The National Academies of
SCIENCES · ENGINEERING · MEDICINE

TRANSPORTATION RESEARCH BOARD

Part-Time Shoulder Use

Thursday, October 12, 2017
2:00-3:30PM ET

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.

RCEP

REGISTERED CONTINUING EDUCATION PROGRAM

Purpose

Discuss information about planning, designing, implementing, and operating dynamic, static, and bus-only part-time shoulder use facilities.

Learning Objectives

At the end of this webinar, you will be able to:

- Describe what part-time shoulder use is and list its three major types
- Identify whether part-time shoulder use is viable on a specific highway
- Describe the basics of planning and designing a part-time shoulder use facility
- Compare the operational and safety considerations of part-time shoulder use to a conventional highway widening project

Part-time Shoulder Use

FHWA Guide

TRB Webinar

October 2017

Motivation for PTSU Guide

- Congressional interest
- Practical Design, Practical Solutions (State)
- Performance-Based Practical Design (FHWA)
- TSMO and Active Traffic Management
- Lack of guidance
  - Multi-disciplinary topic!

Performance Based Practical Design

- Modifying the traditional “top down, standards first” approach to a “design up” approach
- Project decisions are based on critical examination of **geometric** elements
- Utilizes relevant, objective data to inform decisions – engineering judgement
- Choices made to serve project priorities while trying to make cost effective decisions
- **Project savings Benefit System Needs**

Transportation Systems Management and Operations Strategies

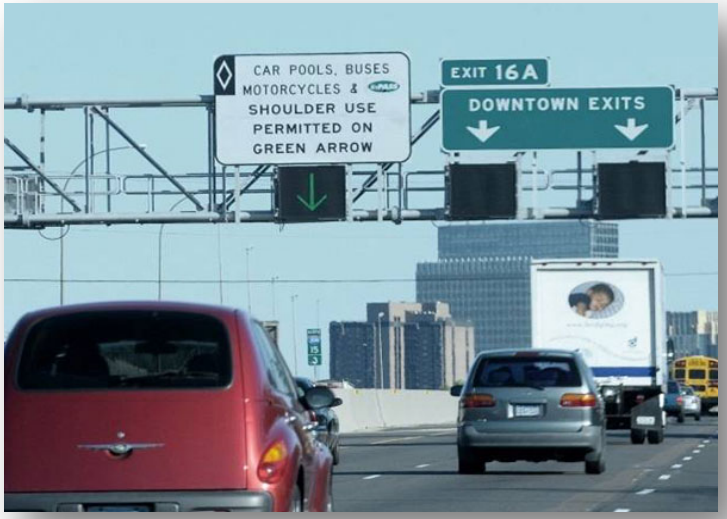
- Work Zone Management
- Traffic Incident Management
- Service Patrols
- Special Event Management
- Road Weather Management
- Transit Management
- Freight Management
- Traffic Signal Coordination
- Traveler Information
- Ramp Management
- Managed Lanes
- **Part-Time Shoulder Use**
- Active Traffic Management
  - Dynamic Speed Limits
  - Dynamic Lane Assignment
  - Queue Warning
  - **Dynamic Part-Time Shoulder Use**

What is Part-Time Shoulder Use?

- Various names
  - Hard shoulder running (European)
  - Shoulder running
  - Temporary shoulder use
  - Part-time shoulder use
- Same meaning: use of the left or right shoulders of an existing roadway for travel during certain hours of the day.
  - TSM&O strategy for addressing congestion and reliability issues
  - Preserves shoulder as shoulder during most hours of day

What is Part-Time Shoulder Use?

- Use of the safety shoulder as a travel lane during congested conditions – Not a permanent conversion of a shoulder
- Add capacity only when needed
- Keep shoulder intact for most hours of the day
- Do what is physically and financially possible
  - Support decisions with analysis

