

ESTIMATING POTENTIAL CAPACITY INCREASE OF FREEWAY WEAVING SEGMENT DUE TO AUTOMATED VEHICLES

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Agenda

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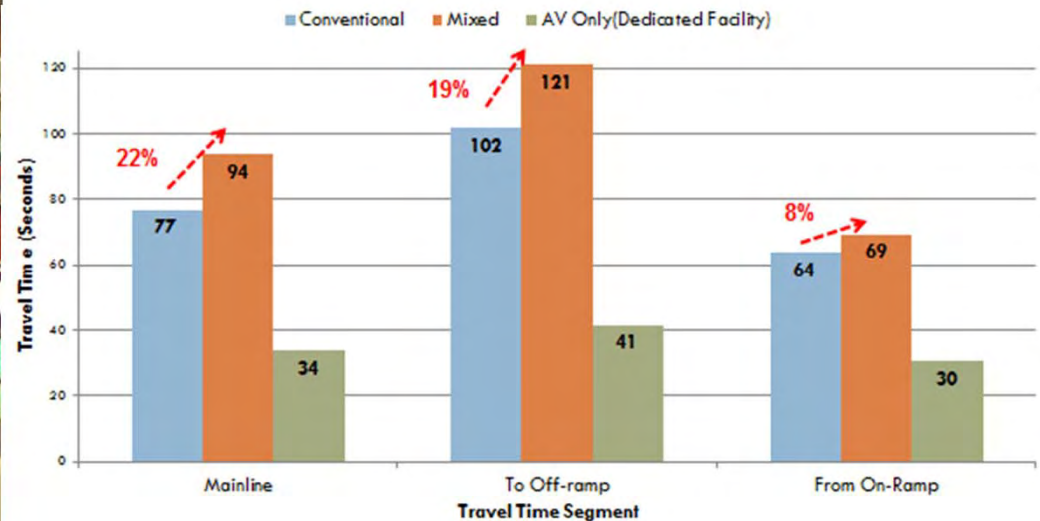


- ❑ Background
- ❑ Problem Statement
- ❑ Case study and Methodology
- ❑ Lesson Learned

Near Term Impact of AVs on Traffic Congestion

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2017 ITE Mid-Colonial District Annual Conference



Business Case for Utilizing Highway Median Shoulders for AVs Deployment

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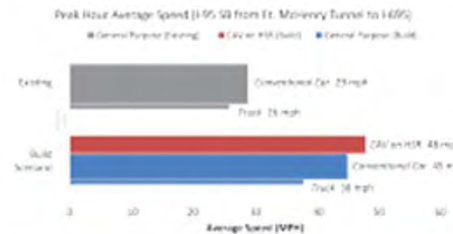
4. METHODOLOGY

- CAVs are able to operate in narrow lanes - 8 to 9 feet
- **Retrofit highway median shoulders and use them exclusively for CAVs**
- Implement speed harmonization strategy to reduce construction costs by minimizing the need for cross slope adjustments
- Modeled conversion of I-95 southbound inside shoulder to CAV only HSR between the Fort McHenry Tunnel and I-695 Interchange
- Used Maryland Transportation Authority (MDTA) Vism model to capture the travel time savings
- **This strategy resulted in 68% increase in average peak hour speed for corridor**



Model Parameters

- A 15' shoulder
- Existing average daily traffic volume, vehicle frequency 250 vehicles per hour during PM peak hour, and 200 vehicles per hour during AM peak hour
- 1.5 ft shoulder width (1.5 ft shoulder width by 200 ft) and 1.5 ft shoulder width (1.5 ft shoulder width by 200 ft)
- Annual vehicle delay reduction 2,700 CVH per year at 1.2 second headway
- 68% increase in average peak hour speed
- Other cost savings of 48 MPH to 55 MPH and 300 ft shoulder width to 1.5 ft



CAV HSR lane decreases delay & increases throughput

5. BENEFIT-COST ANALYSIS

	User's Benefit Calculation	
	Passenger Cars	Trucks
Peak Hour Traffic Volume (V) - 2005 ADMT	5,926	388
Value of Time (VOT) in \$/hr	\$37	\$87
Peak Hour Travel Time Savings (minutes)	4	4
Peak Hour Consumer Benefits	\$8,719	\$3,438
Daily Consumer Benefits	\$47,809	\$14,000
Total Daily Consumer Benefits	\$61,809	
Work Days per Year	250	
Annual Consumer Benefits	\$15,452,225	

- Developed planning level cost estimates for retrofitting the inside shoulder
- Two typical sections: At grade with grass median and guardrail, and elevated, concrete highway with F shaped barrier, inside shoulder width ranging between 5 feet and 12 feet
- Assuming static aluminum signs and minimal pavement cost (grinding/resurfacing) it approximately cost \$1M to complete the work. No structural work and storm water management or environmental costs were considered
- **The estimated cost will increase to approximately \$20M with addition of dynamic signs, safety enhancements such as upgraded concrete barriers in the median, cameras and electronic highway signs to help with incident response and traveler information dynamic signs, approximately \$2.7M per mile**
- AECOM recently did a cost estimation for converting 34 miles of median shoulder to a functional lane without trucks. Estimated \$100M, approximately \$4.2M per mile
- VDOT spent \$20M to fully reconstruct 1.5 miles of I-495 inside shoulder to allow all traffic, including trucks. Approximately \$13M per mile

