VASITE Annual Meeting, 2011

Safety Effects of NEW Traffic Management Techniques

Presented by
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MANAGED LANES

- HOV (High Occupancy Vehicle)
- HOT (High Occupancy Tool)
- Truck only Toll (TOT)
- Bus Rapid Transit (BRT)

Let's get CREATIVE:

- Bus & Cars
- Trucks & Cars
- Trucks & Buses
- Bus & Motorbikes
- Truck & Motorbikes

Get MORE Creative:

AM: Bus & Cars with Toll, Noon: All Vehicles, PM: Cars & Trucks Only,
Night: Emergency Vehicles Only

MANAGED LANES

- Empirical Evidence
- Current Analysis Techniques
  - Traffic Demand Projections
  - Traffic Operations Analysis (LOS, etc.)
  - What about Traffic Safety???

We ALL agree that
EMPTY lanes are REALLY safe!

- Buses & Cars safer than Trucks & Cars?
- Buses & Trucks safer than Cars only?
- How about mix and match during different Times of Day – how safe would that be?

GOAL

Need to Empower Agencies to weigh in on Traffic Safety in selection of Managed Lanes Techniques

GROUND REALITY

- HOV/HOT/BRT have ground implementations
- Most other Combinations don't
- Traffic volumes and vehicle compositions vary across facilities
- Managed Lane implementations vary across facilities

NEED

- Need Unifying Analysis Framework
- Need Tools empowering Agencies to incorporate Traffic Safety considerations in selection of Managed Lanes Techniques

With only $200K to solve this problem, what would you do?

Parse Vehicle Trajectories for 2 NGSIM Freeway Segments to Ascertain Actual Field Conflicts
- 2100 foot segment of US-101
- 1/2 mile segment of I-80

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Calibrate Simulation Model of the NSGIM Freeway Segments to match the Simulation Conflicts with Actual Field Conflicts

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Develop Calibrated Driver Behavior Parameters for Use in All Traffic Simulations Scenarios

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Build 216,000 Unique Traffic Simulation Cases
- 100 Highway Building Blocks, 5 Traffic Demand Scenarios
- 144 Traffic Composition Scenarios, 3 Free Flow Speeds

Apply Surrogate Safety Measures of Effectiveness to the Microsimulation results to obtain:
- Traffic Operational Measures of Effectiveness
- Surrogate Safety Measures of Effectiveness

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Develop Predictive Statistical Equations Estimating Operational Performance of Selected TMTs:
- Operating Speeds on General Purpose Lanes and TMT Lanes
- Vehicular Throughput on General Purpose Lanes, TMT Lanes and Ramps