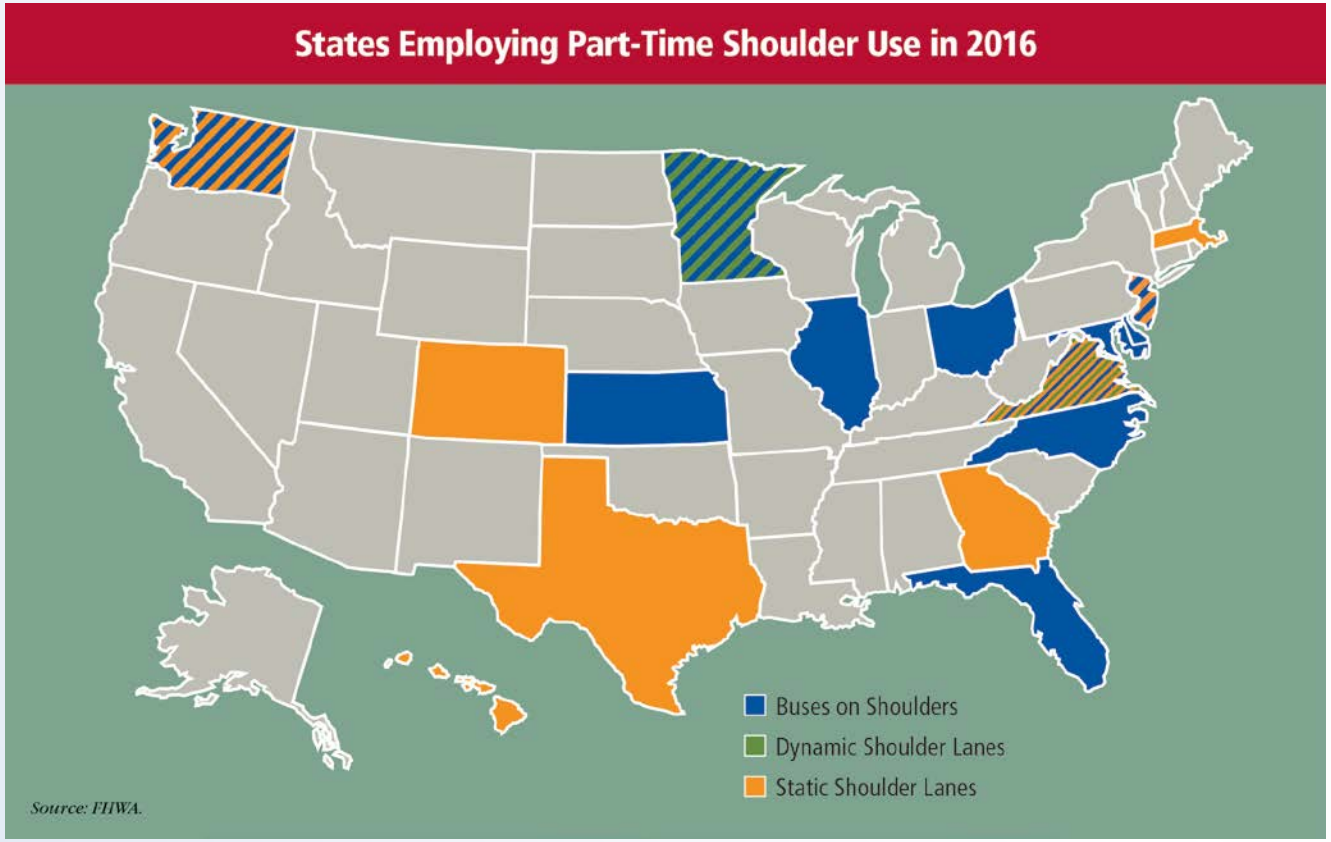


Types of Part-Time Shoulder Use

- Static shoulder use – open to passenger vehicles during predetermined hours of operation
- Dynamic shoulder use – open to passenger vehicles based on need and real-time conditions
- Bus-on-Shoulder (BOS) – open only to buses, usually at driver's discretion

Shoulder use typically implemented on freeways; but can be applied to arterials

Where is Part-Time Shoulder Use?



- Now 16 states
- Many international applications as well

Bus On Shoulder (BOS) in Minneapolis-St. Paul

Left-Shoulder Bus on Shoulder (BOS) in Chicago

Bus on Shoulder (BOS) on US 29 Arterial in Maryland

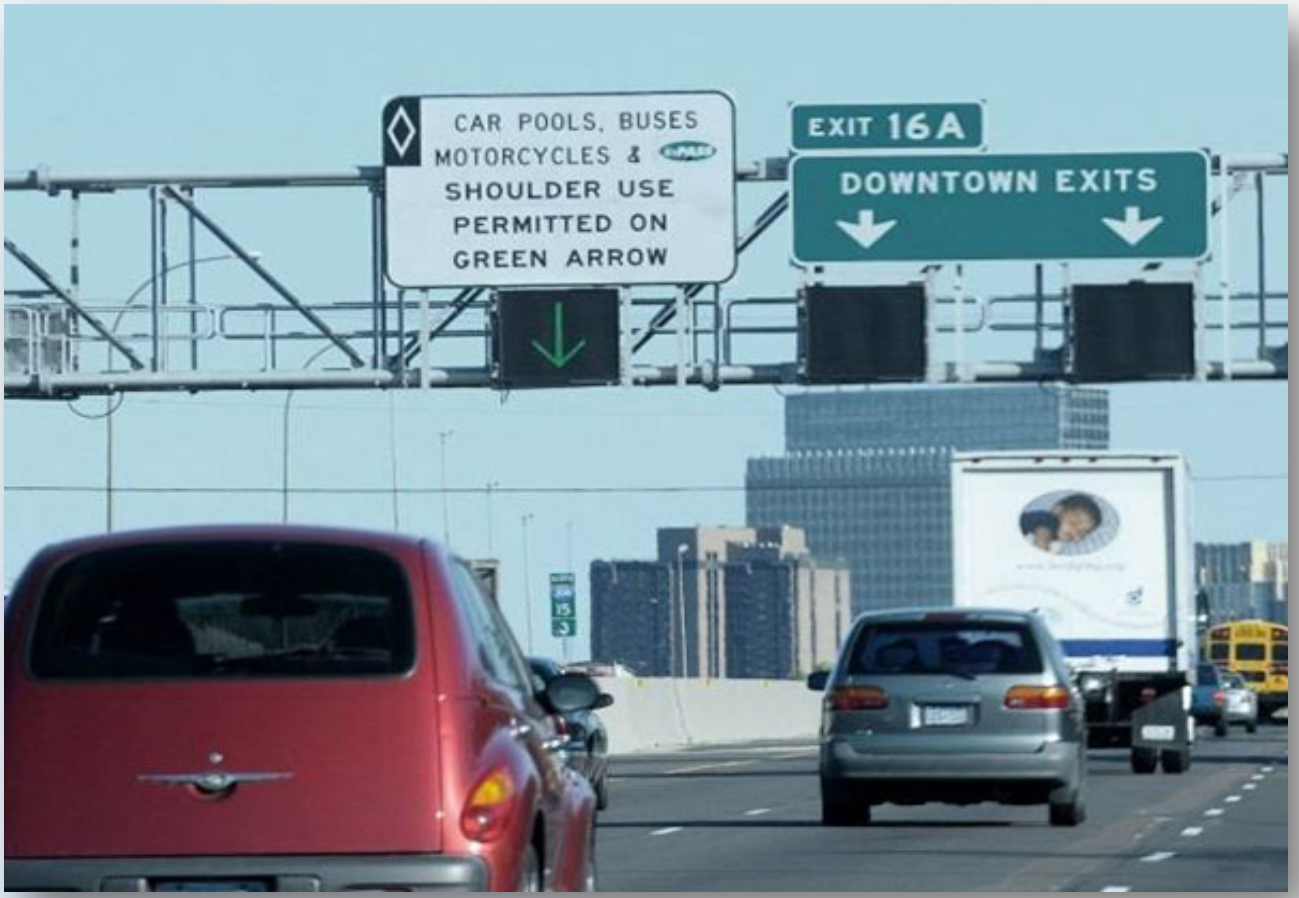
Static Shoulder Use – US 2 in Washington State