6. CONCLUSION AND FUTURE WORK

- It is practical to use highway median shoulders as dedicated HSR for CAVs
- **Retrofitting highway median shoulders to serve CAVs is economically viable**
- The dedicated HSR can be used as managed lane with lane control system to allow for emergency response and incident management prioritization
- Estimate induced capacity by connected and autonomous vehicles
- Model connected trucks and their impacts on traffic operations

7. ACKNOWLEDGEMENT

- Maryland Department of Transportation (MDOT) / State Highway Administration (SHA)
- Maryland Department of Transportation (MDOT) / Maryland Transportation Authority (MDTA)

Economical solution to maximize CAV benefit

Problem Statement

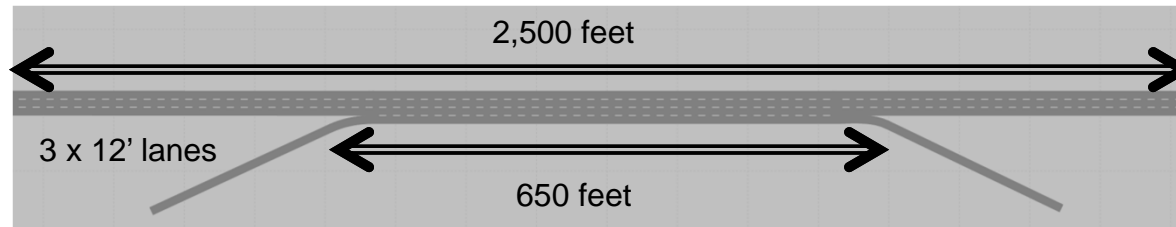
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- ❑ AVs are expected to increase roadway capacity
 - ❑ Automatic breaking system (2,000vphpl to 4,000 vphpl)
 - ❑ Platooning (2,000vphpl to more than 6,000 vphpl)
 - ❑ Smoother merge and diverge
- ❑ Requires high market penetration
- ❑ How much capacity will increase?
- ❑ How weaving impact theoretical capacity increase?

Case Study – Typical weaving segment

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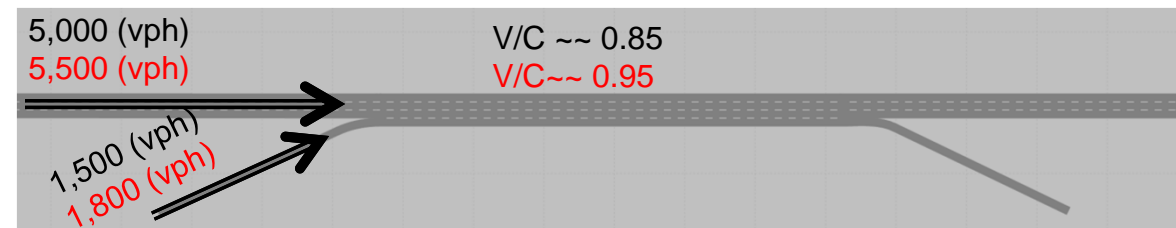
Geometry