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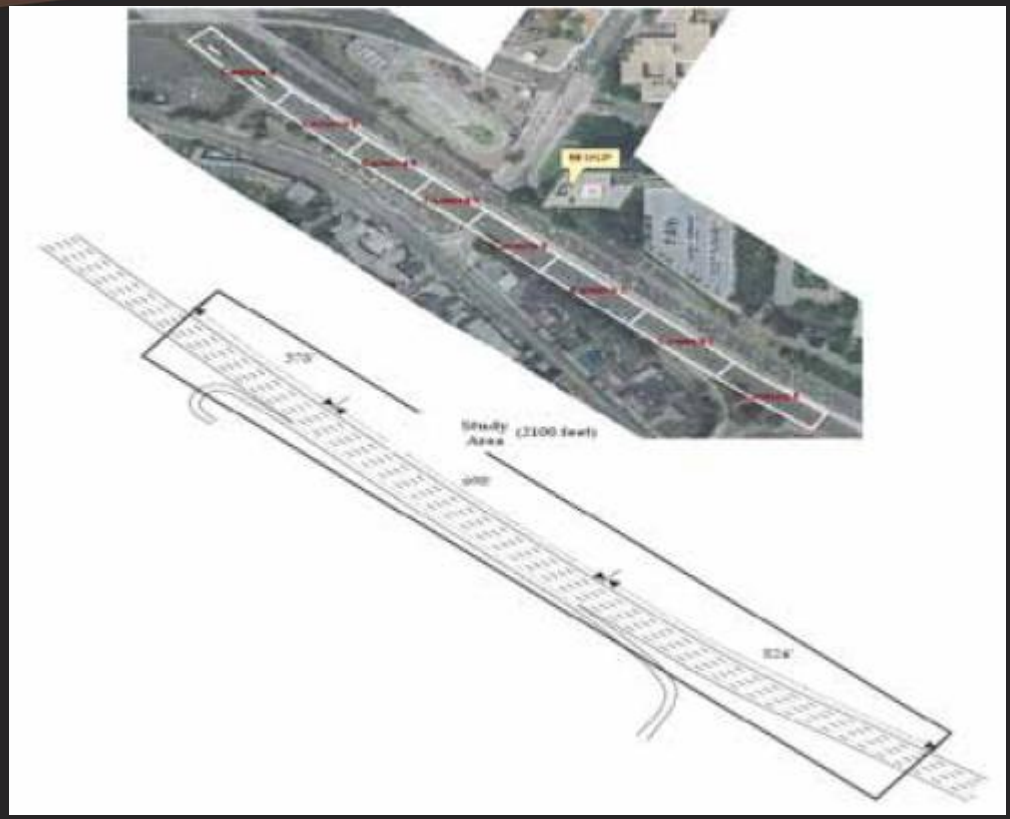
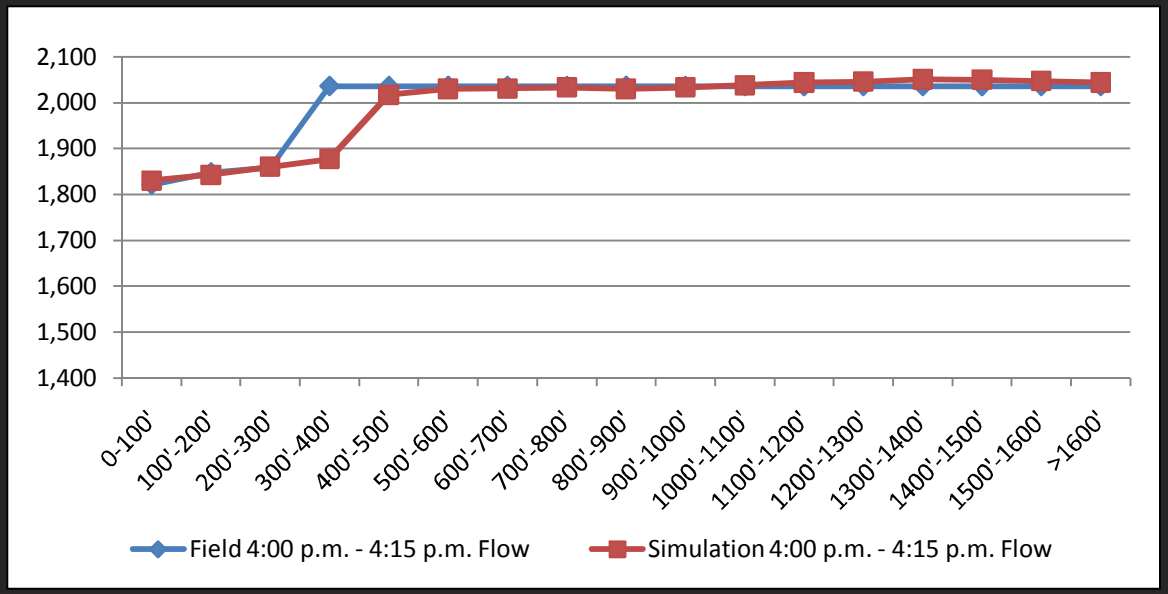
Generate a Relative Scale to provide guidance on the Safety Performance of Selected TMTs

