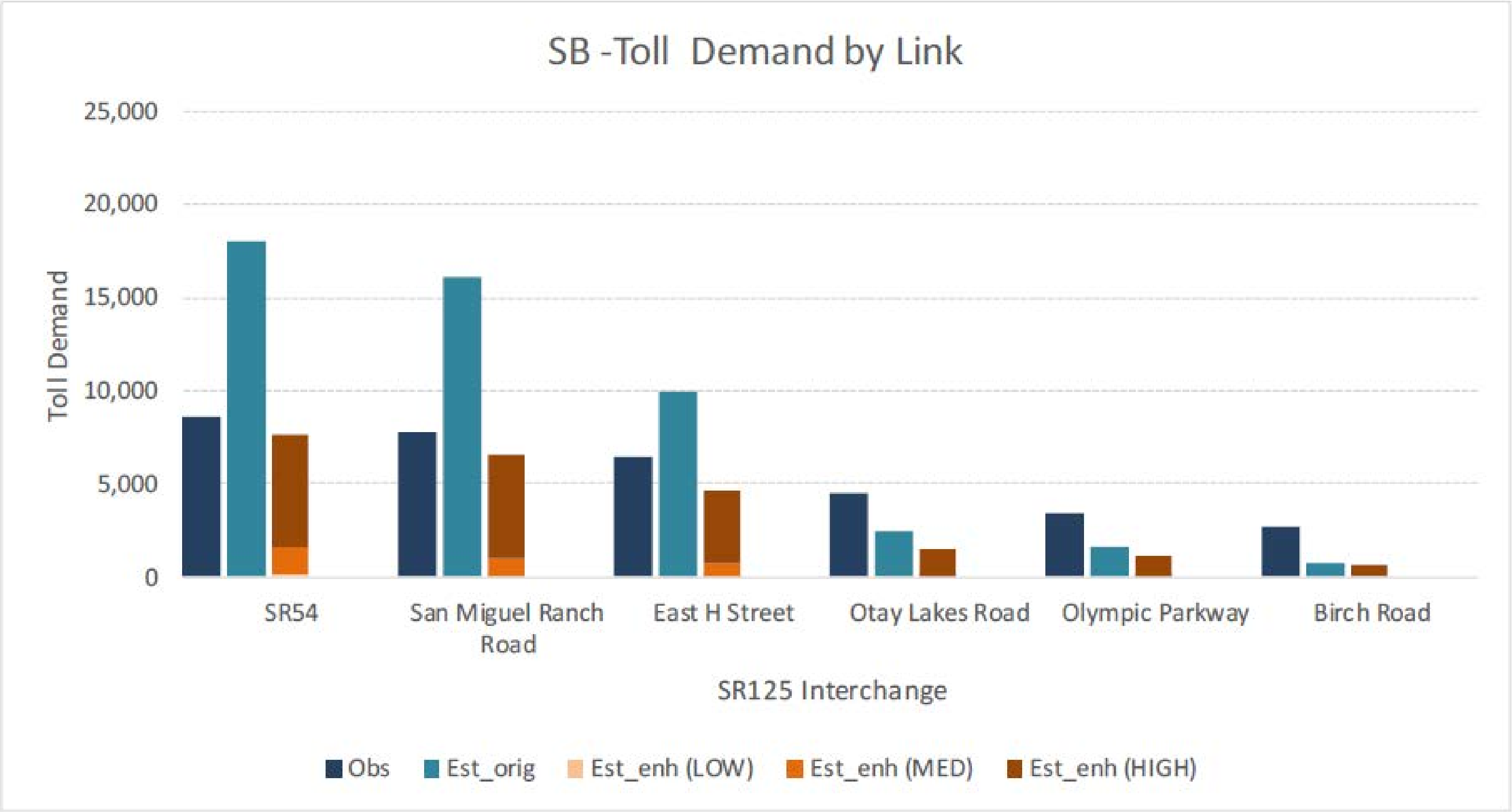
- Link level and gate-to-gate comparisons on I-15 and SR-125 toll facilities