Speed



Traffic



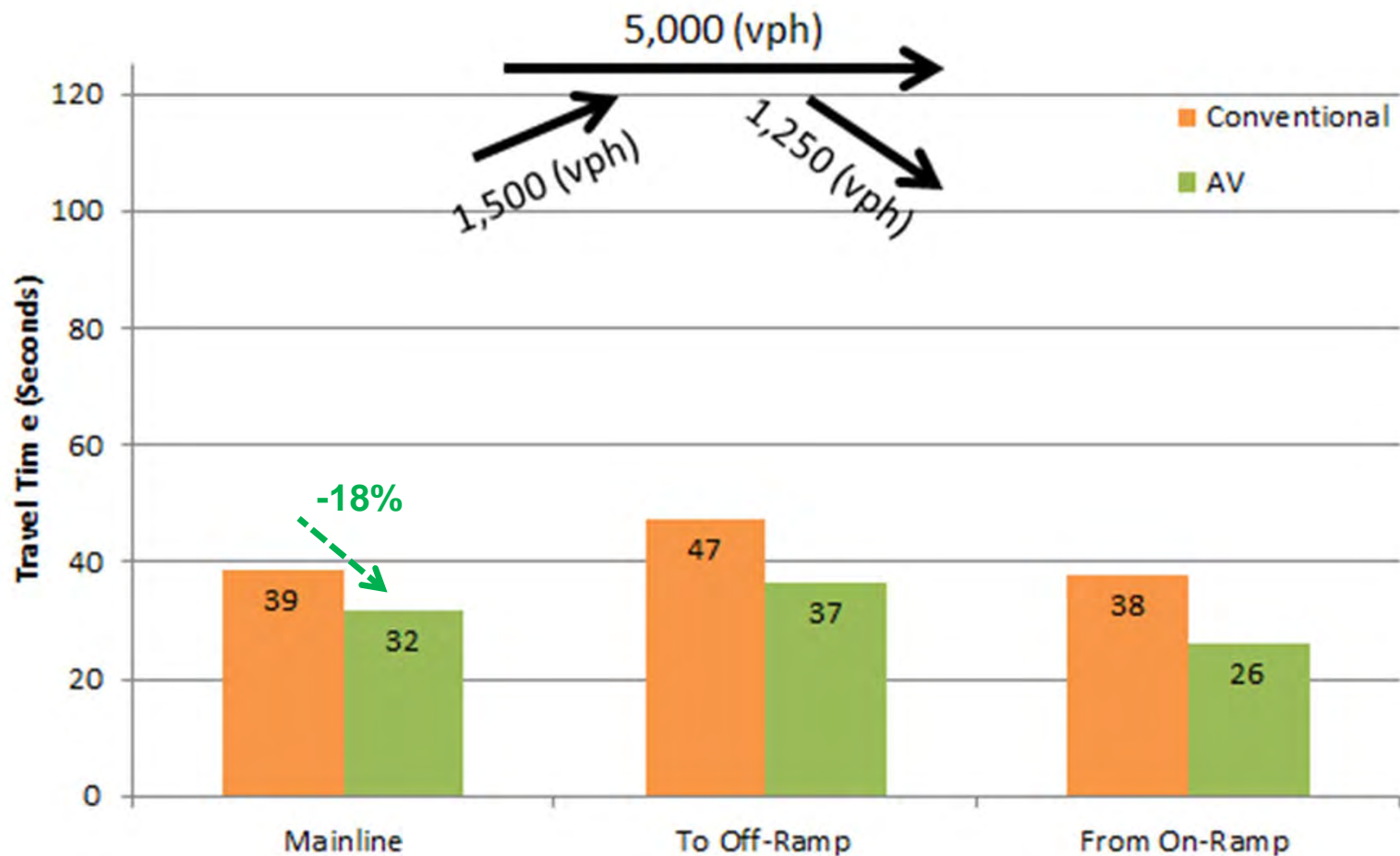
Methodology

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- ❑ Used VISSIM to estimate travel time/delay for conventional and AVs
 - ❑ Through movement, on-ramp merge, off-ramp diverge
 - ❑ Moderate and heavy traffic volume
 - ❑ Used PTV's AV Modeling Assumptions
 - ❑ Used VDOT's TOSAM guideline for conventional vehicle modeling
- ❑ AVs reduced delay between 18 and 30 percent for moderate traffic
- ❑ Delay reduction increased as traffic congestion increased (+50% range)
- ❑ Increase AV volume to match conventional vehicle delays
 - ❑ **Challenge: Increase of volume for a movement impacts other movements delay**

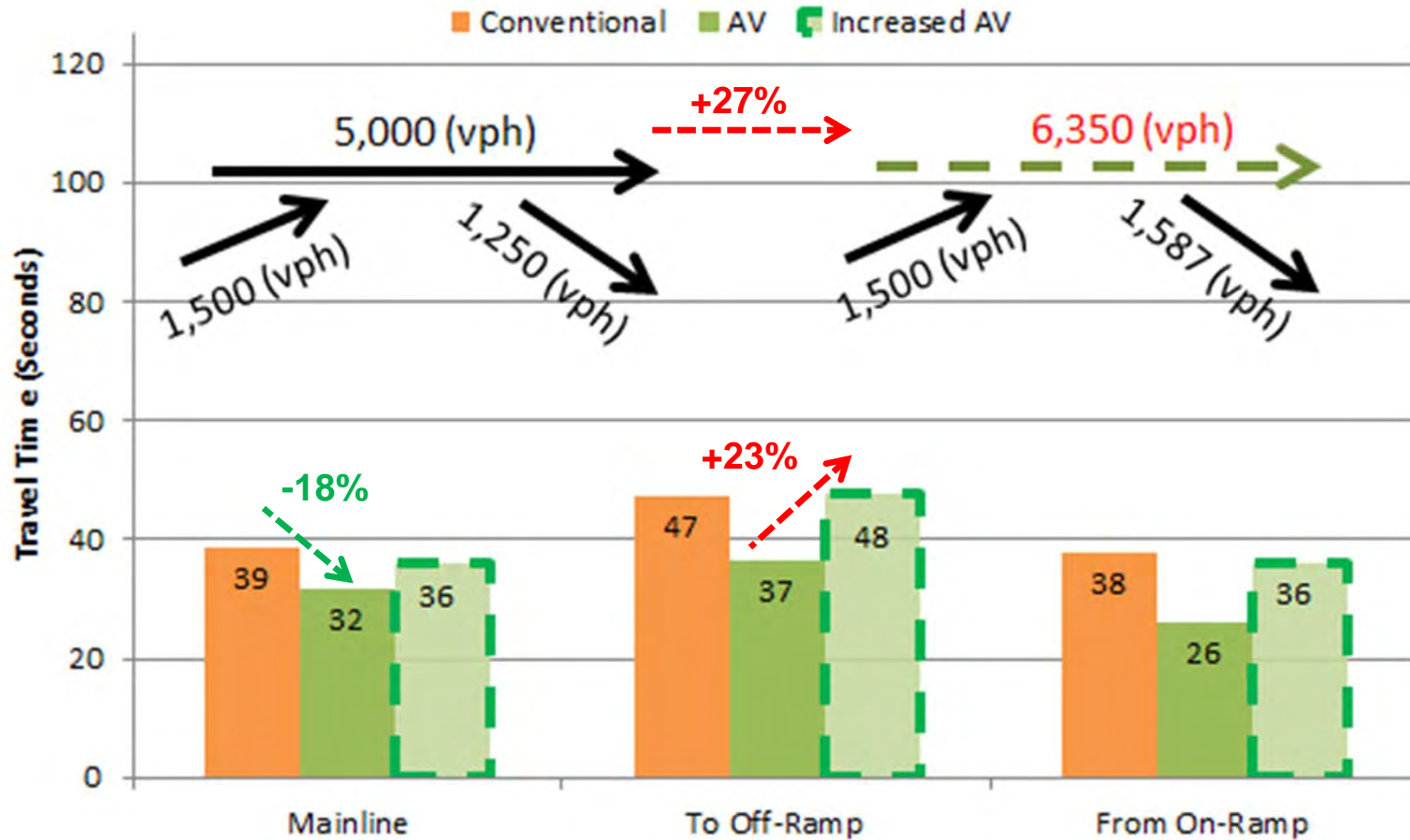
AV Impact on Travel Time for Moderate Congestion $V/C \approx 0.85$