NGSIM Calibration

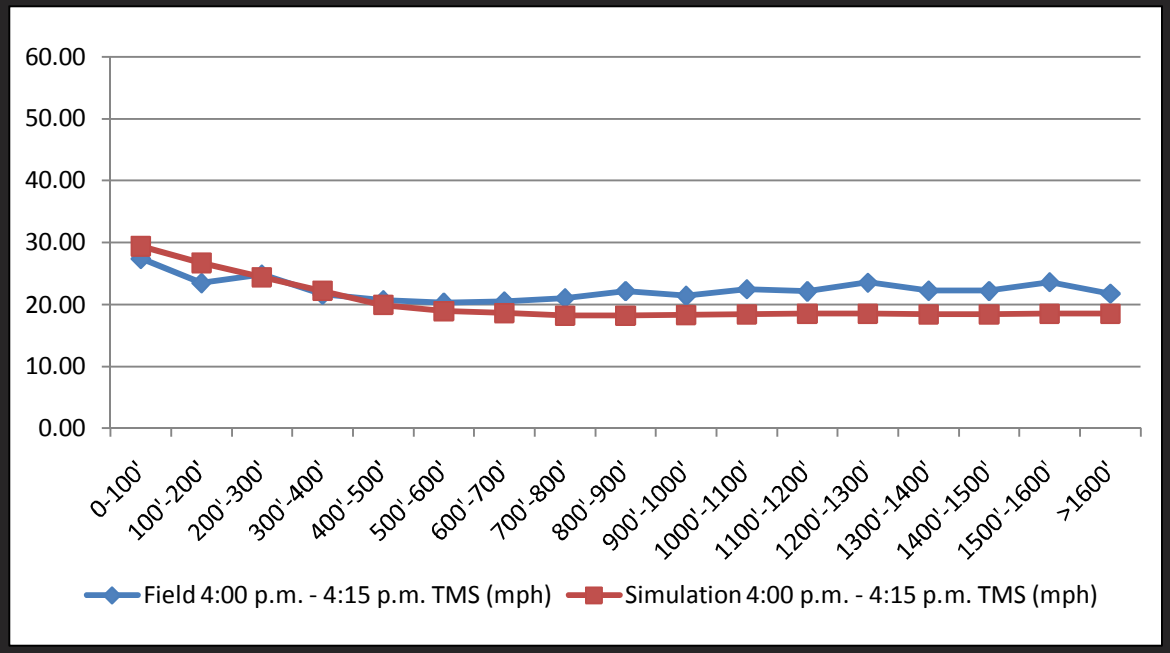
- Two DATA SETS, US 101 & I-80
- 45 minute peak period data
- Calibrated for:
  - Vehicular throughput and speed by section and time period
  - Aggregate lane changes by time period
  - Number of conflicts



NGSIM Calibration



NGSIM Calibration (cont'd.)