Static Shoulder Use – I-66 in Virginia (Made Dynamic in 2015)

Dynamic signs over shoulder; but fixed hours of operation

Dynamic Shoulder Use – I-66 in Virginia

Dynamic Shoulder Use – I-35W in Minneapolis



- Part of Managed Lane (HOT) operation

Purpose of Shoulder Guide

Why did we need a Guide?

- No national guidelines
  - Existing research scattered in many sources
- Growing interest - Division Offices getting requests for projects
- Regulatory uncertainty/complexity
  - Air and noise analysis
  - NEPA
  - Design exceptions
  - Signing and pavement marking (MUTCD)
- The Guidebook is not a standard/directive/policy/etc.
  - Collection of referenced standards and applied best practices
- Consistent with other FHWA initiatives
  - PBPD
  - TSM&O and Active Traffic Management

Guide Chapters - Planning

Chapter 1 – What is Part-time Shoulder Use?

- Also contains summary of entire guide

Chapter 2 – Planning, Decision Making, and Preliminary Engineering

- Planning considerations
- NEPA requirements
- Preliminary Engineering
- Relationship to Planning for Operations and PBPD

Guide Chapters - Analysis

Chapter 3 – Mobility Analysis
- How to do it (HCM/FREEVAL, Simulation)
- Observed and simulated shoulder use capacities

Chapter 4 – Safety Analysis
- Before/after studies
- How to do analysis
- What Highway Safety Manual says

Chapter 5 – Environmental Analysis
- Air quality
- Greenhouse gas emissions
- Noise

Chapter 6 – Costs and Benefits Analysis
- Life cycle costs
- Benefit-cost ratio

Guide Chapters – Design / Implement / Operate

Chapter 7 – Design Considerations

- Geometry
- Pavement/Drainage
- Signing and pavement marking

Chapter 8 – Implementation Process

- Design exceptions
- MUTCD
- Stakeholder/public involvement

Chapter 9 – Day-to-Day Operations

- Maintenance
- Incident management
- Law enforcement
- Opening and closing the shoulder

Some Design and Operations Questions

Preliminary Engineering

- Is shoulder width adequate, or can it be widened?
- Are vertical clearances adequate?
- Is the shoulder pavement structural capacity adequate in terms of drainage and rideability?
- Is it feasible to provide supplemental emergency turn-out or refuge areas beyond the shoulder at reasonable intervals?
- Is a sufficiently long segment available, or is an acute bottleneck being relieved?

Operations Concepts

- Should the right or left shoulder be used?
- What vehicles will the shoulder be open to?
- If the shoulder is open to more than buses, should it be static (fixed hours of operation) use dynamic use
- Will there be speed restrictions?
- Use in conjunction with other operational strategies?