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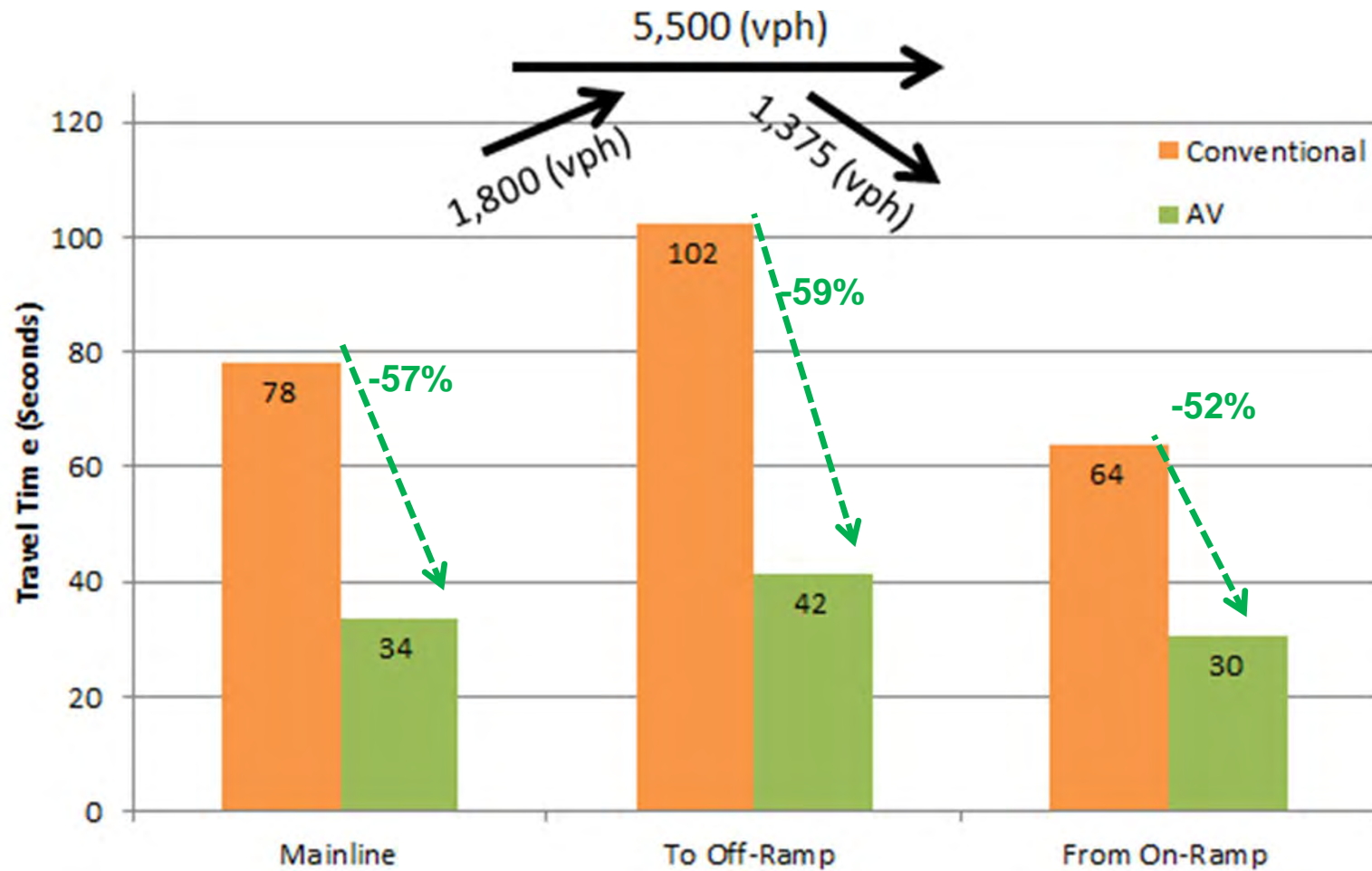
Increase AV volume for Moderate Traffic Congestion

