

# **ESTIMATION AND COMPARISON OF VOLUME DELAY FUNCTIONS FOR ARTERIALS AND FREEWAY HOV AND GENERAL PURPOSE LANES**

Lee Klieman and Dr. Vincent Bernardin,  
Bernardin, Lochmueller & Associates

Wang Zhang and Vladimir Livshits, Maricopa  
Association of Governments



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# PRES<sup>E</sup>NTATION TOPICS

- Benefits of effort
- Model background
- VDF estimation methodology and results
- Data
- VDF calibration
- Future work



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# IMPROVING THE MAG TDM THROUGH VDF CALIBRATION

- VDF estimation based on empirical data
- Realistic travel times and congested speeds
  - Traffic assignment
  - Air quality
  - Intermodal comparisons
- Refined differentiation between functional classes
  - Evaluation of improvements
- Reduce the instance of “special case” roads



# CONTRIBUTION TO MODELING PRACTICE

- Empirically fitted VDF curves
- Compares 4 different VDF forms
- Independently validates predicted speeds with separate data source
- Estimates VDF parameters for Freeway HOV lanes separately



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# MAG TRAVEL DEMAND MODEL

- Traditional 4-step model
- 5 area types
- 10 functional classifications
- Existing BPR curve for VDF
  - Freeways
  - Surface streets



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# DATA AVAILABLE FOR VDF ESTIMATION

Roadway Types	CBD	Outlying CBD	Mixed Urban	Sub-urban	Rural
Fwy HOV Lanes	✓	✓			
Fwy General Purpose Lanes	✓	✓	✓		
Major Arterials	✓	✓	✓	✓	✓



# ESTIMATION OF VDFS

- Inputs
  - Volume and Speed (simultaneous)
  - Volume/Capacity Ratio
  - Free Flow Speed
- Results
  - VDF Form
  - Parameters

# ESTIMATION OF VDFS

- Volume and Speed
  - Flows converted to hourly flows
- Volume/Capacity Ratio
  - Based on density
  - Volume and speed used to calculate density
  - Capacity as density at maximum flow (HCM)
- Free flow speed

# VDF FORMS AND PARAMETERS

- BPR curve
- Spiess conical function
- IITPR (link delay portion only)
- Akcelik
- Existing MAG BPR –  $\alpha = 0.10$ ,  $\beta = 8.00$
- Traditional BPR –  $\alpha = 0.15$ ,  $\beta = 4.00$
- Revised trad'l BPR –  $\alpha = 0.20$ ,  $\beta = 10.00$



# EVALUATION OF VDF CURVE FITS

- R-Squared
- RMSE
- Visual examination and professional judgment



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# INITIAL ESTIMATION OF VDFS

- Freeway – CBD

VDF Form	R-squared	RMSE			
BPR	0.92	4.8%			
Spiess	0.91	5.7%			
IIT	0.92	5.2%			
Akcelik	0.89	6.7%			
MAG BPR	0.66	21.7%	BPR	$\alpha$	$\beta$
Trad BPR	0.88	13.7%	MAG BPR	0.10	8.00
Rev'd BPR	0.71	11.4%	Trad BPR	0.15	4.00
Observations = 7,457			Rev'd BPR	0.20	10.00



# INITIAL ESTIMATION OF VDFS

- HOV Lane – CBD

VDF Form	R-squared	RMSE		$\alpha$	$\beta$
BPR	0.88	6.6%			
Spiess	0.89	7.7%			
IIT	0.87	7.0%			
Akcelik	0.87	9.1%			
MAG BPR	0.69	15.1%	BPR	0.74	4.21
Trad BPR	0.82	13.6%	MAG BPR	0.10	8.00
Rev'd BPR	0.77	9.8%	Trad BPR	0.15	4.00
Observations = 6,113			Rev'd BPR	0.20	10.00