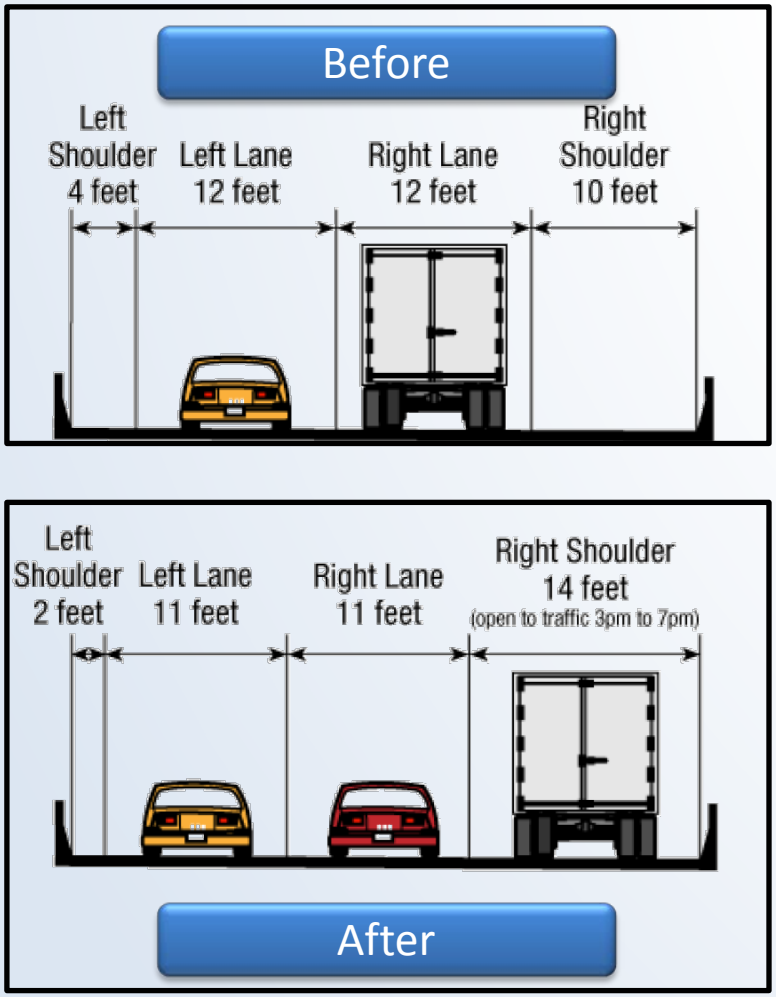
Shoulder Use Capacity Findings

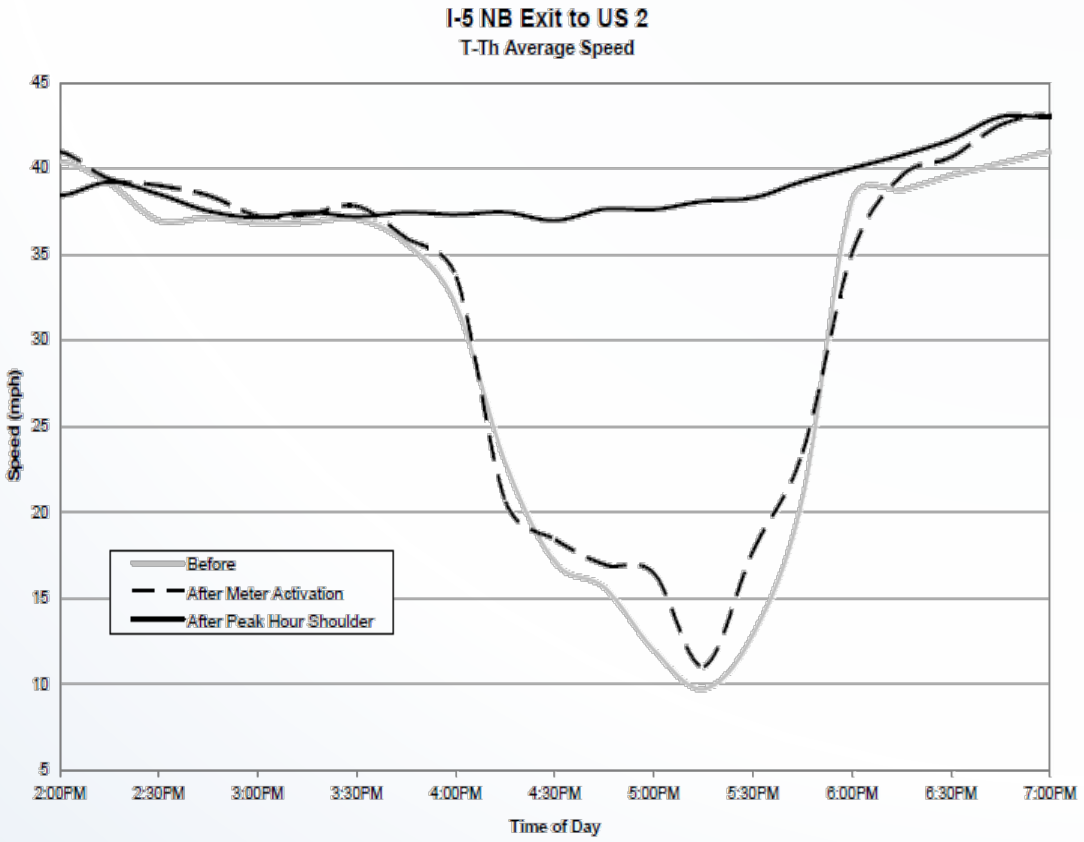
- Shoulder utilization and capacity is highly dependent on design features
- Dimensions meeting or exceeding the AASHTO criteria for non-shoulder use freeways should be provided when possible
- Data on left shoulder use is limited

Observed Shoulder Lane Usage/Capacity

Facility	Shoulder Capacity	Speed Conditions
I-66 in Virginia	~2000 veh/hr	5-10 MPH lower than general purpose lanes
I-35W in Minnesota	1100 veh/hr (lane is priced)	55 MPH, same as general purpose lanes
US 2 in Washington	1/3 per lane volume of adjacent lanes	50 MPH (5-10 MPH lower than general purpose lanes)
I-93 in Massachusetts	~1000 veh/hr	35-40 MPH (general purpose lanes ~55 MPH)