Validation Results



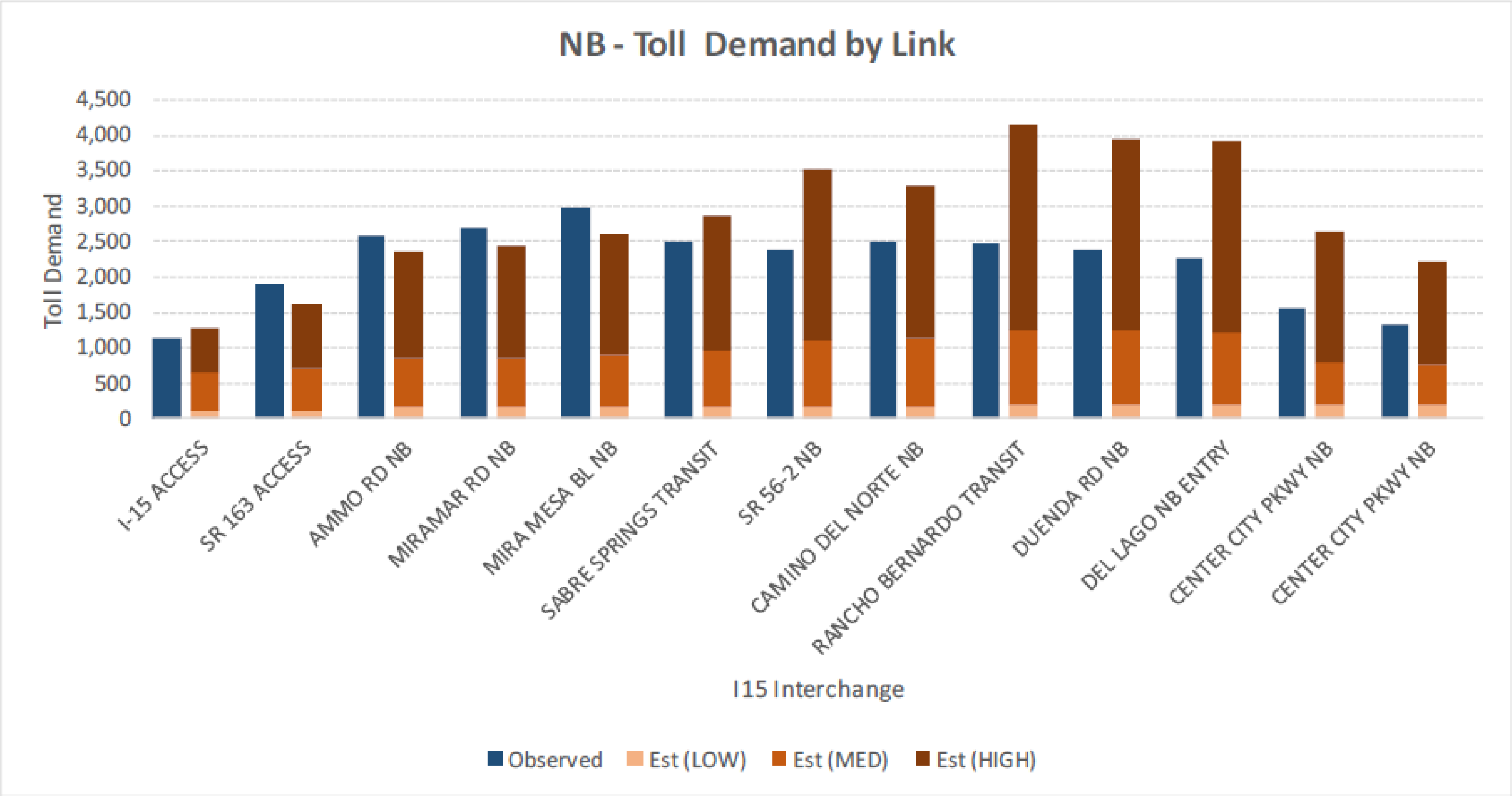
SR-125: Northbound by Segment

Validation Results



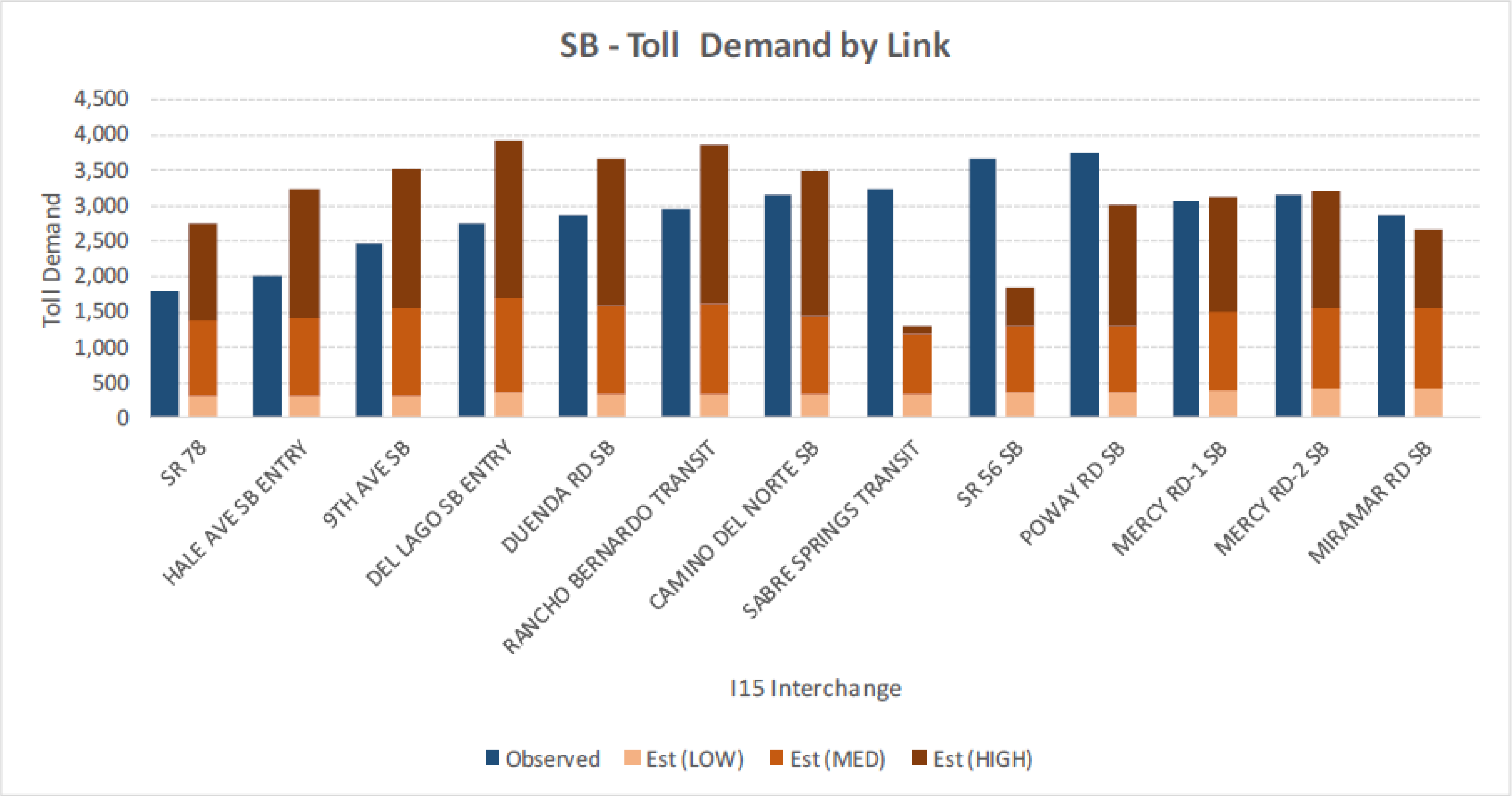
SR-125: Southbound by Segment

Validation Results



I-15: Northbound by Segment

Validation Results



I-15: Southbound by Segment

Sensitivity Tests

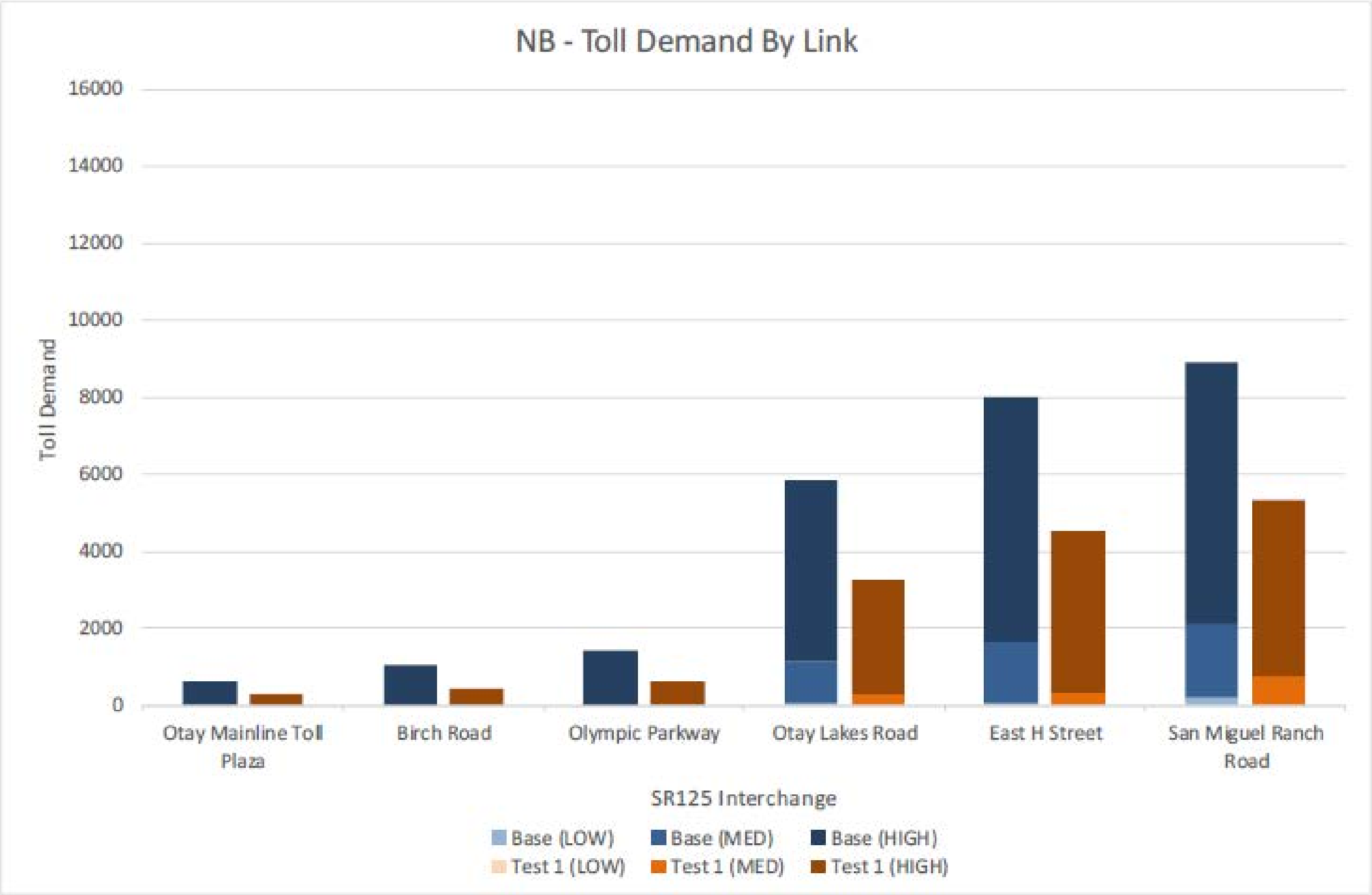
- Test 1: Half toll
  - All tolls reduced to 50% of reference case
- Test 2: Double toll
  - All tolls doubled
- Literature review of toll elasticity ranges
- Results
  - Reasonable demand responses
  - Higher elasticities for toll decrease than toll increase (right-skewed VOT distribution)
  - Elasticities generally in range of literature

Toll Elasticities

Plaza 1	Plaza 2	Base	Test 2	Diff (%)	Elasticity
Otay Mainline Toll Plaza	**Birch Road**	643	278	-57%	-0.57
Birch Road	**Olympic Parkway**	1038	449	-57%	-0.57
Olympic Parkway	**Otay Lakes Road**	1397	614	-56%	-0.56
Otay Lakes Road	**East H Street**	5867	3273	-44%	-0.44
East H Street	**San Miguel Ranch Road**	8010	4522	-44%	-0.44
San Miguel Ranch Road	**SR54**	8889	5315	-40%	-0.40