# INITIAL ESTIMATION OF VDFS

- Major Arterial – Outlying CBD

VDF Form	R-squared	RMSE			
BPR	0.43	21.7%			
Spiess	0.40	22.0%			
IIT	0.38	22.4%			
Akcelik	0.39	22.3%			
MAG BPR	0.19	27.2%	BPR	1.13	2.64
Trad BPR	0.23	25.1%	MAG BPR	0.10	6.00
Rev'd BPR	0.22	25.2%	Trad BPR	0.15	4.00
Observations = 2,914			Rev'd BPR	0.20	10.00



# QUALITY DATA IS THE BASIS FOR SOUND VDF ESTIMATION

- Comprehensive data collected in MAG region are used exclusively
  - Volume and Speed
  - Vehicle classification
  - GPS data
  - Roadway geometry



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# DATA STRUCTURE

1500+ loc, on 5 area types

Two core weekday duration

Vehicle classification data

Volume, speed and vehicle classification by 15-min by lane including HOV lane

Dozens of loc on freeway from different of area type

AM, MD and PM in core weekday

Freeway, HOV, and arterial

Average link speed in 30-min by peak period, sec-by-sec GPS data

Travel Speed Study (sec-by-sec GPS data)

**Volume-Delay Function**

**VDF Calibration  
(By Area and Facility Class)**

**Free-Flow Speed**

**Capacity**

Freeway Management System (FMS) Data

3 months in 2008, core weekdays only

Highway Performance Monitoring System Data

Roadway geometry info: lane width, shoulder width, median width...etc

Freeway and arterial

# MODEL IMPLEMENTATION AND VDF ESTIMATION

- Free flow speeds from observed data sources
- Newly estimated VDF forms and parameters
- Roadway capacity based on HCM methodology



# VDF VALIDATION

- Model (with new VDF) validation performed iteratively during calibration and review
- Current and future horizon year model results
- Volume:
  - Individual link (R-squared, RMSE, etc)
  - Screenline/cutline
  - Corridor
- Speed: by area type, facility type, time period from GPS travel time surveys
- Sensitivity analysis on v/c, VMT, VHT, trip length