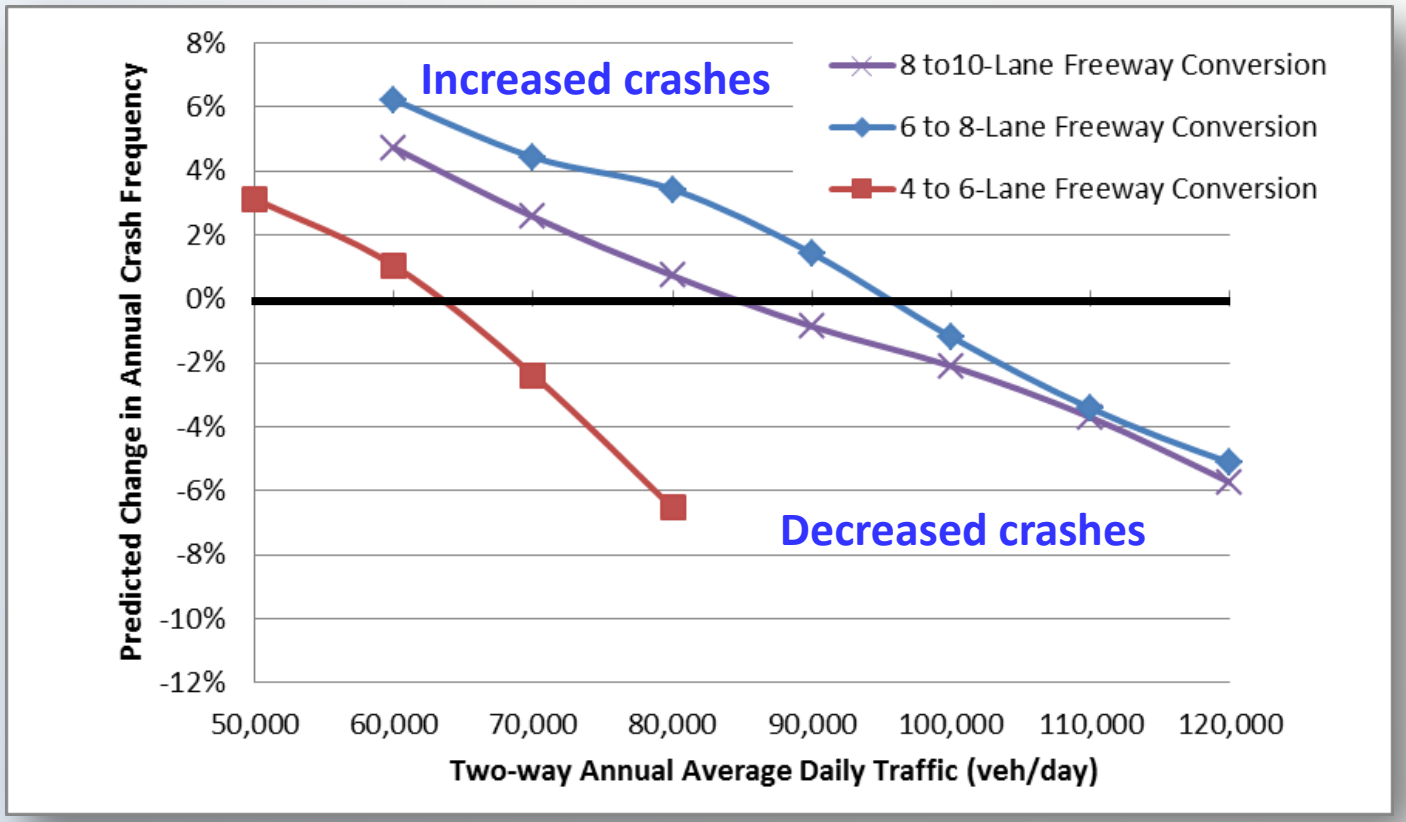
Operational Benefits of Shoulder Use - Example





Highway Safety Manual (HSM) Model Findings

- Narrowing shoulders and adding a lane reduces crashes if the volume is high enough



Environmental Effects of Part-Time Shoulder Use

- Changes in traffic volumes or speeds may effect:
  - Air quality
  - Greenhouse gas emissions
  - Noise
- Likely minimal changes in roadway footprint with minimal effect:
  - Water quality
  - Plants and animals
  - Cultural resources
- Cannot generalize air and noise effects
  - Reduced congestion -> generally good for air quality
  - Increased volume -> generally bad for air quality

Typical Capital Costs

Component	Description
Systems Engineering	Concept of Operations documents, testing, typical project management and documentation
Shoulder widening or reconstruction	If necessary. Also includes drainage modifications, guardrail/sign relocation, and turnout construction
Ramp treatments	Ramp widening/gore area modifications sometimes necessary
Training	TMC, maintenance, and law enforcement training; bus operator training for Bus on Shoulder
Emergency Patrols	Typically increased
Public Outreach	More extensive than conventional project
ITS	CMS, overhead lane control signs, controllers/cabinets, CCTV, communications, TMC enhancements

