

# *Simulation Modeling Training*

## *Webinar 4: How to Interpret and Apply Simulation Model Results*

*presented to*

Caltrans

*presented by*

Diane Jacobs, Caltrans

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Richard Ge, Associate

Vassili Alexiadis, Executive Vice President



# *Webinar Four-part Series*

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- **Webinar 1 - Transportation Analysis and Simulation Overview**
- **Webinar 2 – Scoping a Simulation Project**
- **Webinar 3 - How to Develop, Calibrate & Review Models**
- **TODAY - Webinar 4 - How to Interpret and Communicate Model Results and How to Produce Output for Design Support and Transportation Studies from Simulation Models**

# *Today: Webinar 4 Overview*

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- **Overview of Simulation Model Output;**
- **Examples of Typical RAW and REFINED model output;**
- **Case Studies: Modeling Output Examples**
  - » Highway Capacity Improvement
  - » Bus Rapid Transit (BRT)
  - » Managed Lanes
  - » Road Diet/One-way Streets
  - » Active Transportation and Demand Management
- **Output for Draft and Final Reports**

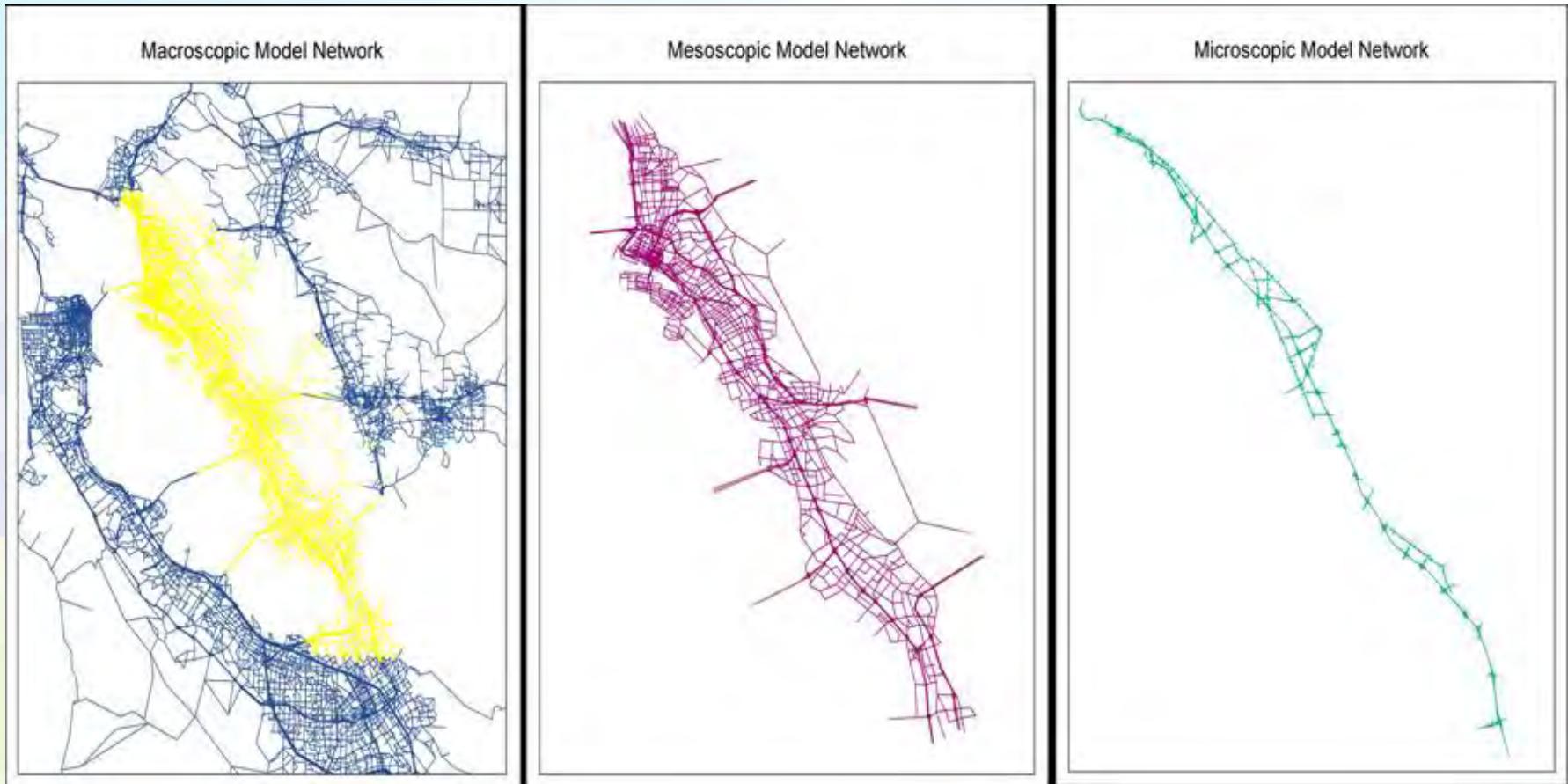


# *Travel Demand vs. Simulation Model Applications*

Model Type	Benefits	Challenges
Travel Demand Model	Best at estimating regional-level impacts of long-term travel demand changes resulting from capacity changes and mode shift	Cannot analyze system optimization strategies; not good for estimating route shifts due to incompatibility with dynamic nature of travel choices. <b>Output is link level and not detailed</b>
Mesoscopic Simulation	Best at evaluating dynamic traveler diversions in large-scale networks	Less effective and reliable in analyzing system optimization strategies at specific intersections or corridors than microscopic models
Microscopic Simulation	Best at analyzing traffic control strategies at smaller scales; allows the use of static and dynamic assignment methods. <b>Produces detailed &amp; more accurate output</b>	Not compatible for larger network analyses

# *Analysis Resolutions and Output*

- Output differs by model type and study area



# Travel Demand vs. Simulation Output

Model Output	Travel Demand Model		Microsimulation	
	Peak Period	Daily	Peak Period	Daily
Volume Forecasts	✓	✓	Flow	Flow
Speeds	Estimate	Estimate	Accurate	Accurate
Trip Length	✓	✓	✓	✓
Travel Time	Estimate	Estimate	Accurate	Accurate
VMT	✓	✓	✓	✓
VHT	Estimate	Estimate	Accurate	Accurate
Delay	Estimate	Estimate	Link level + Intersection	Link level + Intersection
Stops/Stopped Time	No	No	✓	✓
LOS	Link level	Link level	Detailed	Detailed
Queuing	Estimate	Estimate	Accurate	Accurate
Bottleneck	Estimate	Estimate	Accurate	Accurate

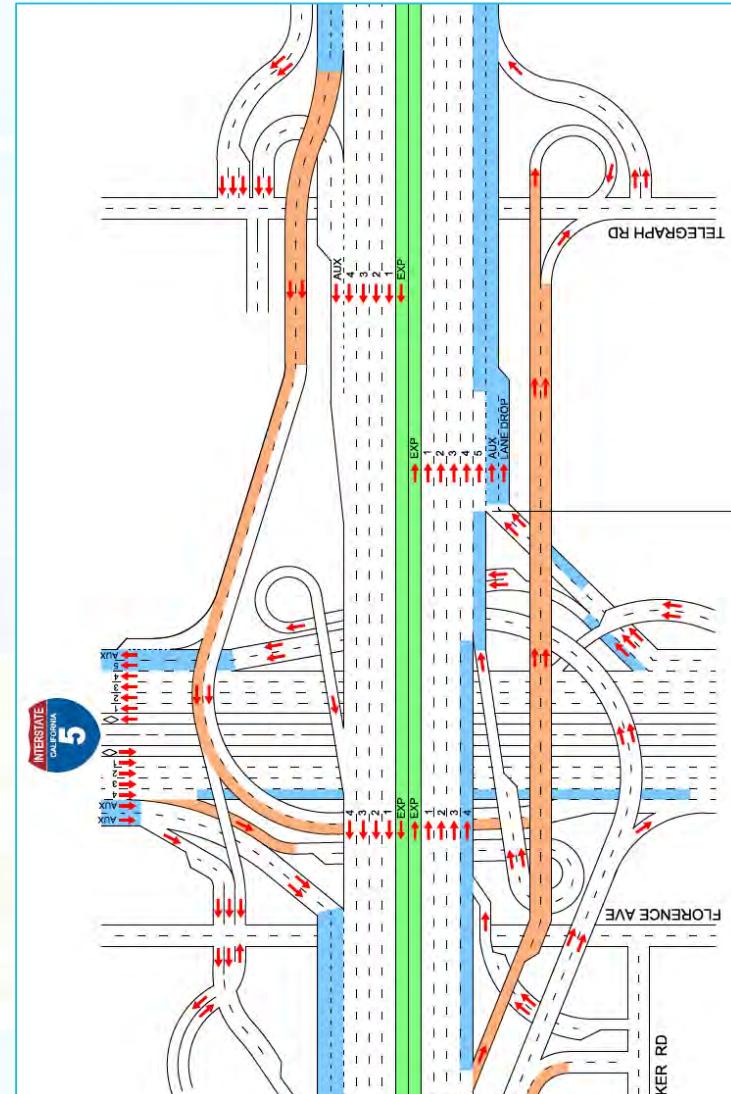
# *Microsimulation Modeling Supports:*

## ➤ Design Refinement

- » Density (LOS)
- » Delay (LOS)
- » Queue Length
- » Volume throughput

## ➤ Alternative Analysis

- » VMT
- » VHD
- » Travel Time
- » Volume/Person throughput



# *Microsimulation Modeling Supports:*

## ➤ Environmental Studies

- » Air Quality
  - Volumes
  - VMT
  - Speeds
- » Noise
  - Volumes
  - Truck Percentages

## ➤ Traffic Studies

- LOS
- Delay
- queues



Westbound State Route 91 (SR-91) Improvement Project from  
Approximately Shoemaker Avenue to Interstate 605 (I-605)  
and Northbound I-605 to Alondra Boulevard Project Approval  
& Environmental Document  
Cities of Cerritos and Artesia, California

## Traffic Operations Analysis Report

*prepared for*  
**Los Angeles County Metropolitan Transportation Authority**  
*prepared by*  
**Michael Baker International**  
*with*  
Cambridge Systematics, Inc.

# Common Microsimulation Output

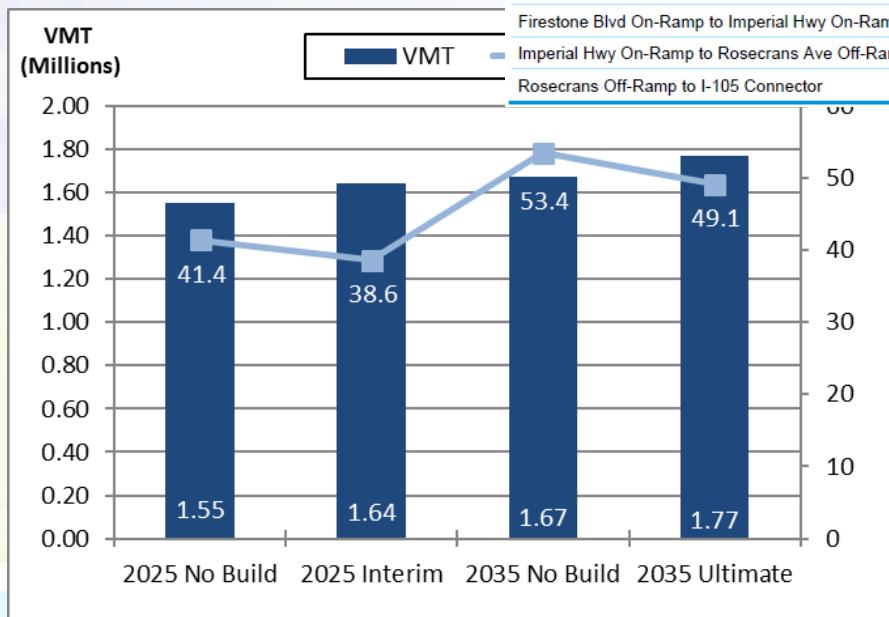
➤ Speeds

➤ Travel Times

➤ VMT

➤ VHT

Freeway Segment	6:00-7:00	7:00-8:00	8:00-9:00	9:00-10:00
<b>I-605 Southbound General Purpose Lanes</b>				
North of Washington Blvd Off-Ramp	14.4	15.1	14.0	15.4
Washington Blvd Off-Ramp to Slauson Ave Off-Ramp	14.1	28.4	30.3	31.4
Slauson Ave Off-Ramp to Washington Blvd/Slauson Ave On-Ramp	10.5	12.3	11.2	13.8
Washington Blvd/Slauson Ave On-Ramp to I-5 Connector	16.8	16.5	14.5	18.6
Telegraph Rd Off-Ramp to I-5 Connector	18.9	17.2	16.4	19.4
I-5 Connector to Telegraph Rd On-Ramp	17.8	15.6	15.8	18.0
Telegraph Rd On-Ramp to I-5 NB Connector	16.1	14.2	13.2	12.9
I-5 NB Connector to I-5 SB Connector	38.8	29.3	27.4	24.2
I-5 SB Connector to Florence Rd On-Ramp	40.9	32.9	31.4	28.0
Florence Rd On-Ramp to Firestone Blvd Off-Ramp	42.9	39.2	40.1	36.2
Firestone Blvd Off-Ramp to I-105/Imperial Hwy Off-Ramp	57.8	57.3	58.0	57.1
I-105/Imperial Hwy Off-Ramp to Firestone Blvd On-Ramp	65.3	65.4	65.5	65.5
Firestone Blvd On-Ramp to Imperial Hwy On-Ramp	63.1	61.9	62.3	63.8
Imperial Hwy On-Ramp to Rosecrans Ave Off-Ramp	63.9	63.4	62.4	64.6
Rosecrans Off-Ramp to I-105 Connector	63.4	61.9	61.8	63.8