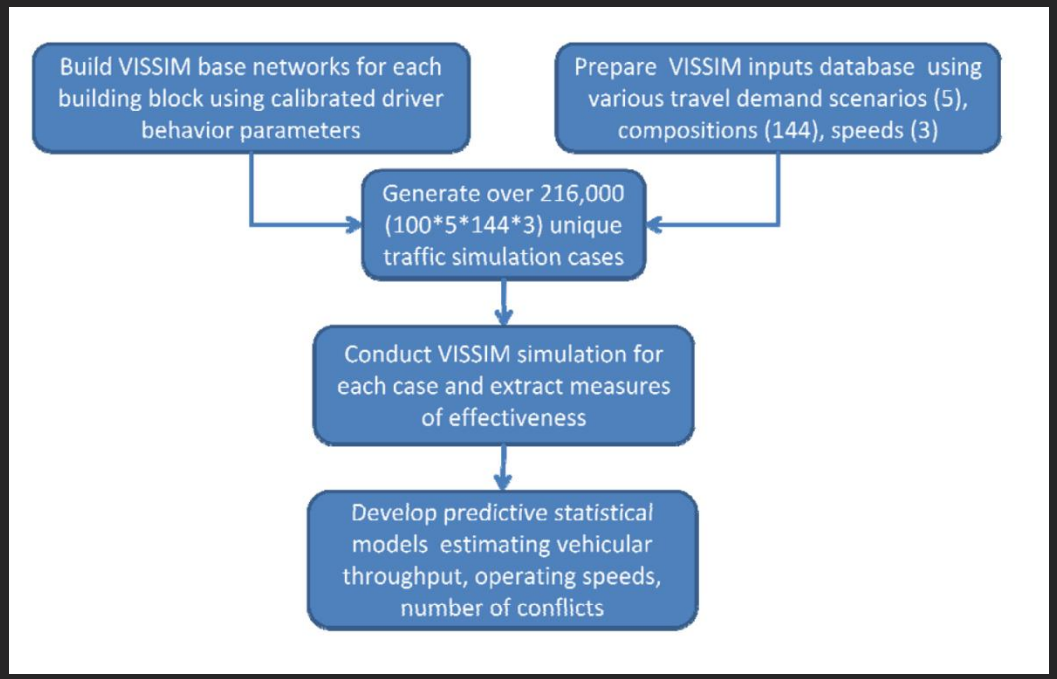


NGSIM Calibration (cont'd.)

Lane changes with 0.1 seconds of lack of attention and 10% probability

I-80 Lane Change Comparison	Field	VISSIM
4:00 - 4:15 PM	1,002	1,087
5:00 - 5:15 PM	904	945
5:15 - 5:30 PM	905	856
Total	**2,811**	**2,888**
US-101 Lane Change Comparison	Field	VISSIM
7:50 - 8:05 AM	986	880
8:05 - 8:20 AM	656	765
8:20 - 8:35 AM	645	584
Total	**2,287**	**2,229**

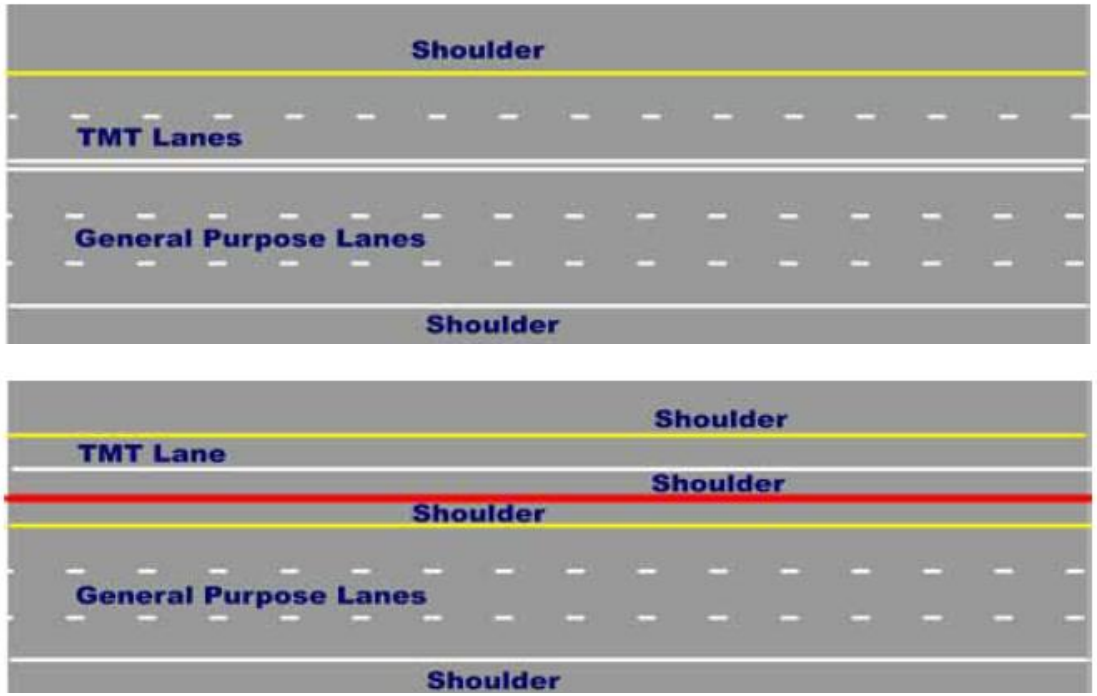
Microscopic Simulation Analysis (VISSIM)