Typical O & M Costs

Component	Description
Compliance	Additional police enforcement typically needed
Driver training	Continuous training of new bus drivers for Bus on Shoulder
Sweeps	Police or maintenance typically drive length of facility before opening to traffic each day
ITS	Additional TMC staff, field and TMC maintenance
Roadway maintenance	Similar to general purpose lanes, sometimes facility-specific issues like snow removal

Part-Time Shoulder Effects on Design Criteria

- Likely effected
  - Shoulder width and bridge width (always will be less than minimum)
  - Lane width (on shoulder or narrowed full time lanes)
- Possibly effected
  - Superelevation and cross slope (unusual drainage on shoulder)
  - Horizontal alignment (slightly tighter curves)
  - Lateral offset to obstruction
  - Vertical clearance
  - Stopping sight distance
- Unlikely or never effected: design speed, vertical alignment, grade, structural capacity

Ramp Freeway Junctions

- Shoulder use can “pass through” ramps/interchanges
- “Geometry” of ramp-freeway junctions modified by pavement markings
- Additional pavement usually not needed

Turnoffs

- Have refuge for disabled vehicles approximately every half mile
- Construct turnoffs where other refuge spaces (ramps, gores, etc.) don't exist
- If turnoffs cannot be constructed, part-time shoulder use still possible
- Not necessary for BOS, but still helpful

UK Turnoff

Signing and Pavement Marking

- Bus on shoulder
  - Minimal
  - Too much shoulder markings may make passenger car drivers think lane is open to them
- Static shoulder use
  - Static regulatory and warning signs
  - Can have dynamic lane control signs
- Dynamic shoulder use
  - Dynamic lane control signs

Regulatory Sign Examples (static shoulder use)

GA 400 Mainline

GA 400 Ramp

Regulatory Sign Examples (static shoulder use)

I-H-1 (Hawaii)

Massachusetts

Regulatory Sign Examples (static shoulder use)

New Jersey Turnpike Newark Bay Extension (I-78)

Day-to-Day Operation

- Maintenance
  - More similar to a general purpose lane than shoulder
  - Presence of traffic clears debris
  - Some major snowfall removal issues if roadside barriers present
- Incident Management
  - Plans often in place already on freeways where shoulder use being considered
  - Potential enhancements:
    - Turnouts
    - Service patrols
    - CCTV
    - Changeable lane control signs

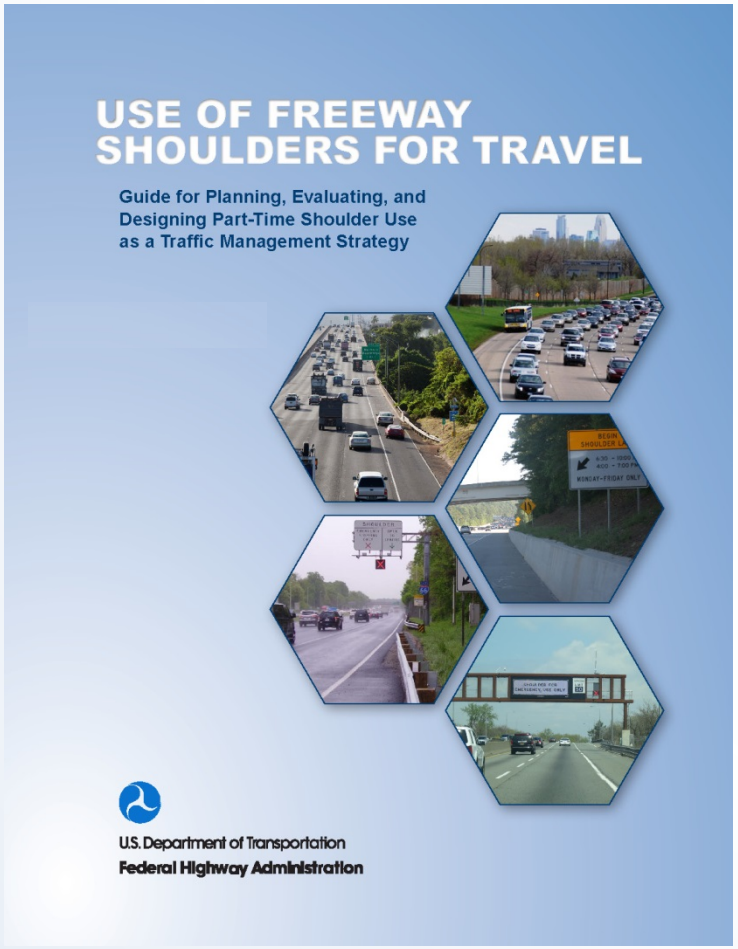
Day-to-Day Operation

- Law Enforcement
  - Police must know when lanes are open/closed
  - Targeted enforcement where roadside space available
- Opening and closing
  - “Sweep” the lanes before opening
    - Driving the facility most common
    - CCTV also used
    - Unnecessary for BOS
  - Police and/or TMC have authority to order closure of shoulder for incidents or other reasons.