# *Common Microsimulation Output*

➤ Delay

➤ Density

➤ LOS

➤ Queues

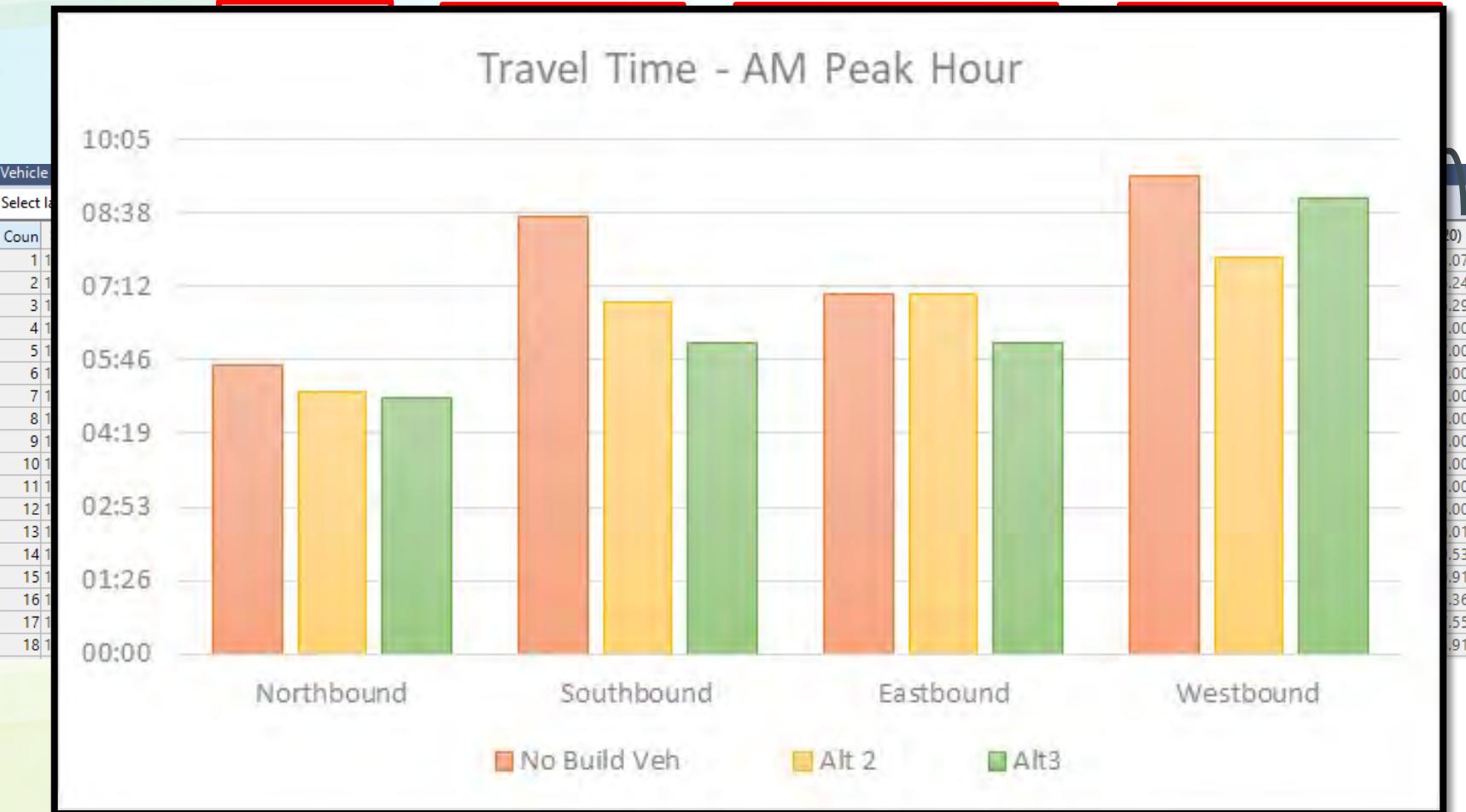
➤ Videos

Freeway Segment	6:00-7:00	7:00-8:00	8:00-9:00	9:00-10:00
<b>I-605 Southbound General Purpose Lanes</b>				
North of Washington Blvd Off-Ramp	F	F	F	F
Washington Blvd Off-Ramp to Slauson Ave Off-Ramp	F	F	F	F
Slauson Ave Off-Ramp to Washington Blvd/Slauson Ave On-Ramp	F	F	F	F
Washington Blvd/Slauson Ave On-Ramp to I-5 Connector	F	F	F	F
Telegraph Rd Off-Ramp to I-5 Connector	F	F	F	F
I-5 Connector to Telegraph Rd On-Ramp	F	F	F	F
Telegraph Rd On-Ramp to I-5 NB Connector	F	F	F	F
I-5 NB Connector to I-5 SB Connector	F	F	F	F
I-5 SB Connector to Florence Rd On-Ramp	E	F	F	F
Florence Rd On-Ramp to Firestone Blvd Off-Ramp	D	E	D	E
Firestone Blvd Off-Ramp to I-105/Imperial Hwy Off-Ramp	C	C	C	C
I-105/Imperial Hwy Off-Ramp to Firestone Blvd On-Ramp	C	C	C	C
Firestone Blvd On-Ramp to Imperial Hwy On-Ramp	C	D	C	C
Imperial Hwy On-Ramp to Rosecrans Ave Off-Ramp	C	C	C	C
Rosecrans Off-Ramp to I-105 Connector	C	D	D	C
I-105 Connector to Rosecrans Ave Loop On-Ramp	D	D	D	C



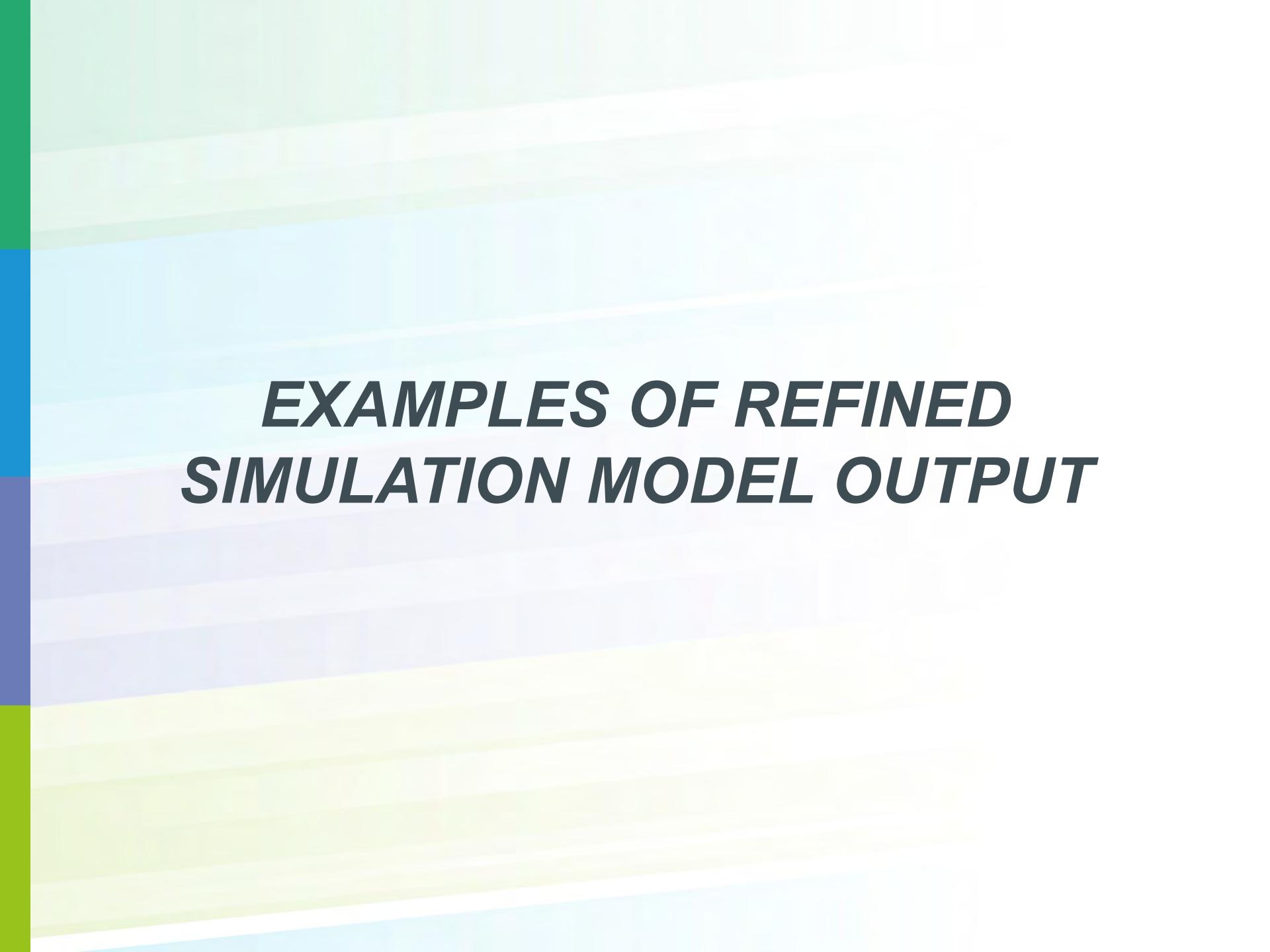
# ***EXAMPLES OF “RAW” SIMULATION MODEL OUTPUT***

# “Raw” Simulation Outputs – Segment



# “Raw” Simulation Output - Intersection

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	Sim Run	Time	Movement	Qlen	Qlen M	Veh	Per	Veh Del	Per Del	Stop Del	Stops		Veh x Delay	Avg Delay	
422	Average	900-4500	7: Diamond Bar Blvd & SR-57 SB Ramps - 120@207.0 - 193@98.9	4.1	55.7	626	628	2.8	2.8	1.5	0.1		1744.9	2.8	
423	Average	900-4500	7: Diamond Bar Blvd & SR-57 SB Ramps - 132@163.3 - 123@21.1	201.7	750.4	5	5	68.8	68.8	38.7	0.9		344.0	68.8	
424	Average	900-4500	7: Diamond Bar Blvd & SR-57 SB Ramps - 132@163.3 - 199@98.9	210.2	764.4	56	56	19.5	19.5	2.4	1.2		1094.1	19.5	
425	Average	900-4500	7: Diamond Bar Blvd & SR-57 SB Ramps - 132@163.3 - 10137@84.2	201.7	750.4	451	451	77.9	77.9	54.9	1.2		35115.2	77.9	
426	Average	900-4500	7: Diamond Bar Blvd & SR-57 SB Ramps - 135@6.4 - 123@21.1	70.8	291.0	225	225	64.2	64.2	45.7	1.3		14448.7	64.2	
427	Average	900-4500	7: Diamond Bar Blvd & SR-57 SB Ramps - 534@1492.4 - 123@21.1	8.3	173.2	710	710	9.1	9.1	0.2	0.2		6439.2	9.1	
428	Average	900-4500	7: Diamond Bar Blvd & SR-57 SB Ramps - 534@1492.4 - 10135@71.7	18.0	149.4	395	395	15.1	15.1	10.3	0.4		5959.5	15.1	26.4
429	Average	900-4500	8: Diamond Bar Blvd & SR-57 NB Ramps - 5@2852.0 - 5@2894.7	0.0	0.0	920	920	1.4	1.4	1.4	0.1				
430	Average	900-4500	8: Diamond										216.5	108.3	
431	Average	900-4500	8: Diamond										22933.7	90.3	
432	Average	900-4500	8: Diamond										38225.2	108.6	
433	Average	900-4500	8: Diamond										890.1	55.6	
434	Average	900-4500	8: Diamond										7341.9	8.8	
435	Average	900-4500	8: Diamond										47.3	0.3	
436	Average	900-4500	8: Diamond										7112.7	14.3	
437	Average	900-4500	8: Diamond												36.6
438	Average	900-4500	8: Diamond												
439	Average	900-4500	8: Diamond												
440	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 273@659.8 - 300@429.7	36.3	274.7	1147	1147	14.6	14.6	0.5	0.5		6173.6	11.1	
441	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 273@659.8 - 300@429.7	74.6	259.1	310	310	166.4	166.4	46.5	4.6		16046.3	14.0	
442	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 300@295.4 - 271@197.9	74.6	259.1	0	0						51574.4	166.4	
443	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 300@295.4 - 303@406.3	74.6	259.1	601	601	165.1	165.1	45.1	4.6			0.0	0.0
444	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 300@295.4 - 308@429.7	74.6	259.1	601	601	165.1	165.1	45.1	4.6		99219.6	165.1	
445	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 300@295.4 - 308@429.7	6.6	63.6	18	18	67.4	67.4	61.2	1.0		1213.6	67.4	
446	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 302@177.8 - 271@197.9	6.6	63.6	0	0						0.0	0.0	
447	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 302@177.8 - 298@22.2	0.7	21.4	2	2	69.3	69.3	62.2	1.0		138.7	69.3	
448	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 302@177.8 - 308@429.7	21.7	200.0	2544	2544	10.4	10.4	3.5	0.3		26508.4	10.4	
449	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 552@4053.2 - 271@197.9	0.0	0.0	0	0						0.0	0.0	
450	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 552@4053.2 - 298@22.2	21.7	200.0	2	2	5.3	5.3	2.3	0.3		10.7	5.3	38.8
451	Average	900-4500	9: Grand Ave & SR-60 WB Ramps - 552@4053.2 - 303@406.3												



# ***EXAMPLES OF REFINED SIMULATION MODEL OUTPUT***

# Measures of Effectiveness (MOE)

## ➤ SR-91 Westbound Imp. Project PA/ED

Table 4-51 - Corridor Performance Measures – AM Period

Time Period	Performance Measure	2044 No-Build	2044 Build	Difference	2044 Diamond Ramps	Difference
AM Period (05:00 to 11:00)	Average Vehicle Delay (s)	131	37	-94 s	49	-82 s
	Total Travel Time (hr)	1,411	995	-30%	1,086	-23%
	Average Flow (veh/hr)	3,235	3,560	+10%	3,613	+12%
	Average Speed (mph)	37.0	53.4	+16.4 mph	51.1	+14.1 mph
AM Peak Period (07:00 to 08:00)	Average Vehicle Delay (s)	179	28	-151 s	33	-146 s
	Total Travel Time (hr)	274	162	-41%	168	-39%
	Average Flow (veh/hr)	3,198	3,695	+16%	3,698	+16%
	Average Speed (mph)	30.0	54.9	+24.9 mph	53.5	+23.5 mph

Source: Cambridge Systematics, Inc., 2017.