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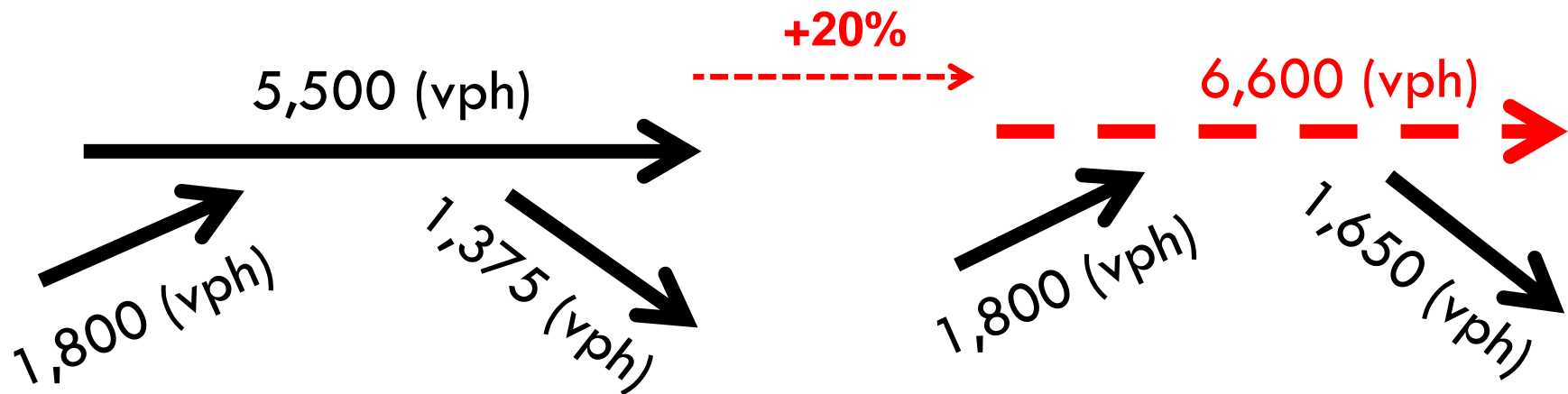
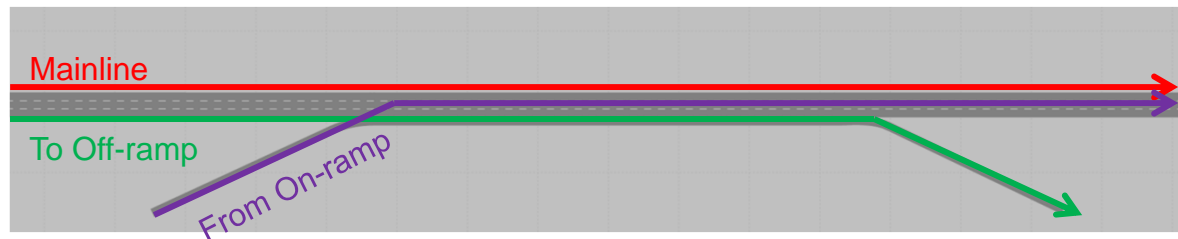
AV Impact on Travel Time for Moderate Congestion $V/C \approx 0.95$

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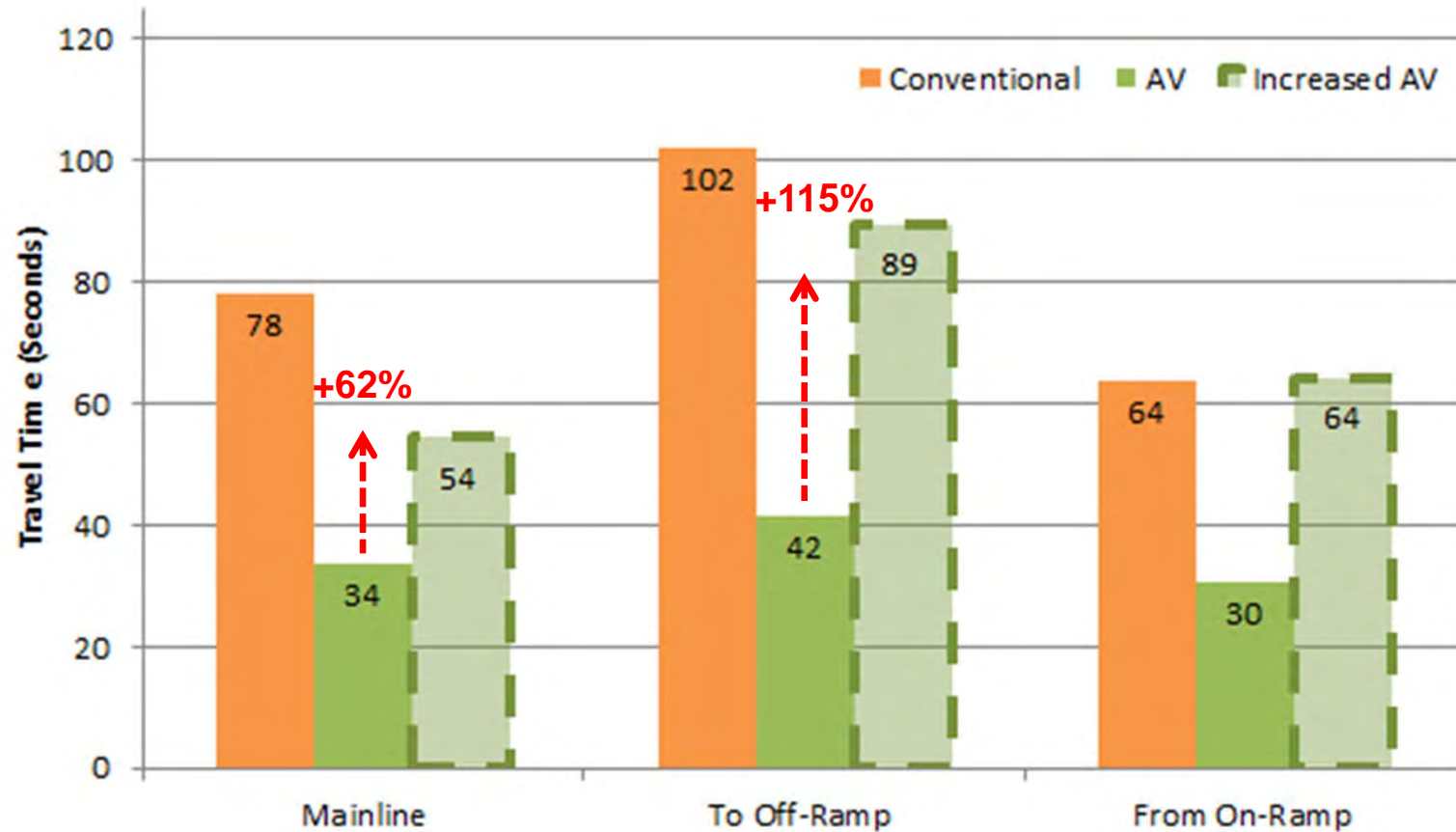
AV Impact on Travel Time for Moderate Congestion $V/C \approx 0.95$