# VALIDATION (VOLUME)

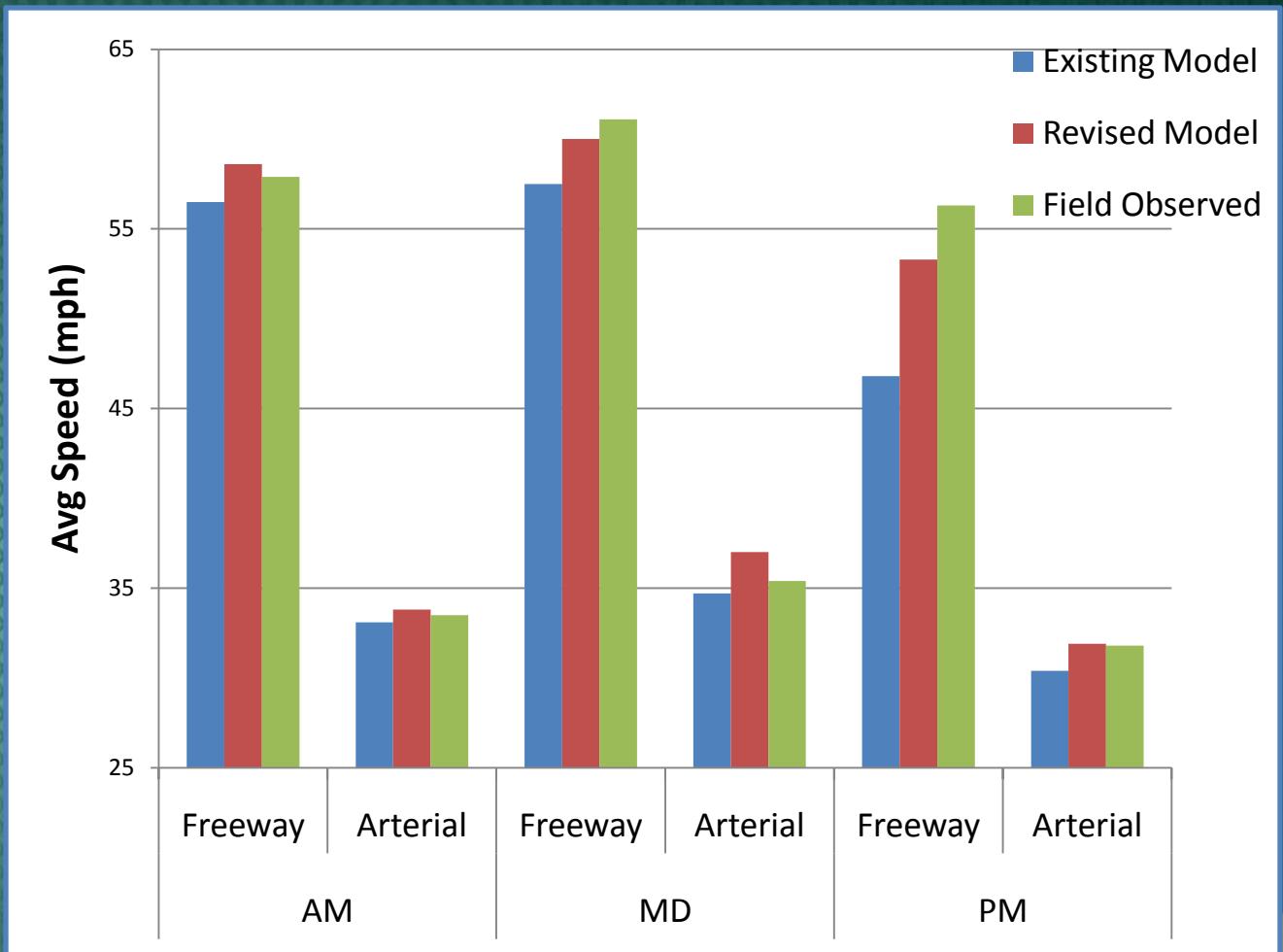
- Model volume validation slightly improved

Serial	ScreenLine	Diff in % in 2-way ADT		Absolute Diff in % in 2-way ADT	
		Existing Model	Revised Model	Existing Model	Revised Model
1	South of I-10	5%	-6%	5%	6%
2	North of I-10	2%	-13%	2%	13%
3	E of I-17	13%	8%	13%	8%
4	W of I-17	14%	-4%	14%	4%
5	River W	3%	5%	3%	5%
6	River P	2%	-9%	2%	9%
7	N of Glendale	3%	-8%	3%	8%
8	W of Scottsdale	3%	-9%	3%	9%
9	S of US 60	1%	-13%	1%	13%
10	N of US 60	2%	-11%	2%	11%
11	Out CBD	2%	0%	2%	0%
12	West of L101	0%	-15%	0%	15%
13	East of L101	5%	-12%	5%	12%
14	S of L202	57%	34%	57%	34%
15	N of L202	22%	4%	22%	4%
<b>Subtotal</b>		<b>8.9%</b>	<b>-3.1%</b>	<b>9%</b>	<b>9.9%</b>



# VALIDATION – SPEED

- Model speed validation greatly improved



# FUTURE WORK

- New Data
  - Recalibrate VDF with continuous arterial data with ideal quality and coverage
  - New speed data (private sector) as new source
- Possible model improvement
  - Impact on trip length due to change of travel time (speed and distance)
  - Explicitly modeling intersection control delay
  - Link-specific capacity estimation



# CONCLUSIONS

- Improvement of model speeds
- Parameter values for VDFs vary significantly by facility type
- Comprehensive data set key to the effort



# THANK YOU!

## QUESTIONS OR COMMENTS?



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