# *Measures of Effectiveness (MOE)*

## ➤ I-605 CIP Project PA/ED

MOE	Existing	Future Alt 2	Future Alt 3
<b>AM Peak Period</b>			
Average Speed	25.9	36.0	40.1
Vehicle Hours of Delay (VHD)	18,100	12,900	9,300
Vehicle Miles of Travel (VMT)	846,140	973,140	1,053,450
<b>PM Peak Period</b>			
Average Speed	33.5	40.3	40.2
Vehicle Hours of Delay (VHD)	11,400	8,800	8,800
Vehicle Miles of Travel (VMT)	890,670	1,024,910	1,023,990

Source: Cambridge Systematics, Inc.

# *Model Calibration Output*

- Model Calibrated to traffic counts (fall 2016) and PeMS speed data.

## Connector Ramp to I- 605

## *Actual Speeds*

63	58	54	47	46	50	47	41	46	52	57	57	53	52	52	50	50	49	48	46	43	43	43	42	37	36	36	36	40	41	43	41	33	32	26	29	27	27	26	22	23	24	24	21	32	37	32	34	31	36	35	28	33	38	40	41	42	43	41	39	38	36	37	39	41	43	45	44	45	45	48	48													
67	57	53	53	49	52	48	44	42	43	44	42	41	40	38	37	38	37	38	37	38	34	34	34	31	30	31	31	32	31	32	33	33	27	25	22	23	23	22	20	18	21	19	21	16	23	28	27	27	25	29	31	31	32	32	29	27	28	26	27	29	30	33	30	32	33	36	40																	
69	69	68	67	59	60	51	47	44	44	45	44	41	41	39	42	44	46	43	40	38	37	38	38	37	38	38	39	38	40	35	34	31	34	33	31	32	30	31	30	31	29	30	35	37	36	34	38	38	34	33	38	39	42	43	43	39	37	38	36	35	37	38	42	43	44	45	46	48																
69	71	71	72	63	59	50	44	42	39	40	41	39	35	36	34	36	35	37	34	32	31	31	30	28	31	28	36	31	28	29	35	27	24	21	21	21	20	21	17	19	19	23	18	20	27	30	26	28	26	31	24	22	29	31	29	36	38	35	32	30	30	28	28	30	32	35	34	35	42	36	41													
68	68	69	69	68	57	47	44	40	36	34	35	32	28	27	25	27	28	28	29	24	23	23	23	22	21	19	19	21	20	22	20	22	21	18	17	16	17	16	18	15	14	15	15	14	12	20	25	21	20	27	21	17	23	23	22	24	24	24	24	22	23	23	22	21	21	21	26	22	30	31	37	31	30	30	28	27	25	26	25	30	35	35	44	46
67	67	67	68	68	59	55	51	48	46	50	52	45	40	33	29	28	32	31	30	26	25	24	27	25	23	22	21	22	21	21	21	24	22	20	19	18	19	20	18	17	19	18	19	15	21	25	26	27	23	32	30	23	23	27	29	29	31	32	30	28	27	25	26	25	30	35	35	44	46															
66	66	66	68	67	61	61	59	58	61	63	66	61	51	45	42	35	35	33	31	30	28	26	27	25	26	25	25	24	23	23	22	18	20	17	19	19	21	20	24	19	20	20	20	18	27	30	27	27	24	23	34	31	26	33	40	42	44	47	44	42	35	32	29	26	26	33	38	42	49	50														
65	65	65	65	65	65	59	56	58	57	59	61	60	51	47	44	39	39	38	38	35	34	34	34	32	33	30	31	30	29	29	27	27	27	29	26	28	27	26	24	23	33	35	32	30	29	36	31	38	43	45	48	49	47	45	39	37	34	31	33	32	38	43	46	53	53																			
69	67	66	67	65	63	61	62	63	67	68	66	70	71	71	66	55	51	48	53	55	39	37	34	28	28	29	23	23	29	29	32	33	44	36	31	27	24	22	27	24	21	21	20	22	19	32	47	56	62	63	67	66	64	64	63	64	67	57	43	41	46	56	58	61	65																			

Carmenita

06:00

07:00

08:00

09:00

10:00

## Connector Ramp to I- 605

## ***Simulated Speeds***

59	53	51	50	50	50	50	51	50	49	49	49	48	46	47	46	45	43	43	41	41	40	40	40	42	44	47	48	48	48	48	49	47	48	48	47	47	47	46	45	45	44	46	48	48	47	45	45	48	49	48																	
57	44	37	38	38	38	40	39	38	39	39	38	38	37	38	38	37	37	36	36	37	37	36	37	36	37	37	37	37	38	36	34	36	36	36	36	37	35	37	35	34	35	33	33	33	32	31	29	31	32	32	33																
55	49	47	44	43	45	42	45	46	47	44	42	38	32	28	27	27	26	25	24	24	23	24	24	25	25	26	26	27	27	27	25	26	27	28	26	25	25	25	24	25	26	27	27	27	28	28	29	30	29	28	27	30	31	30	30												
61	58	53	56	56	56	56	56	56	57	56	56	51	49	42	34	29	24	20	20	21	20	18	16	15	14	15	16	16	17	17	17	17	18	19	20	19	20	21	19	20	19	19	19	19	19	19	19	20	19	21	26	27	26														
61	60	59	59	60	60	59	59	59	59	59	59	59	59	56	52	48	43	39	34	31	30	26	23	20	22	24	24	21	21	22	22	23	23	22	24	25	26	25	25	22	22	22	21	21	22	21	20	23	23	24	25	23	26	27	27	30	31	30									
62	61	61	61	61	61	61	60	61	61	61	61	61	61	61	60	57	55	52	51	47	42	35	30	26	23	23	24	24	23	24	24	24	24	23	23	23	24	25	27	27	28	25	26	25	25	24	26	26	29	30	31	34	39	38	35	40	42	43	44	44	42	42	45				
60	60	59	59	59	59	59	59	59	59	59	59	59	58	58	58	58	58	58	54	53	50	49	45	38	34	29	28	27	26	24	24	24	24	25	25	29	25	27	31	34	35	36	36	34	34	35	35	36	33	35	38	40	41	40	40	41	41	41	43	46	47	50	53	50	55		
60	60	60	60	60	60	60	60	60	60	60	60	60	59	59	58	59	58	59	59	56	53	52	51	51	49	49	39	37	36	36	36	33	32	31	31	32	32	34	34	38	37	41	47	47	46	47	42	45	42	45	48	49	50	52	55	55	55	55	55	55	50	50	50	50	50	50	50
55	55	56	55	56	54	54	55	55	56	54	52	53	52	51	51	52	51	50	51	52	50	49	47	45	43	44	41	40	42	43	43	43	44	44	47	49	47	46	50	45	44	45	45	49	49	49	48	49	48	47	46	50	48	48	51	49	50	50	51	50	50						

Carmenita

06:00

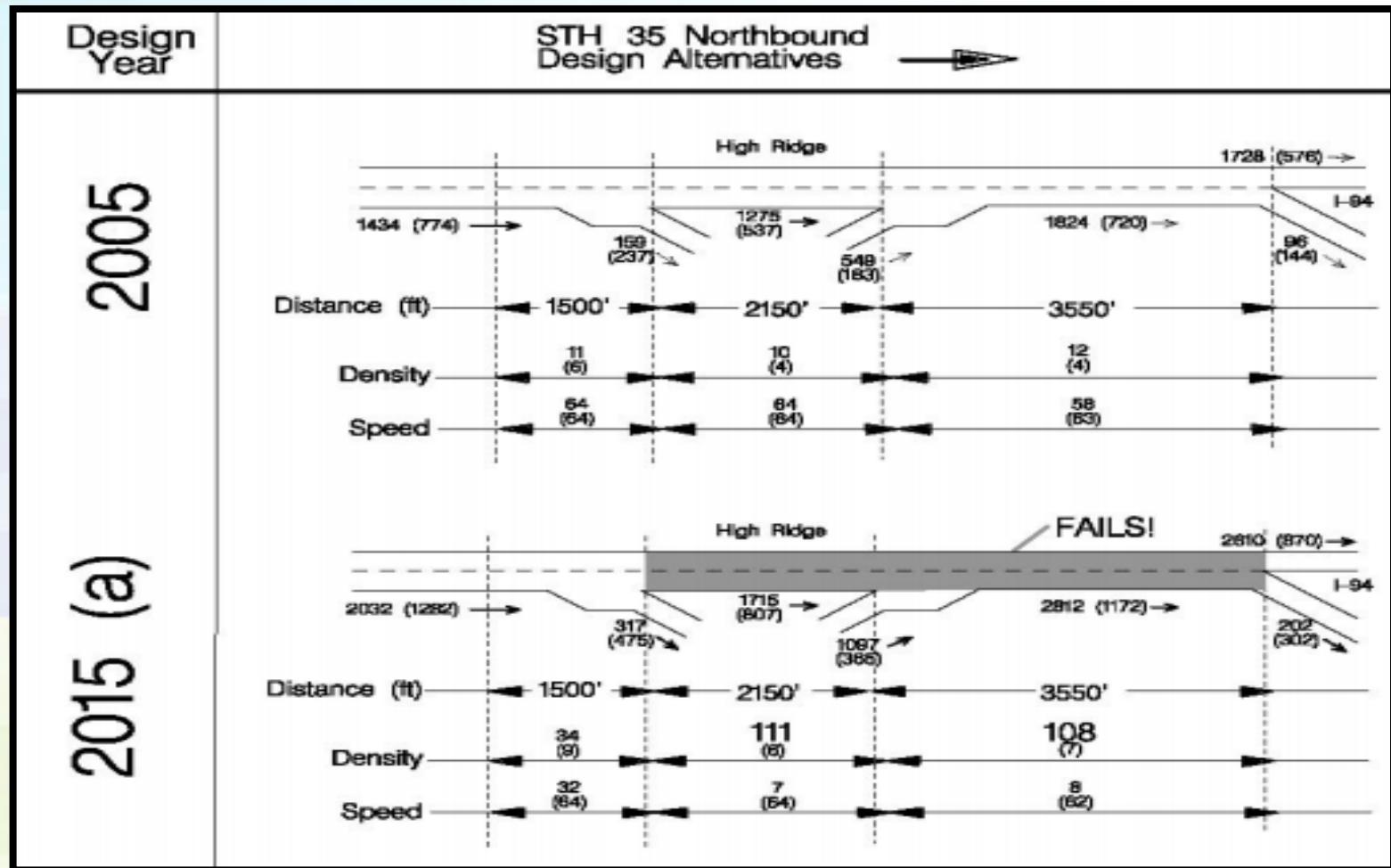
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10:00

# Output - Schematic Comparison



(Source: Minnesota Department of Transportation/ Federal Highway Administration Traffic Analysis Toolbox Volume IV.)