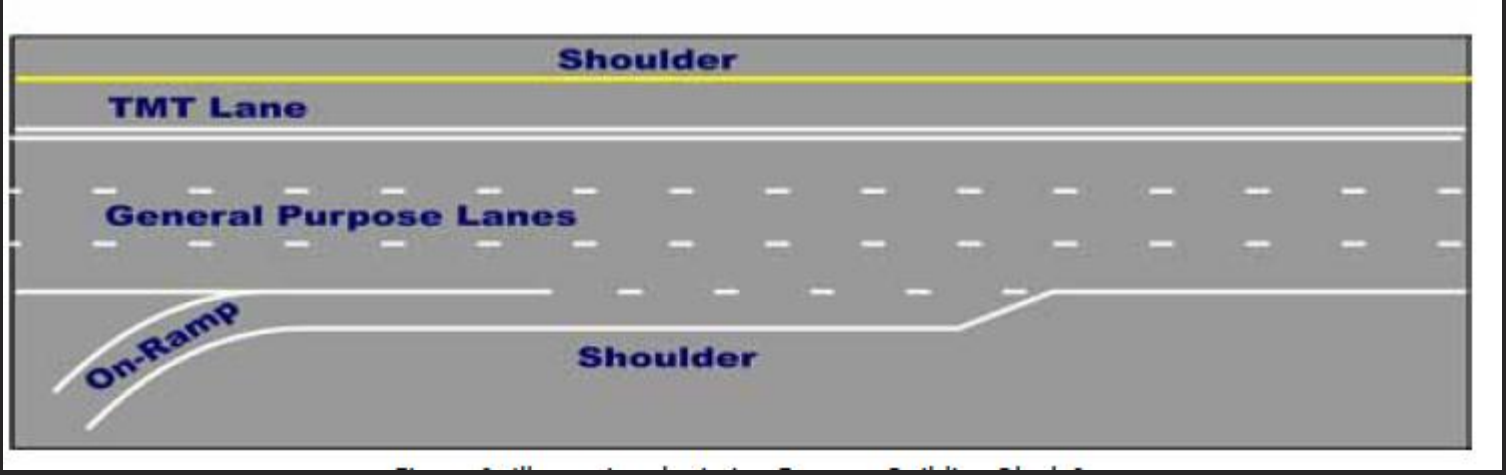
Building Blocks:

- Merge Section with Demarcated TMT Lanes
- Merge Section with Physically Separated TMT Lanes
- Diverge Section with Demarcated TMT Lanes
- Diverge Section with Physically Separated TMT Lanes
- Two-Sided Weave Section with Demarcated TMT Lanes
- Two-Sided Weave Section with Physically Separated TMT Lanes
- Basic “Closed” Highway Section

Building Blocks (Basic Freeway Section)



Building Blocks (Merge Section with Demarcated TMT Lanes)



Traffic Composition for General Purpose Lanes

Traffic Composition Index	Cars	Trucks	Buses
1	100%	0%	0%
2	95%	0%	5%
3	90%	0%	10%
4	80%	0%	20%
5	95%	5%	0%
6	90%	5%	5%
7	85%	5%	10%
8	75%	5%	20%
9	90%	10%	0%
10	85%	10%	5%
11	80%	10%	10%
12	70%	10%	20%
13	80%	20%	0%
14	75%	20%	5%
15	70%	20%	10%
16	60%	20%	20%

Traffic Composition for TMT Lanes

Traffic Composition Index	Cars	Trucks	Buses	TMT Type
1	0%	100%	0%	Truck Only
2	0%	0%	100%	Bus Only
3	0%	90%	10%	Truck/Bus Only
4	0%	10%	90%	Truck/Bus Only
5	90%	5%	5%	HOV/HOT
6	85%	10%	5%	HOV/HOT
7	70%	5%	25%	HOV/HOT
8	100%	0%	0%	HOV/HOT
9	85%	0%	15%	HOV/HOT

Theoretical Lane Throughputs (Car Equivalency)

FFS	100% Cars	100% Trucks	Car Equivalency	100% Buses	Car Equivalency
Highway Segment					
35 mph	2,031	1,533	1.33	1,351	1.50
50 mph	2,213	1,512	1.46	1,486	1.49
65 mph	2,334	1,464	1.59	1,396	1.67
80 mph	2,327	1,451	1.60	1,357	1.71
Ramp Segment					
15 mph	1,065	756	1.41	692	1.54
25 mph	1,705	1,232	1.38	1,091	1.56
30 mph	1,884	1,396	1.35	1,223	1.54
35 mph	2,031	1,533	1.33	1,351	1.50