Elasticities for toll increase on SR-125 Northbound

Toll Volume by Value-of-Time



Volumes for base and toll increase on SR-125 Northbound by VOT

Final Report Completed

PROJECT REPORT

PRICING AND RELIABILITY MODEL IMPROVEMENT

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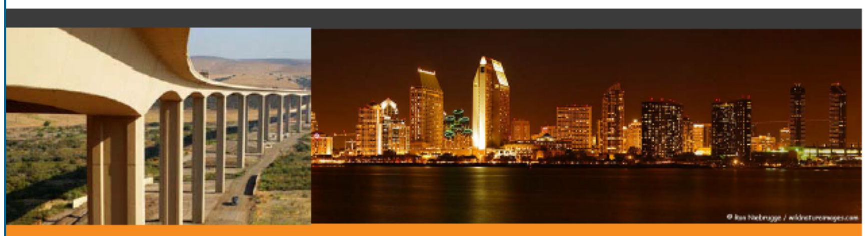
6.30.2016



Pricing and Travel Time Reliability Enhancements in the SANDAG Activity-Based Travel Model: Final Report

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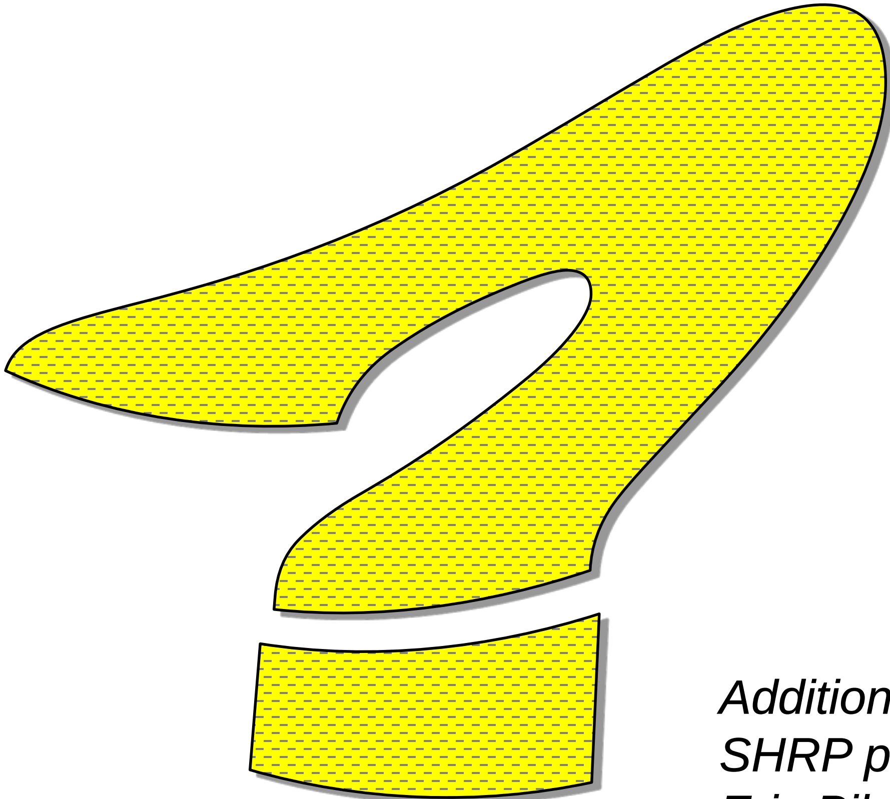
Conclusions and Future Directions

- Overall improvement in model validation
  - Little change on overall PRMSE, somewhat better performance on toll roads
  - Able to remove ‘reliability factor’ for SR-125
  - I-15 improvement largely due to transponder ownership model implementation
- Value-of-time bins provide variable and consistent toll/non-toll paths
- Final report complete, code checked into github, models installed and run on SANDAG servers
- More work is needed on reliability processing and inclusion in network models
  - Time dependent paths through observed data

Questions & Additional Information



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