# Environmental Study Output

			Control Type	Peak Hour Approach Volumes		LOS		Delay		
Northbound Ramps	Existing	NB		AM	PM	AM	PM	AM	PM	
		One-Way Stop Sign	North Leg	0	0	C	F	15.4	61.3	
			South Leg	251	322					
			East Leg	293	1012					
			West Leg	973	505					
	Horizon Year (2040)	Build	One-Way Stop Sign	North Leg	0	0	C	F	18.2	200.5
				South Leg	260	344				
				East Leg	479	1375				
				West Leg	1019	536				
			Roundabout	North Leg	0	0	A	A	4.0	4.8
				South Leg	260	344				
				East Leg	479	1375				
				West Leg	1019	536				

➤ Delay, Level of Service, Speeds

# *Visual Results to Support Design*

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***Numbers don't tell the story so visualization is needed:***



*Without Mitigation*



*With Mitigation*

# *Simulation Output: 5 Case Studies*

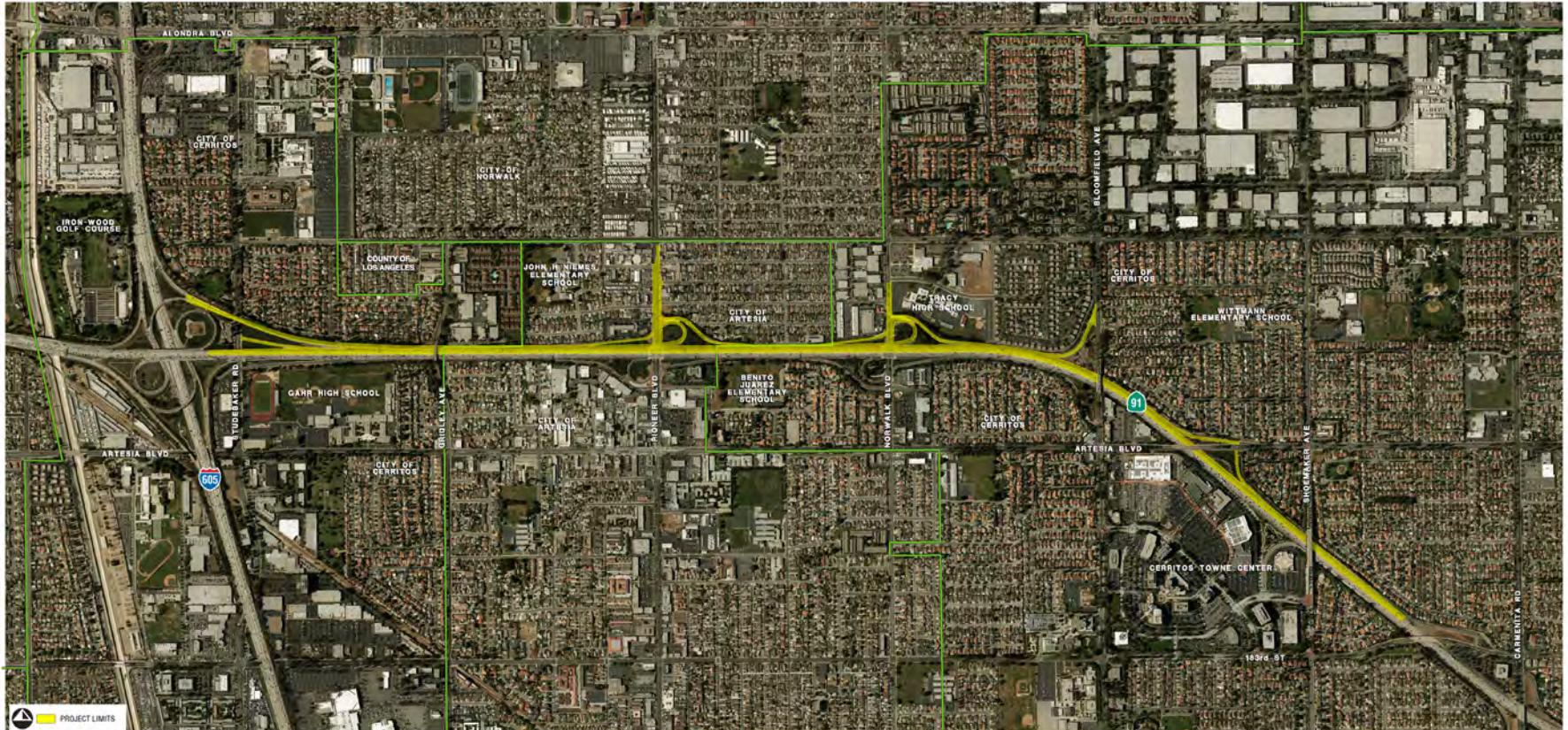
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1. Highway Capacity Improvement
2. Active Transportation and Demand Management
3. Bus Rapid Transit
4. Managed/HOT Lanes
5. Road Diet/One-way Streets

# ***OUTPUT CASE STUDY 1: HIGHWAY CAPACITY IMPROVEMENT***

# SR-91 Westbound Improvement

Westbound SR-91 Improvement Project



→ 3 mile westbound corridor

# *SR-91 Westbound Improvement*

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## ➤ Project Objectives

- » Mitigate freeway to freeway congestion
- » Improve weaving/operations
- » Reduce delay
- » Improve LOS
- » Mitigate high crash locations

## ➤ Project Features

- » Add one lane
- » Reconfigure Interchanges
- » Improve system connector ramp
- » Improve alignments

# *Highway Capacity Simulation*

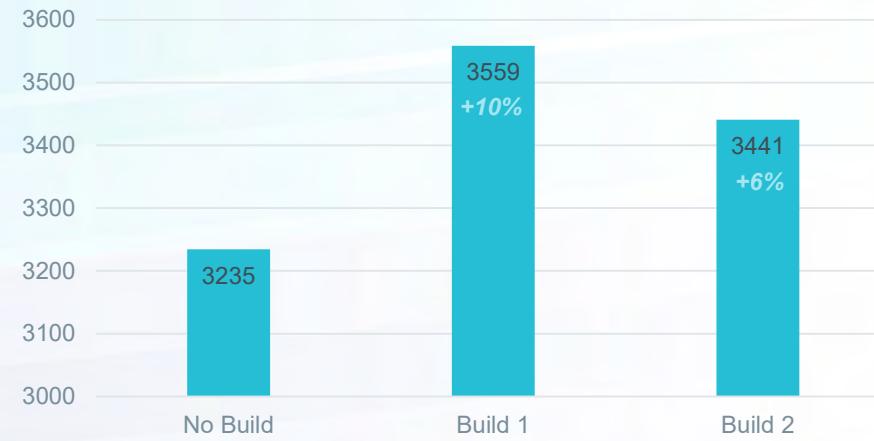
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## ➤ Key Output:

- » Total network delay
- » Delay by location/segment
- » Speeds
- » VMT/VHT
- » Intersection/Approach delay at ramps
- » Average queue length at ramps and mainline
- » Travel time – corridor and segment
- » Animations/visualizations

# *Output Comparisons – Flow vs. Speed*

Average  
Flow  
(veh/hr)

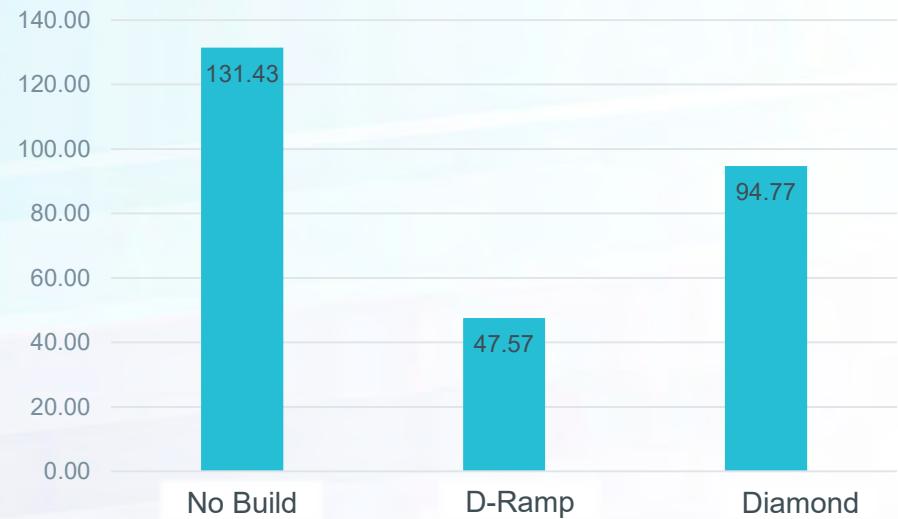


Average  
Speed  
(mph)

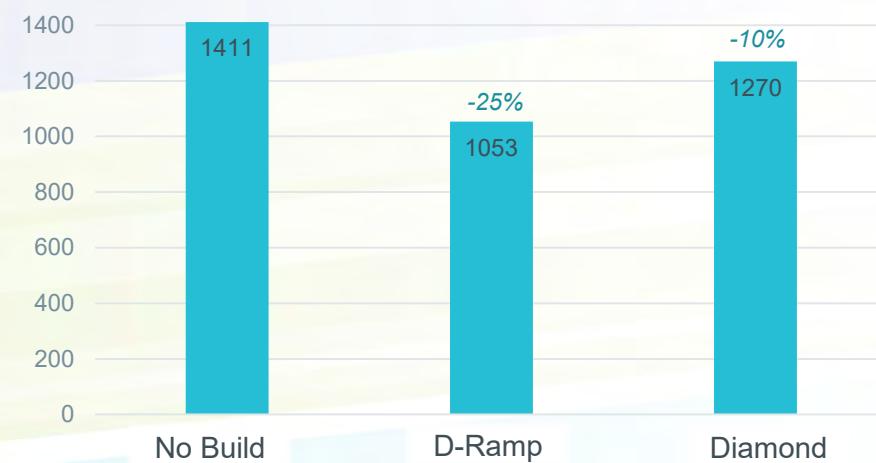


# *Output Comparisons – Delay & Travel Time*

Average Vehicle Delay (sec)



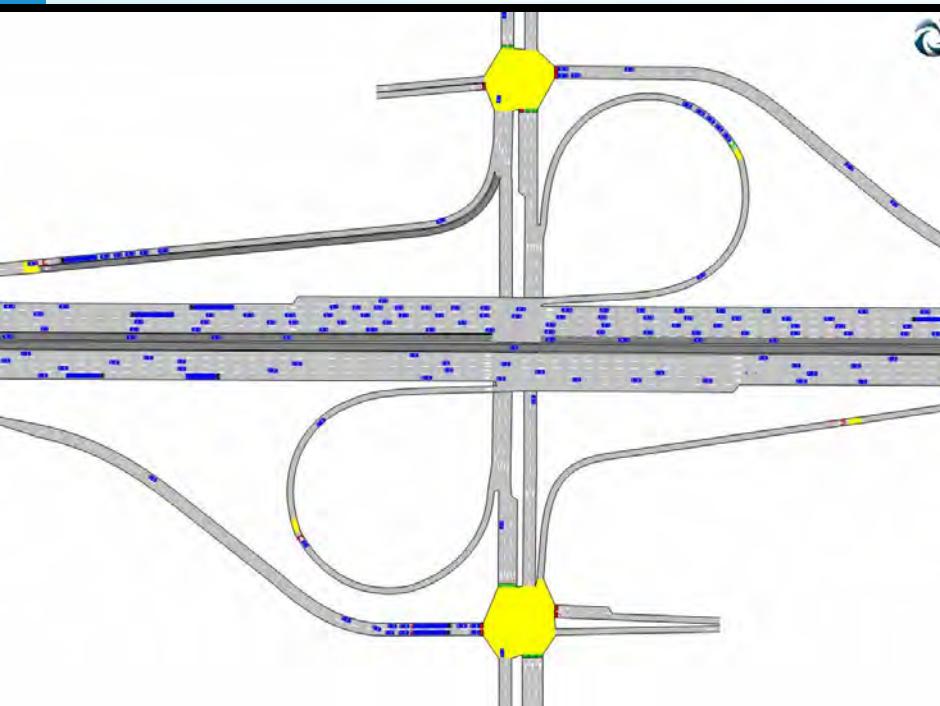
Total Travel Time (hr)