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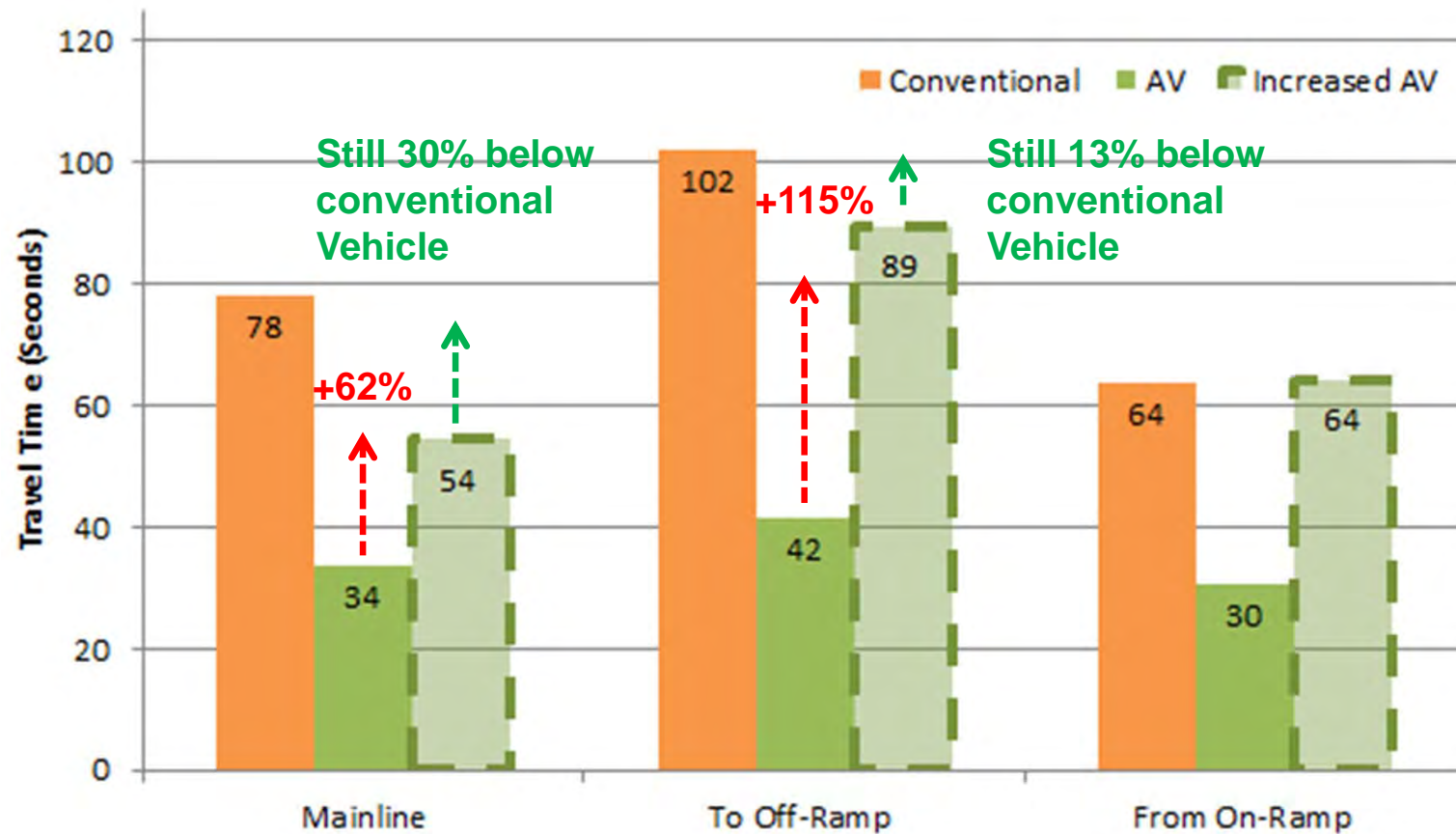
Increase AV volume for Heavy Traffic Congestion

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How many more vehicles can be processed?