Public Outreach and Education

- Critical to success
- Use multiple formats and forums
- Ongoing after opening to traffic

The Guide

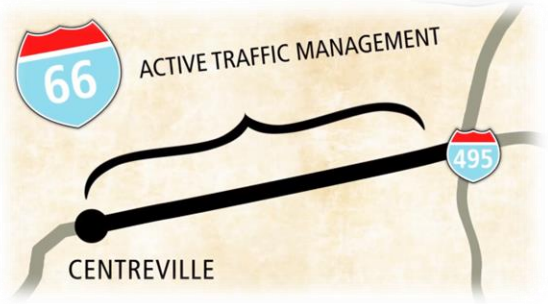


http://www.ops.fhwa.dot.gov/publications/fhwahop15023/index.htm

Part-time Shoulder Use
VA-267, I-495 & I-66

Kamal Suliman, Northern Region Operations Director

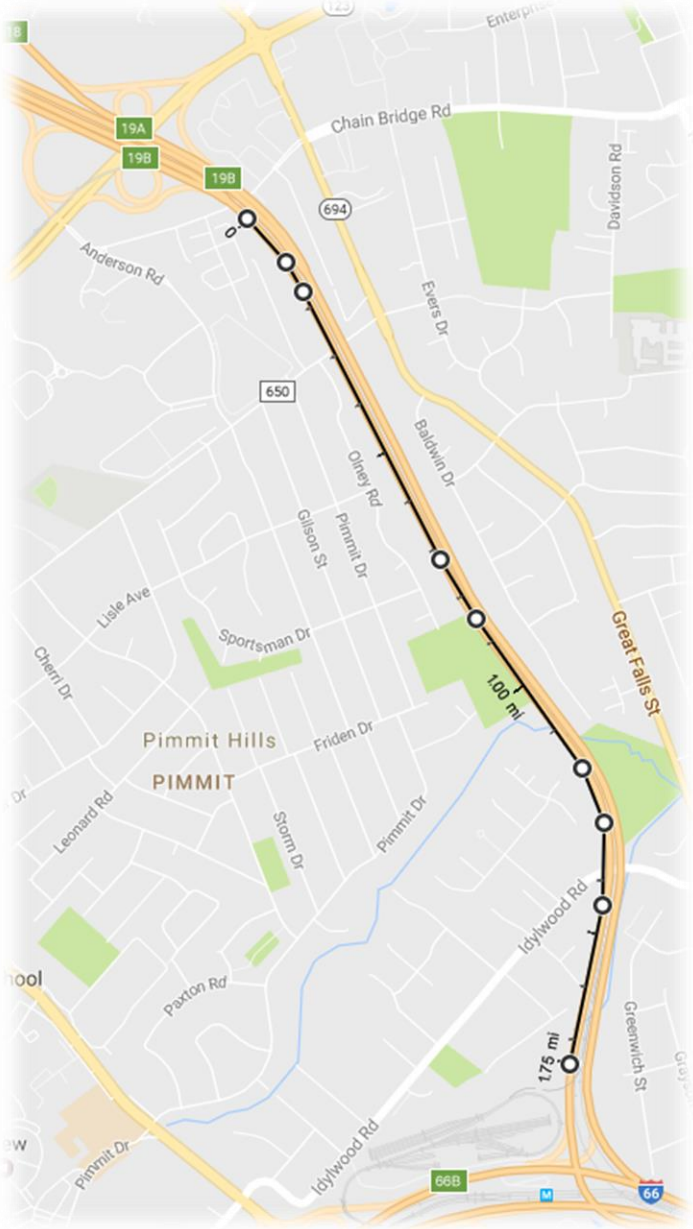
Part-time Shoulder
TRB Webinar
October 12, 2017



VA 267

VA-267

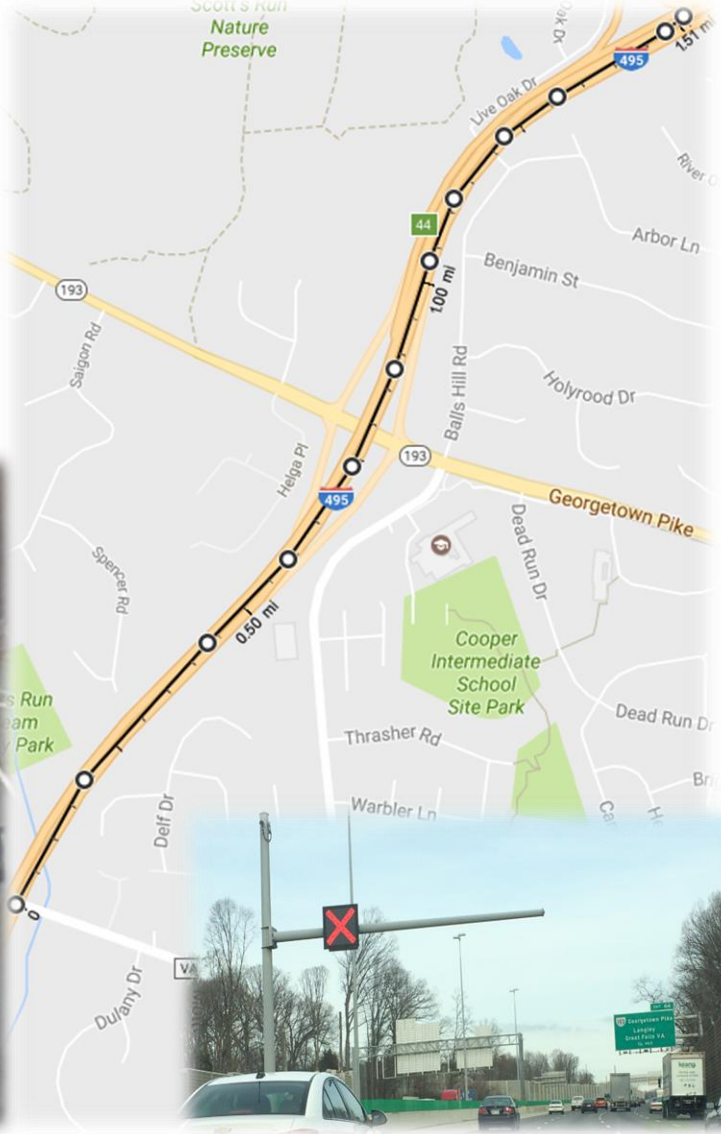
- Mon-Fri peak
- 6:00 - 10:00 AM
- 3:00 - 8:00 PM
- Bus only
- 1.75 Mile on right shoulder
- Advisory Speed 25 MPH