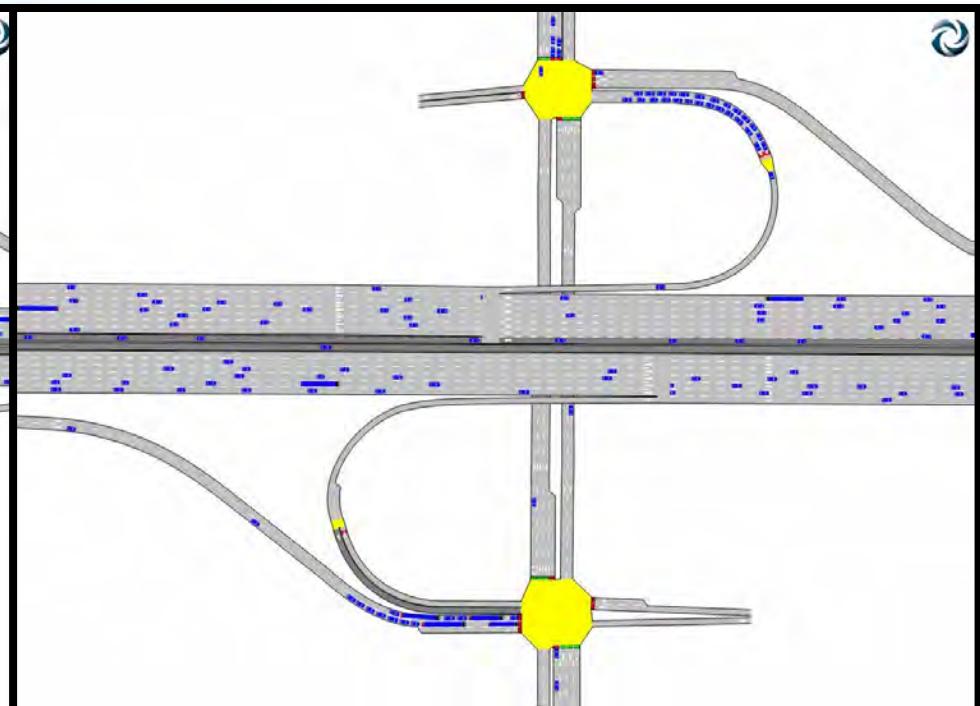


# *Simulation of Ramp Modification*

*Base Year Model*



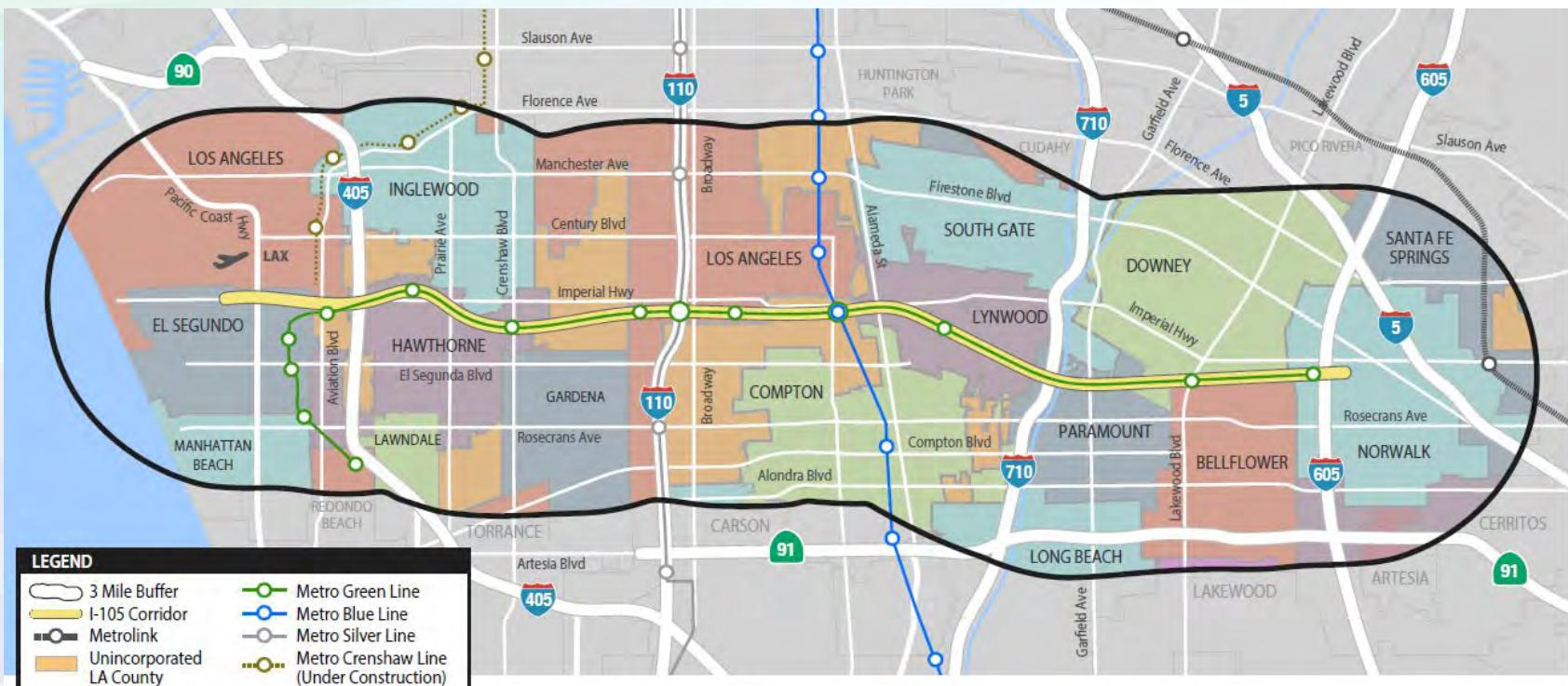
*2035 'Build' Scenario*



*SR-91 & Pioneer*

# ***OUTPUT CASE STUDY 2: ACTIVE TRANSPORTATION AND DEMAND MANAGEMENT IMPROVEMENTS***

# I-105 Frwy. Active Transportation and Demand Management



**Project Objectives:** Test Active Transportation and Demand Management Strategies for I-105 Freeway Corridor

# *Active Transportation and Demand Management*

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## ➤ Key Output:

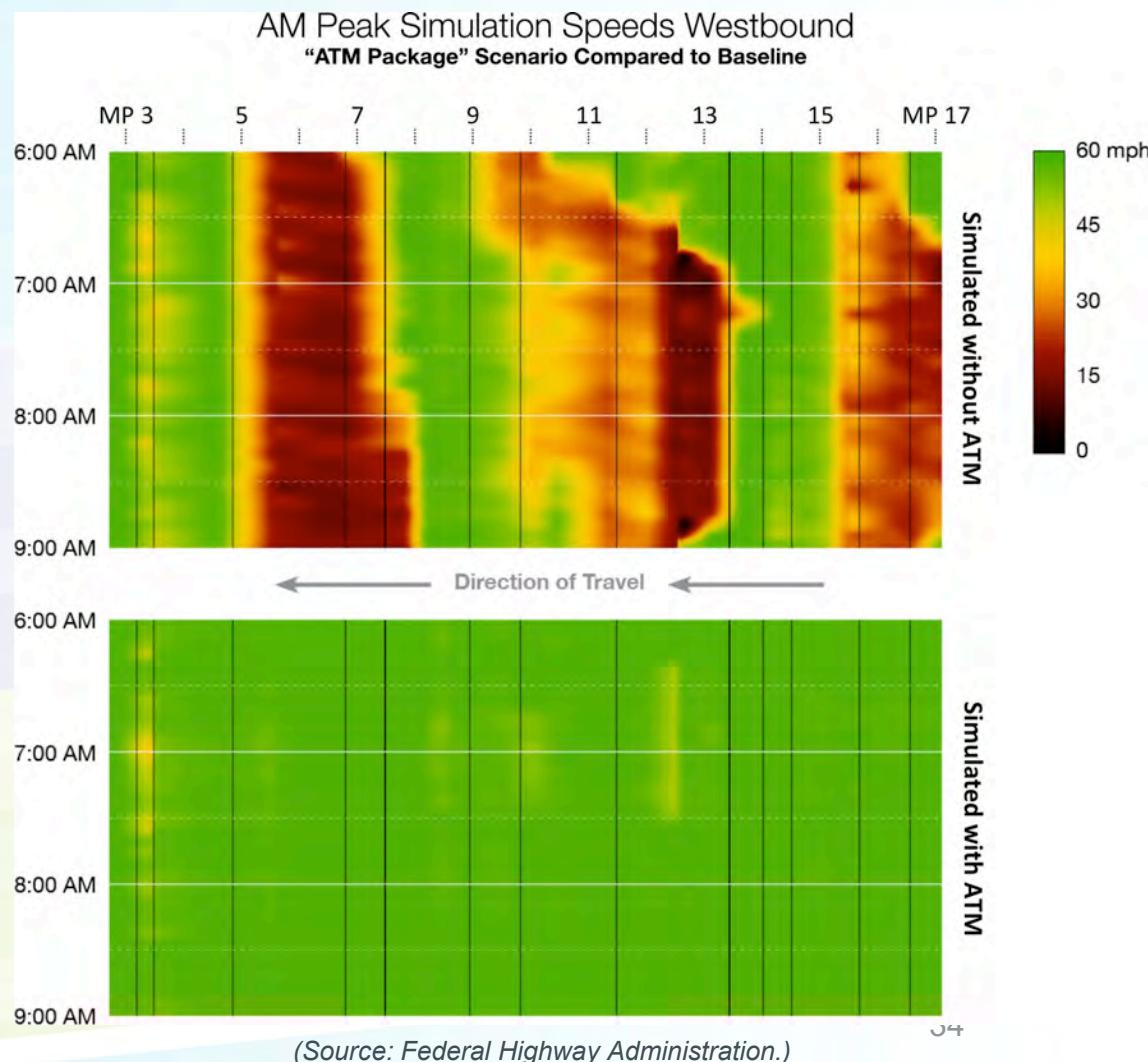
- » Total network delay
- » Delay by location/segment
- » Speeds
- » VMT/VHT
- » Intersection/Approach delay at ramps
- » Average queue length at ramps and mainline
- » Travel time – corridor and segment
- » Animations/visualizations
- » Similar output to capacity analysis project
- » Visualizations can portray ATDM benefits

# *Performance Measures Output*

## AM Performance Measures **System-wide, for a typical day**

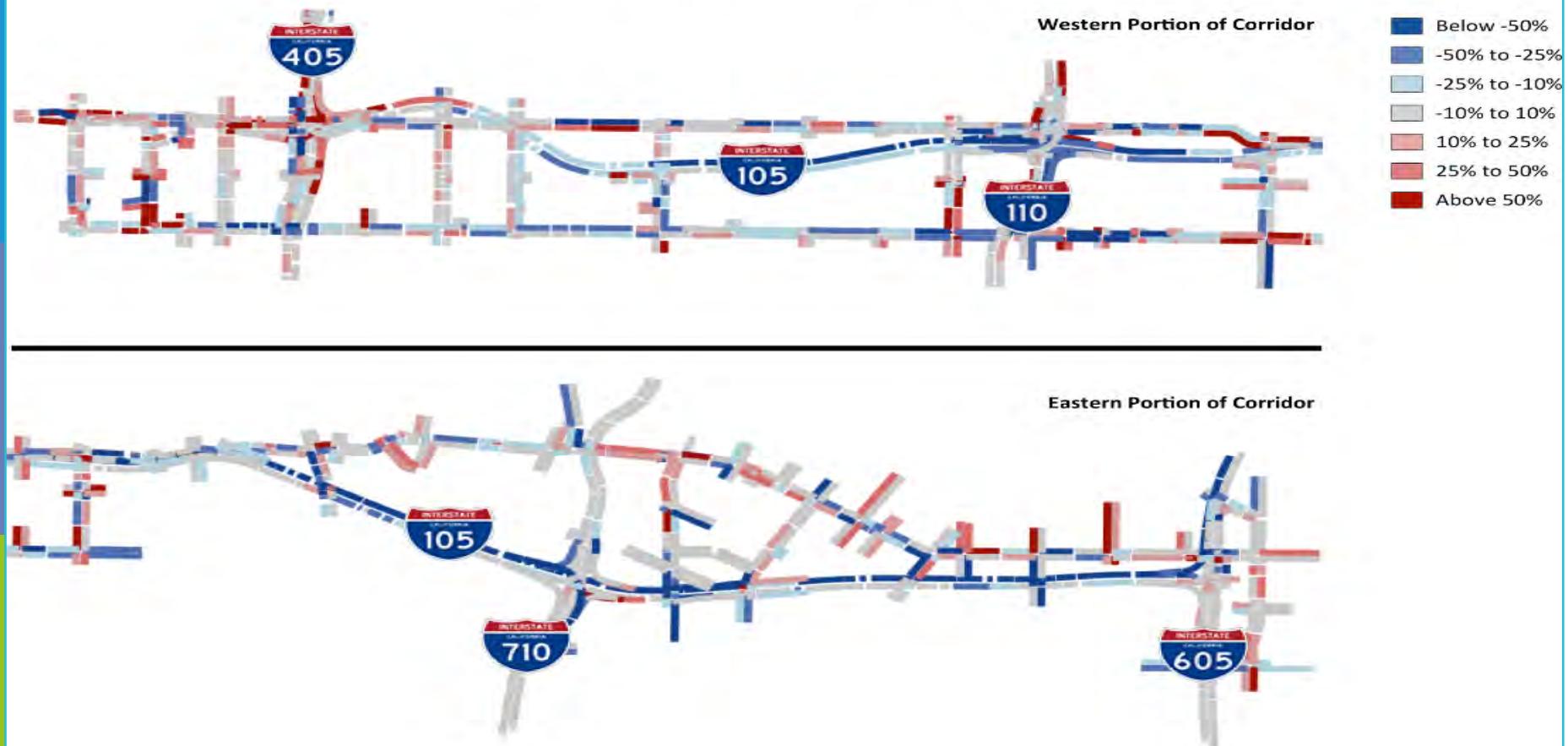
Metric	Without ATM	Percent Change from Baseline	
		ATM Package	HSR Only
VMT (vehicle miles)	1,400,468	1.51%	0.70%
VHT (vehicle hours)	44,832	-26.74%	-22.13%
Vehicle Hours of Delay (vehicle hours)	20,451	-59.59%	-48.64%
Person-Miles Traveled (passenger miles)	1,953,167	1.35%	0.50%
Person-Hours Traveled (passenger hours)	60,453	-25.06%	-20.87%
Person-Hours of Delay (passenger hours)	26,677	-57.68%	-47.30%
Average Travel Time (seconds per mile)	115.24	-27.83%	-22.67%
Average Trip Time (minutes per trip)	6.34	-27.31%	-22.47%