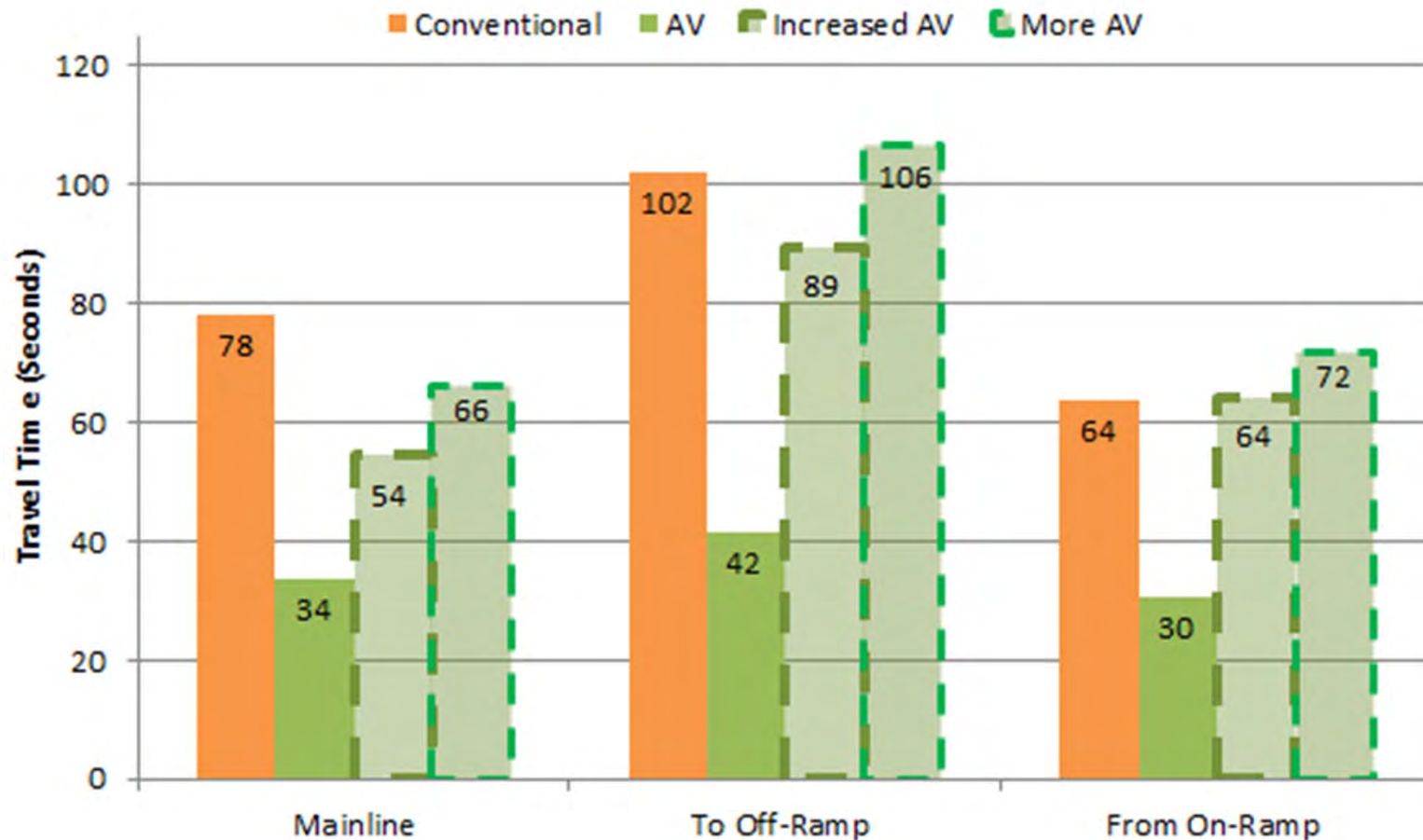
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Delay Increases Rapidly for Heavy Congestion

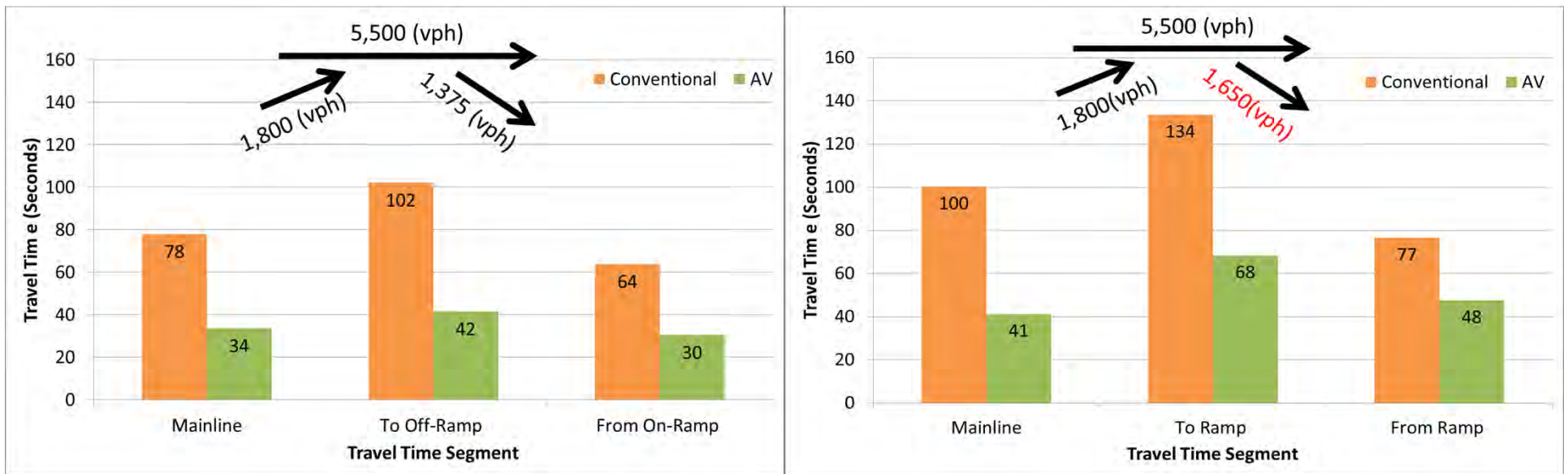
1% Increase in Volume = 13% Increase in Delay