Five Demand Scenarios

Index	Percentage
1	0.5
2	0.75
3	0.9
4	1
5	1.2

Three Freeway Free Flow Speeds

FFS (mph)	1	2	3
Highway	50	65	80
On-Ramp	25	25	25
Off-Ramp	30	35	35

Statistical Modeling

$$DV = \exp(\alpha + \beta_1 * IV_1 + \beta_2 * IV_2 + \ldots + \beta_N * IV_N)$$

Where,
DV = Dependent Variable
α and $\beta_1 – \beta_N$ = constant and coefficients estimated in the statistical analysis
$IV_1 – IV_N$ = Independent variables (inputs) included in the model

Statistical Modeling

Negative binomial regression — Number of obs = 17277
LR chi2(6) = 28654.37
Dispersion = mean — Prob > chi2 = 0.0000
Log likelihood = -51530.411 — Pseudo R2 = 0.2175

gpspeed	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
gpinput	-5.15e-06	1.31e-06	-3.92	0.000	-7.73e-06	-2.57e-06
gpspeedinput	.0149952	.0000824	182.07	0.000	.0148338	.0151566
gpcar	.1888641	.0138526	13.63	0.000	.1617135	.2160148
gptrucks	.1140758	.019034	5.99	0.000	.0767699	.1513818
gplane	.0173111	.0025862	6.69	0.000	.0122421	.02238
onrampinput	-.0000331	7.54e-06	-4.38	0.000	-.0000478	-.0000183
_cons	2.930241	.0181764	161.21	0.000	2.894616	2.965866
/lnalpha	-19.88639	20.11396			-59.30902	19.53624

gpspeed = exp(2.93 – 5.15*10^{-6} *gpinput + 0.149*gpspeedinput + 0.188*gpcar + 0.114*gptrucks + 0.017*gplane – 3.31*10^{-5} *onrampinput)

Statistical Modeling (cont'd.)

GP Throughput = exp (7.344433 + (0.0000751*gp input) + (0.0001941*on-ramp input) + (0.0003443*gp speed input) + (0.1193892*gp car) - (0.0456766*gp trucks) + (0.1379866*gp lanes))

GP speed = exp (2.930241 - (0.00000515*gp input) - (0.0000331*on-ramp input) + (0.0149952*gp speed input) + (0.1888641*gp car) + (0.1140758*gp trucks) + (0.0173111*gp lanes))

TMT throughput = exp (6.339845 + (0.0000522*TMT input) + (0.0003686*on-ramp input) + (0.2714367*TMT car) + (0.0093113*TMT trucks) + (0.4254007*TMT lanes))

TMT speed = exp (3.040779 - (0.0000128* TMT input) + (0.0139507*TMT speed input) + (0.0679383*TMT car) + (0.0247892*TMT trucks) + (0.0432345*TMT lanes))

Relative Safety Scale - Modified Time To Collision (MTTC)

$$MTTC = D_{(l-f)} / [(V_f + 0.1*A_f) - (V_l + 0.1*A_l)]$$

$D_{(l-f)}$ - Distance between the leading and following vehicle
V_f – Velocity of the following vehicle
A_f – Acceleration of the following vehicle
V_l – Velocity of the leading vehicle
A_l – Acceleration of the leading vehicle

Relative Safety Scale

Relative Safety Scale = XXyZZ

where,
XX = speed combination of trailing vehicle and leading vehicle
y = MTTC (segmented every 0.1 sec)
ZZ = leading vehicle type / trailing vehicle type combination

SUMMARY

- Unifying Analysis Framework created for incorporating Traffic Safety considerations for managed lanes
- Equations will soon be available to Agencies looking to incorporate Traffic Safety considerations in selection of Managed Lanes Techniques
- Statistical equations will help agencies perform low-cost “planning level” traffic operational analysis before investing resources in extensive simulation

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THANK YOU!