# Heat Map Comparison of Freeway Speeds between Alternatives

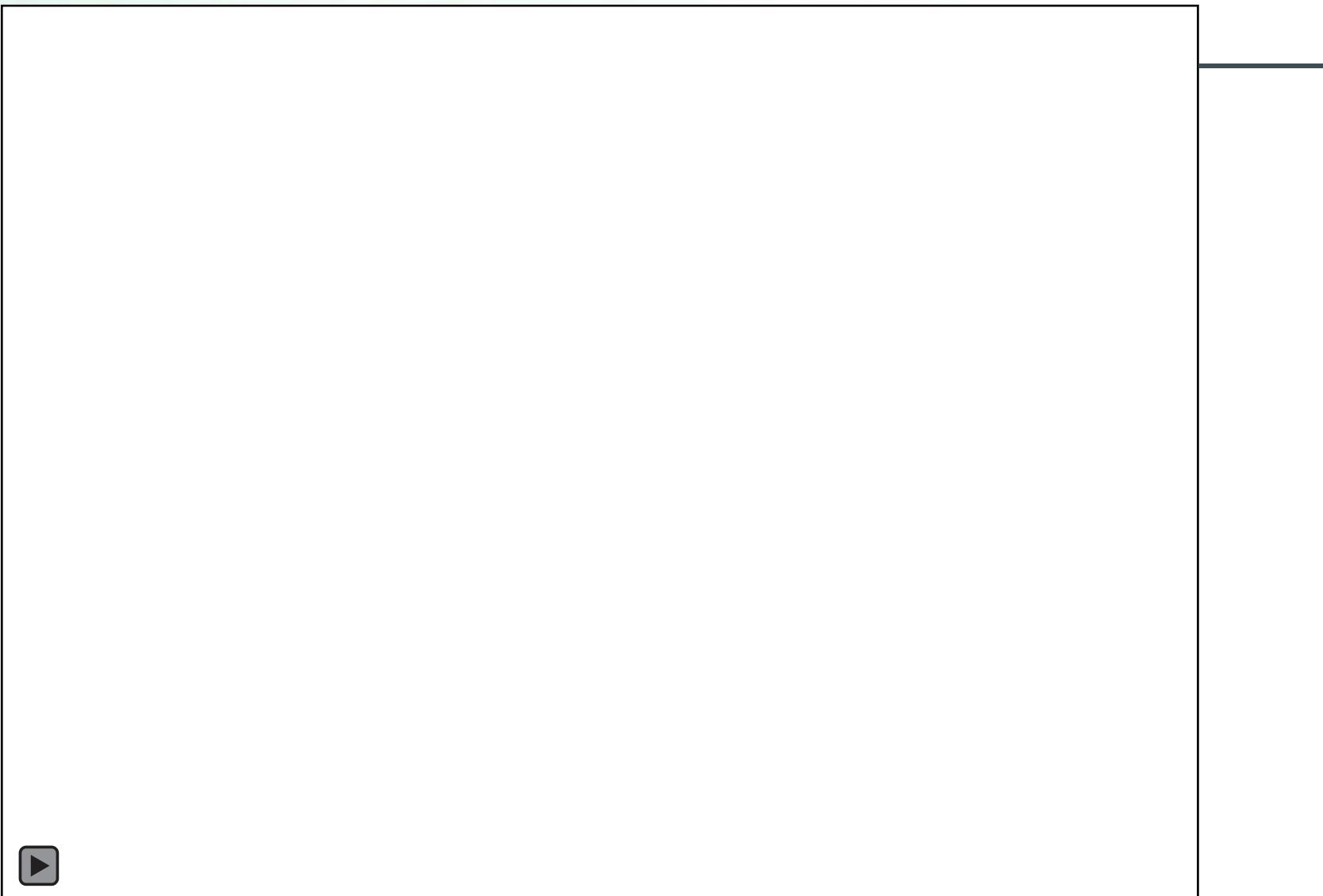


# Comparison of Change in Delays

AM Change in Vehicle Delays  
“ATM Package” Scenario Compared to Baseline, for Full Network



# Hard Shoulder Running Visualization

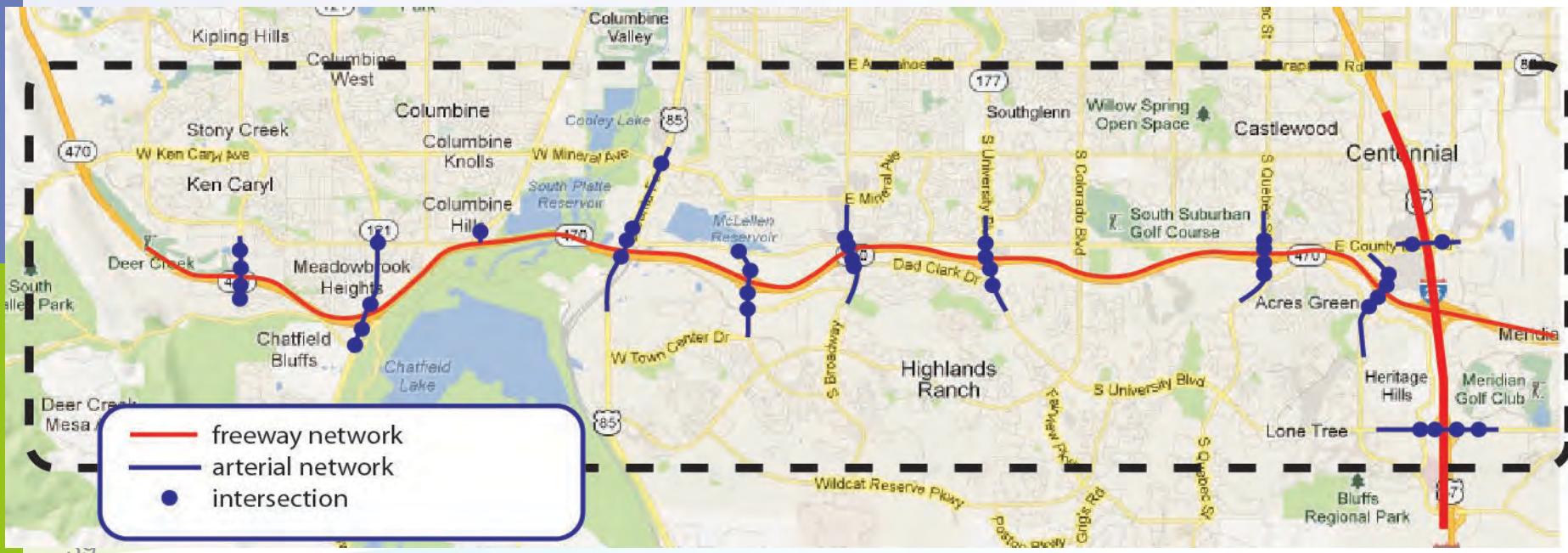


# ***OUTPUT CASE STUDY 3: MANAGED/EXPRESS LANES***

# Toll & Revenue Study

## Project Objective

- » To analyze traffic operations and revenue of a managed lane system proposed on the C-470 corridor (Denver)



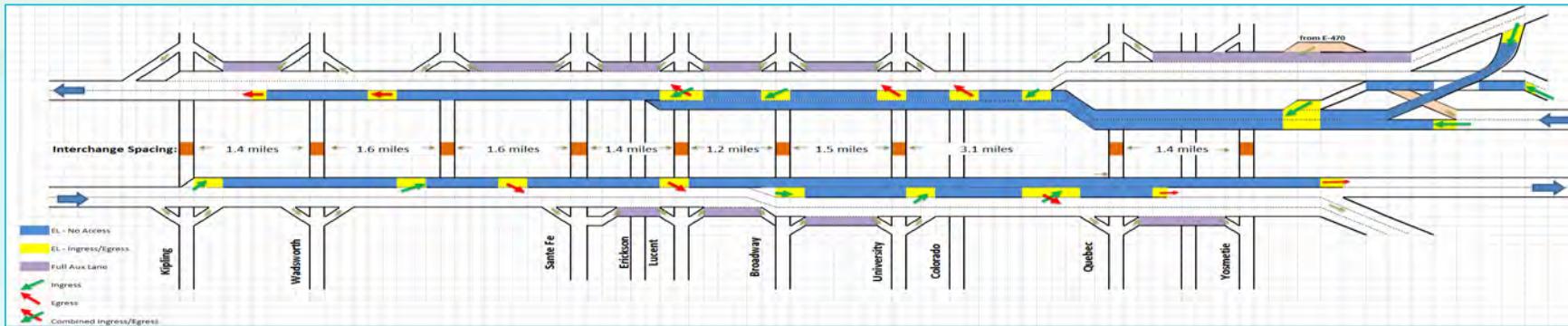
# Toll & Revenue Simulation

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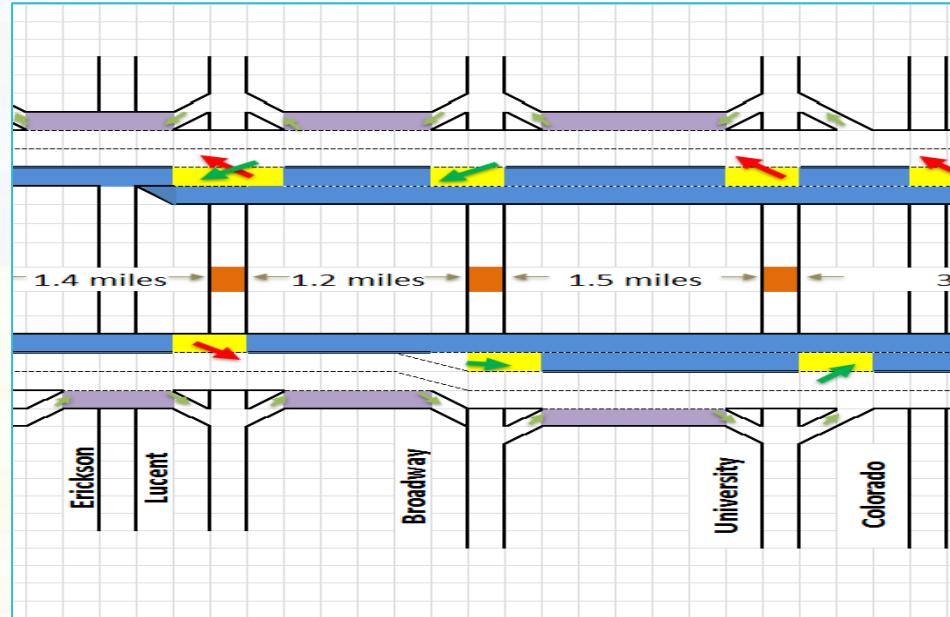
## ➤ Key Output:

- » Total network delay
- » Delay by location/segment
- » Speeds
- » VMT/VHT
- » Intersection/Approach delay at ramps
- » Average queue length at ramps and mainline
- » Travel time – corridor and segment
- » Animations/visualizations
- » *Managed Lanes vs. General Purpose Lanes*
- » *Transactions and Revenue*