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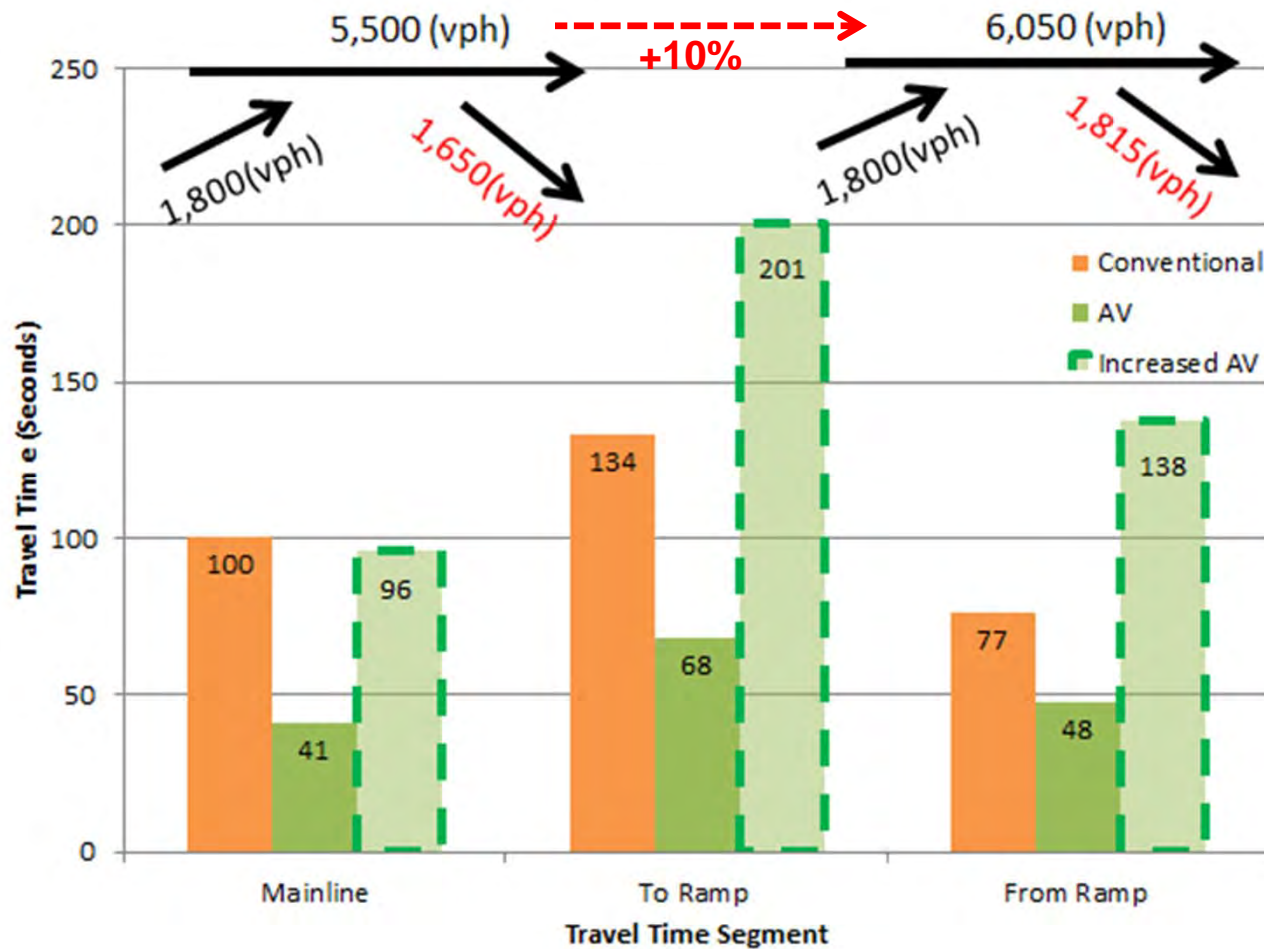
Impact of Higher Share of Off-Ramp Volume

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Heavy Diverge Movement Limit Capacity Increase

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Lesson Learned

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- ❑ Weaving segments of the freeways limit the theoretical induced capacity of AVs
- ❑ Our tests points to 10 to 20 percent capacity increase at bottle necks
- ❑ Capacity increase was capped quickly for congested condition.
- ❑ Segments with heavy diverge movements are critical