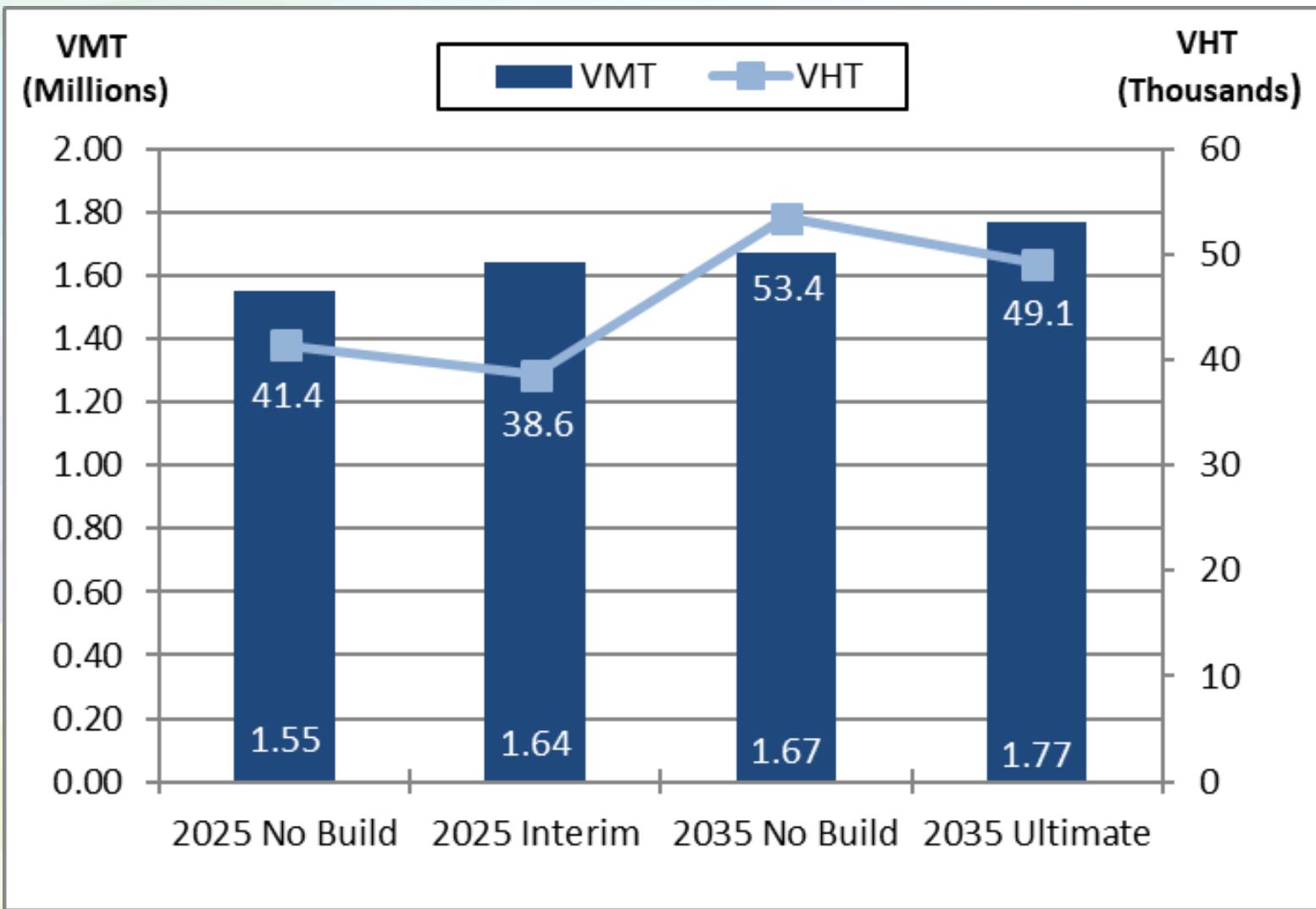
# Dynamic Toll & Revenue Simulation



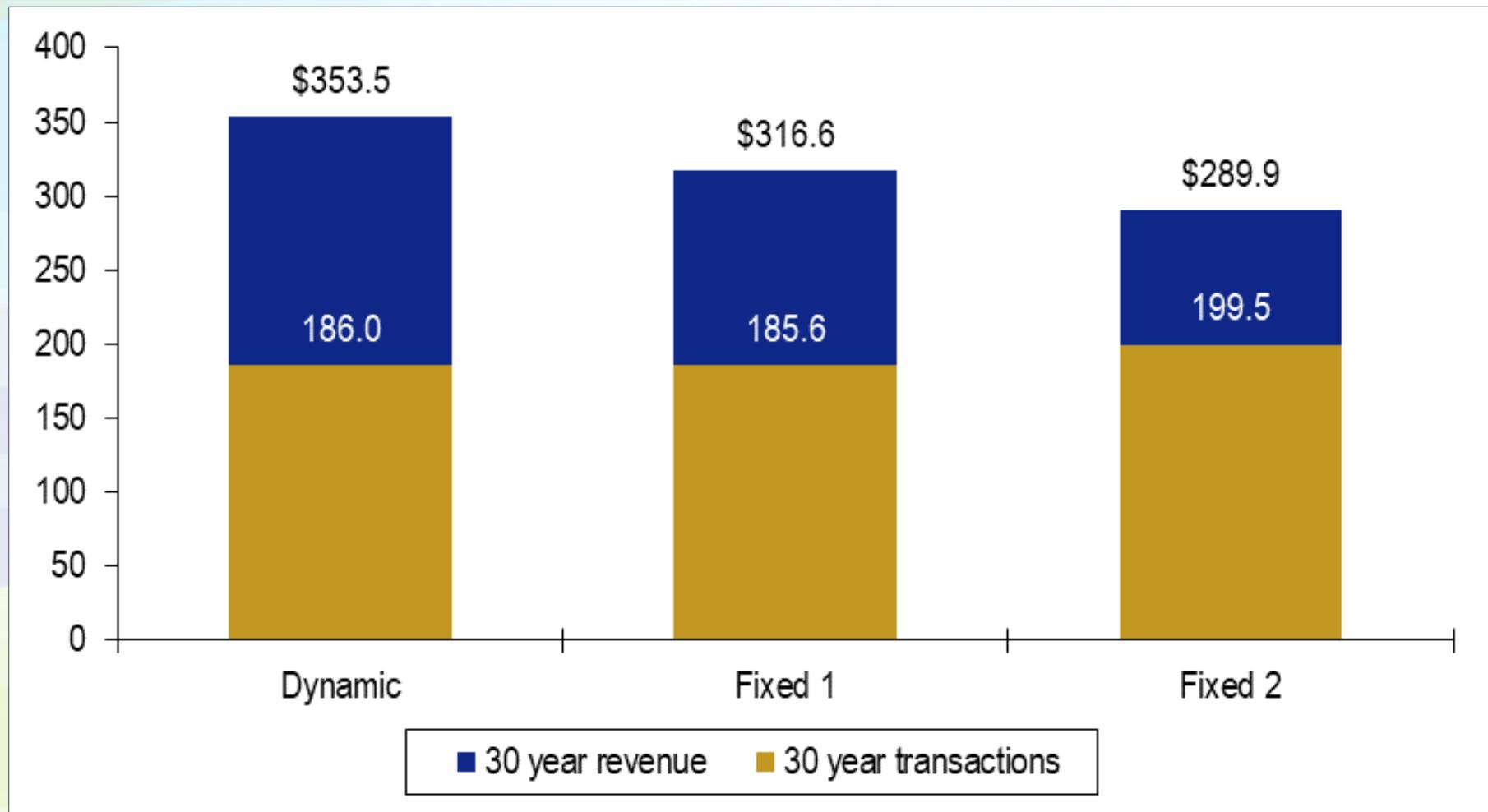
- Toll rates varies by time of day and congestion
- Output for general purpose and managed lanes
- Output focus: corridor-wide and ingress/egress locations



# Toll & Revenue Simulation



# Toll & Revenue Simulation



# Toll & Revenue Simulation

## Toll Lane Travel Time Savings

	Travel Times (Minutes)			
	No-Build 2025	Interim 2025	No-Build 2035	Ultimate 2035
GP	39.0	31.6	47.8	41.7
ETL	-	16.9	-	18.9
ETL Savings	-	14.7	-	22.8

# *Toll & Revenue Simulation*

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C-470 Managed Lane Simulation

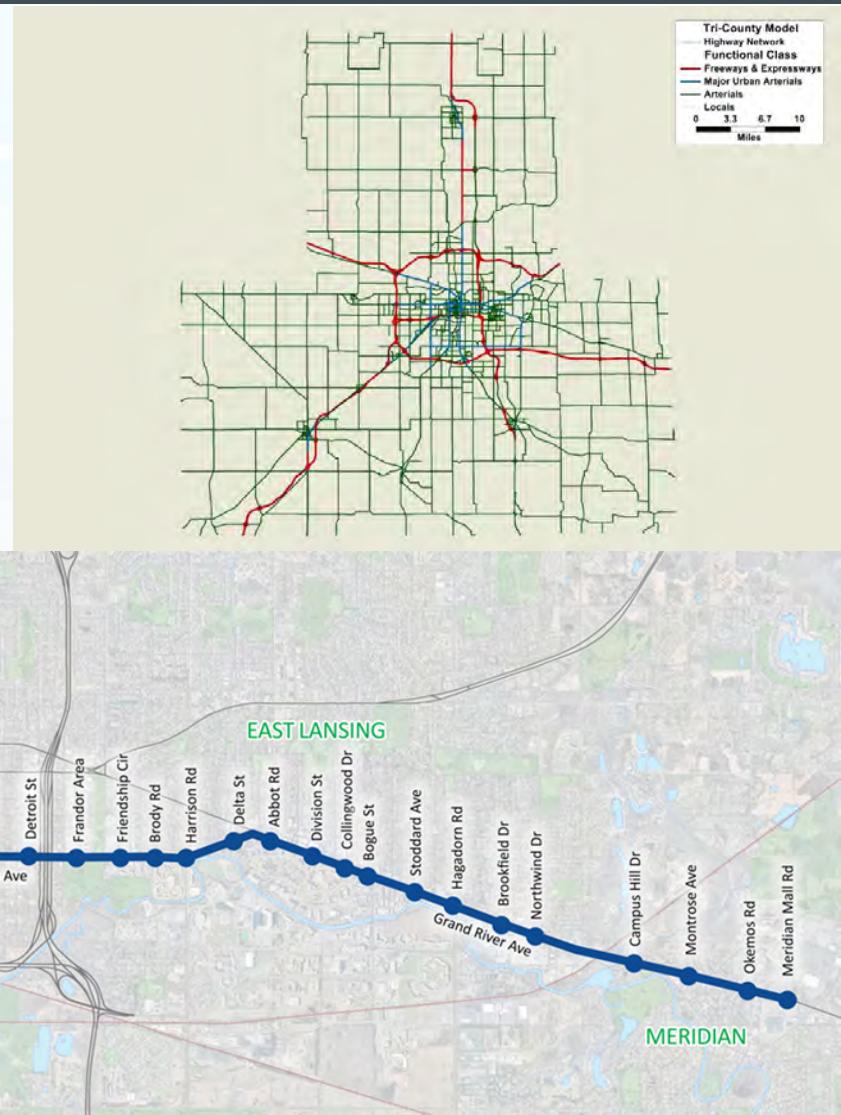


# ***OUTPUT CASE STUDY 4: BUS RAPID TRANSIT (BRT)***

# Bus Rapid Transit (BRT) Study

## Project Objective

- » To test the feasibility of a number of different alternatives for providing BRT services to the main corridor of downtown Lansing and East Lansing, Michigan



# BRT Simulation

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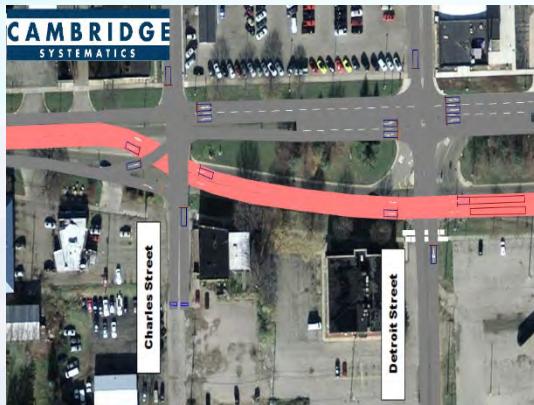
## ➤ Key Output:

- » Total network delay
- » Delay by location/segment
- » Speeds
- » VMT/VHT
- » Intersection/Approach delay at ramps
- » Average queue length at ramps and mainline
- » Travel time – corridor and segment
- » Animations/visualizations
- » *Person throughput and delay vs. vehicle delay*
- » *Signal priority impacts*
- » *Pedestrian impacts*

# BRT Alternatives Simulation

- » Test the feasibility of different BRT alternatives

Exclusive  
ROW



Exclusive  
Lane



# BRT Alternatives Simulation

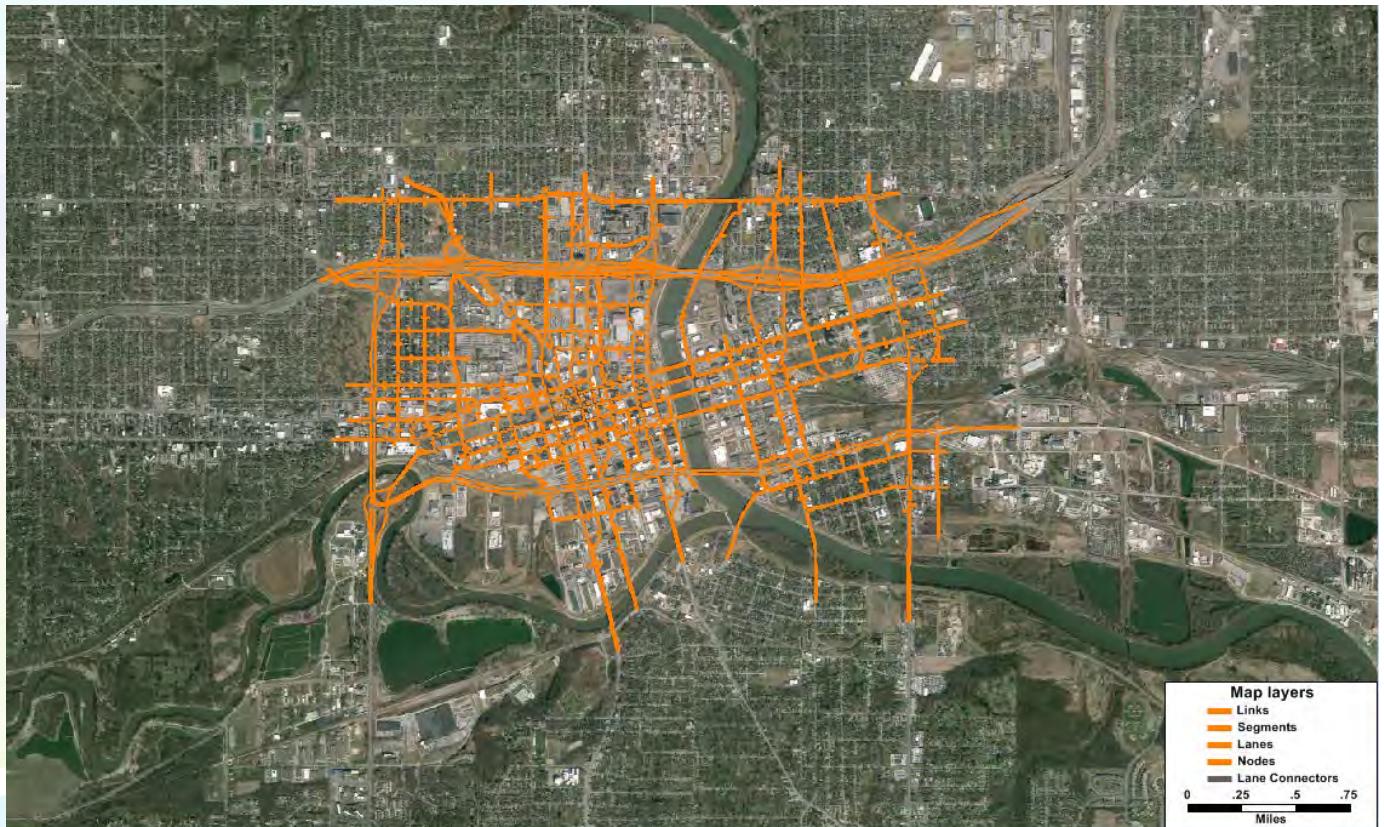


# ***OUTPUT CASE STUDY 5: ROAD DIETS/ONE WAY STREETS***

# Downtown Area Study

## Project Objective

- » Assess impacts and benefits of removing lanes, adding bike lanes and one-way conversions in Des Moines



# *Road Diets/One-way Simulation*

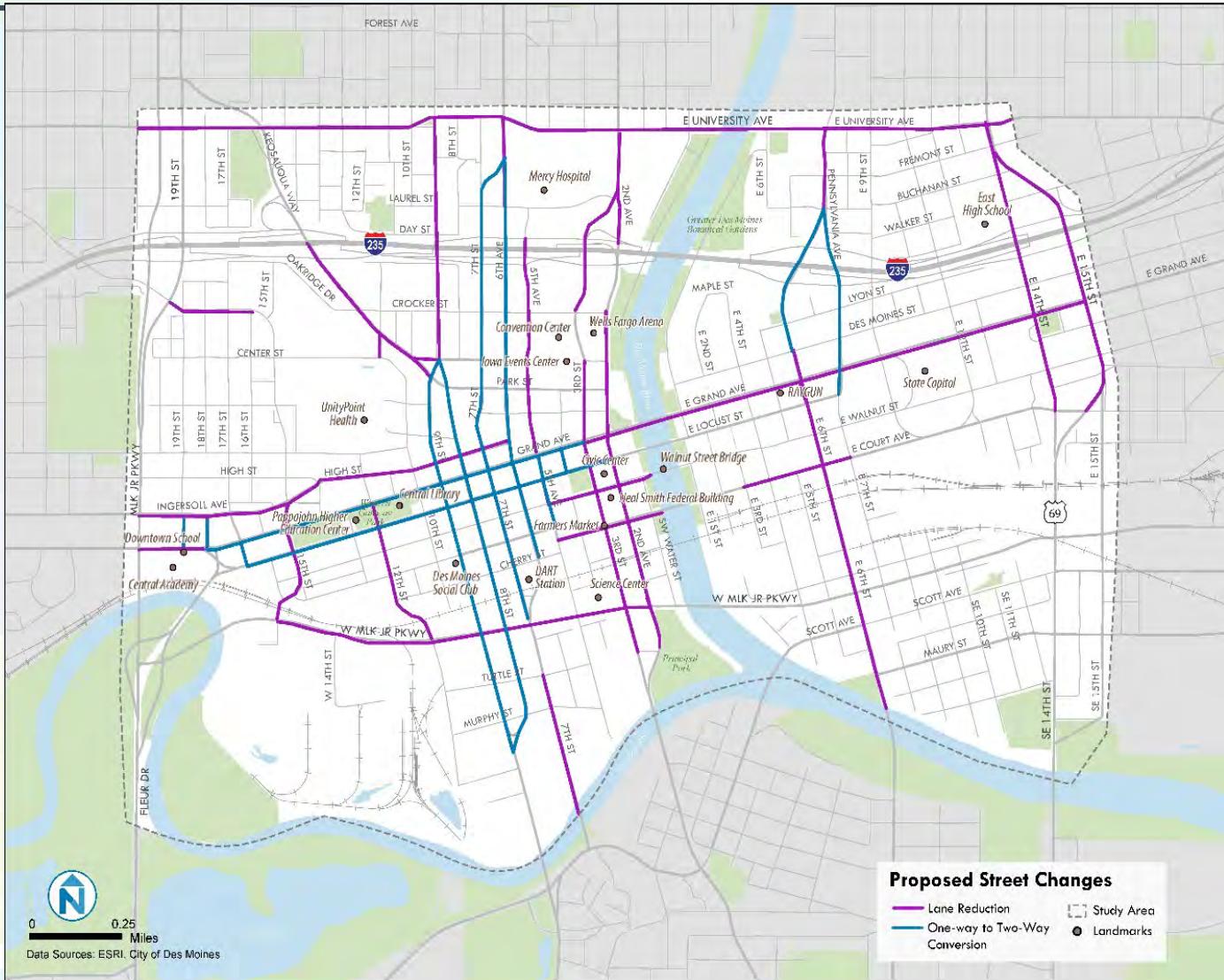
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## ➤ Key Output:

- » Total network delay
- » Delay by location/segment
- » Speeds
- » VMT/VHT
- » Intersection/Approach delay at ramps
- » Average queue length at ramps and mainline
- » Travel time – corridor and segment
- » Animations/visualizations
- » **Intersection LOS**
- » **Systemwide performance measures for capacity reduction**

# *Road Diets/One-way Streets*

- Lane reduction
  - One-way to two-way



# *Road Diets/One-way Streets*

## ➤ Intersection LOS Output



## No Build



## With Road Diet



# Road Diets/One-way Streets

## Link Speed Output



# No Build



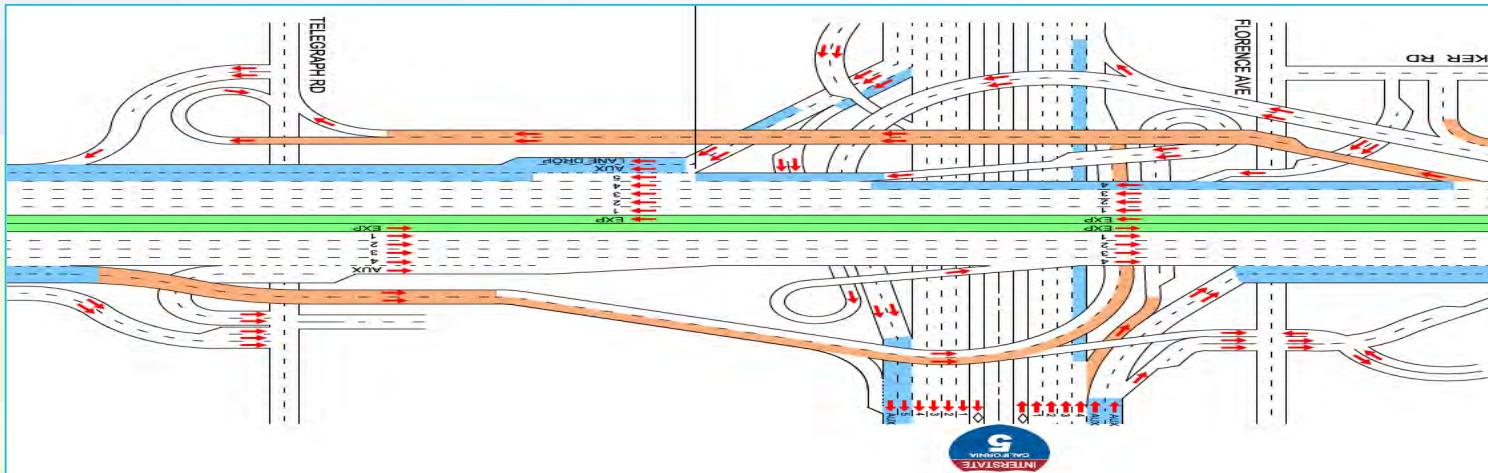
# With Road Diet



# Simulation Output Summary (1)

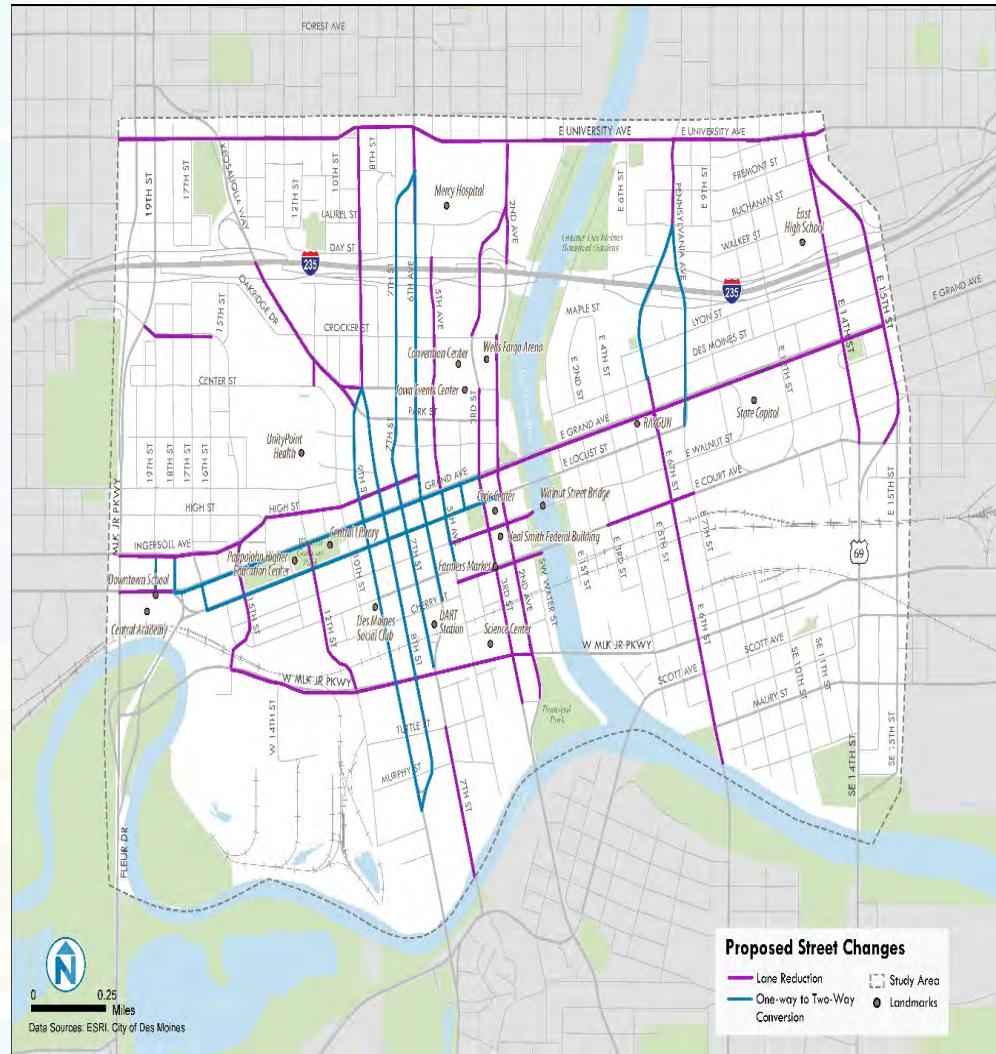
## ➤ Output for many types of Projects:

- » Highway capacity enhancements (add GP lanes)
- » Reductions in vehicle lane capacity (road diets, conversions)
- » Transit/person throughput
- » Revenue/tolling (add managed lanes)
- » Operational improvements



# Simulation Output Summary (2)

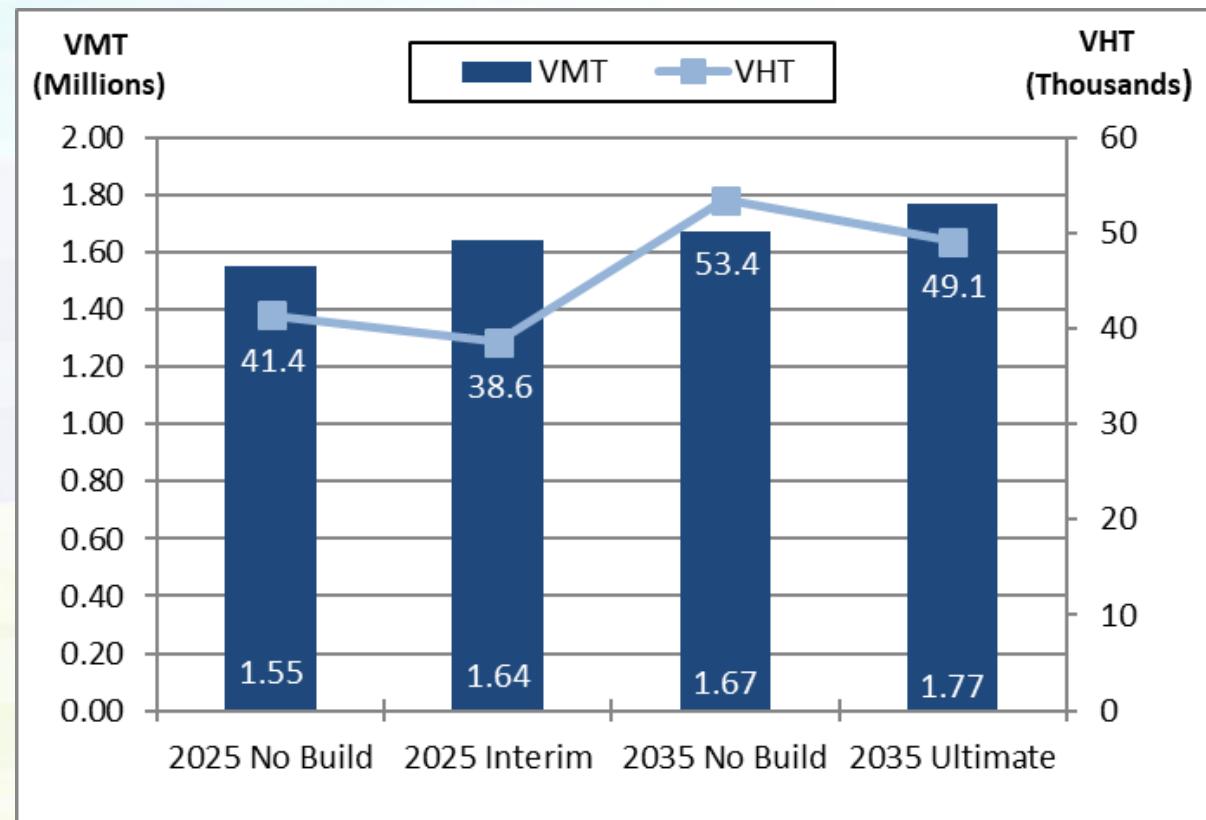
- Output for different parts of transportation systems:
  - » Single segment
  - » Intersections
  - » Corridors
  - » Interchanges
  - » Whole Networks



# Simulation Output Summary (3)

## ➤ Output for many performance measures:

- » Flow
- » Speed
- » Travel time
- » Delay
- » VMT/VHT
- » Level of service
- » Queues



# ***QUESTIONS & COMMENTS***

# **THANK YOU!**

For comments/ questions contact:

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([valexiadis@camsys.com](mailto:valexiadis@camsys.com))