I-495

I-495

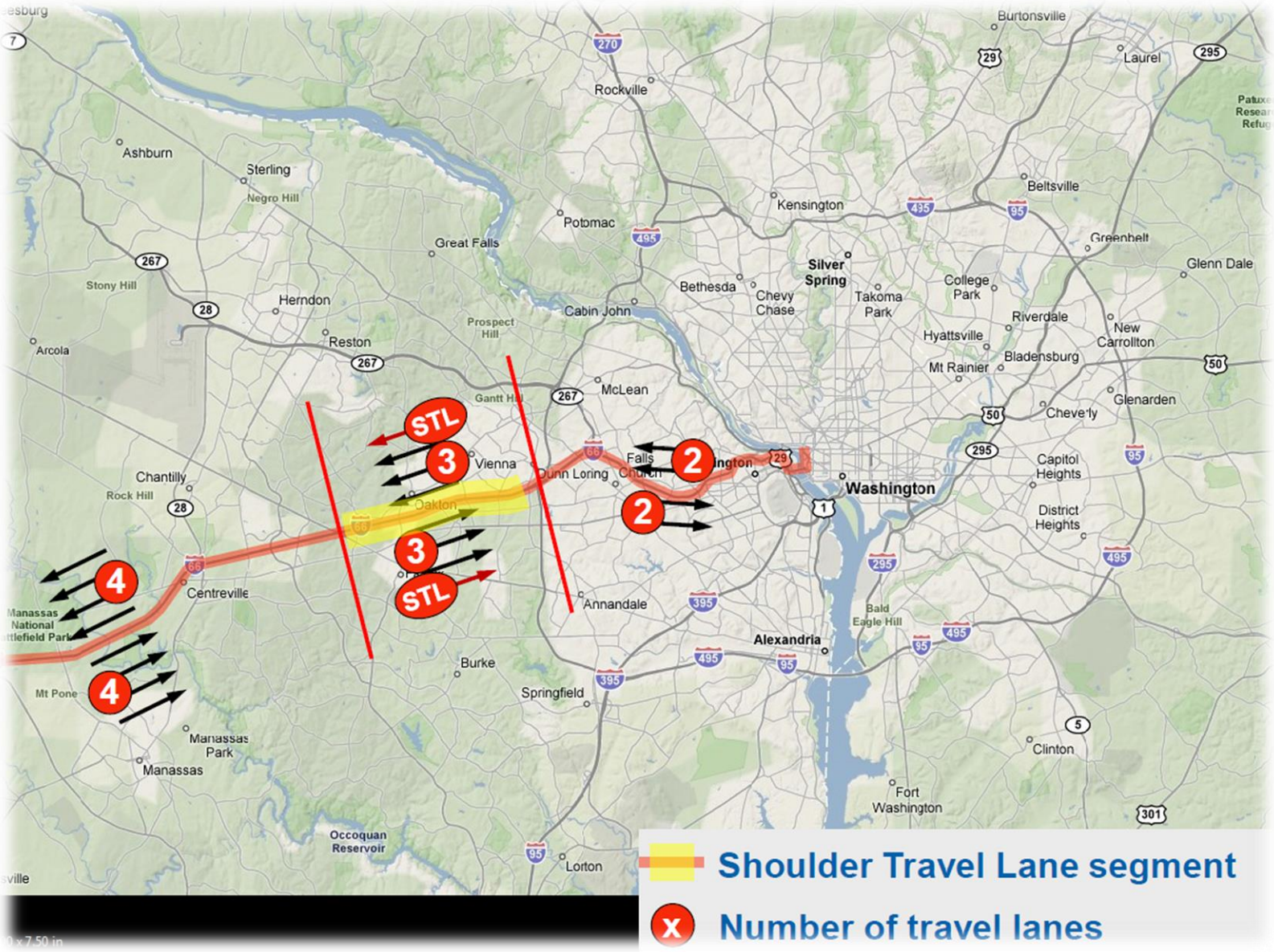
- Mon-Fri peak
- 6:00 - 11:00 AM
- 2:00 - 7:00 PM
- 1.5 Miles left shoulder
- Fixed scheduled opening



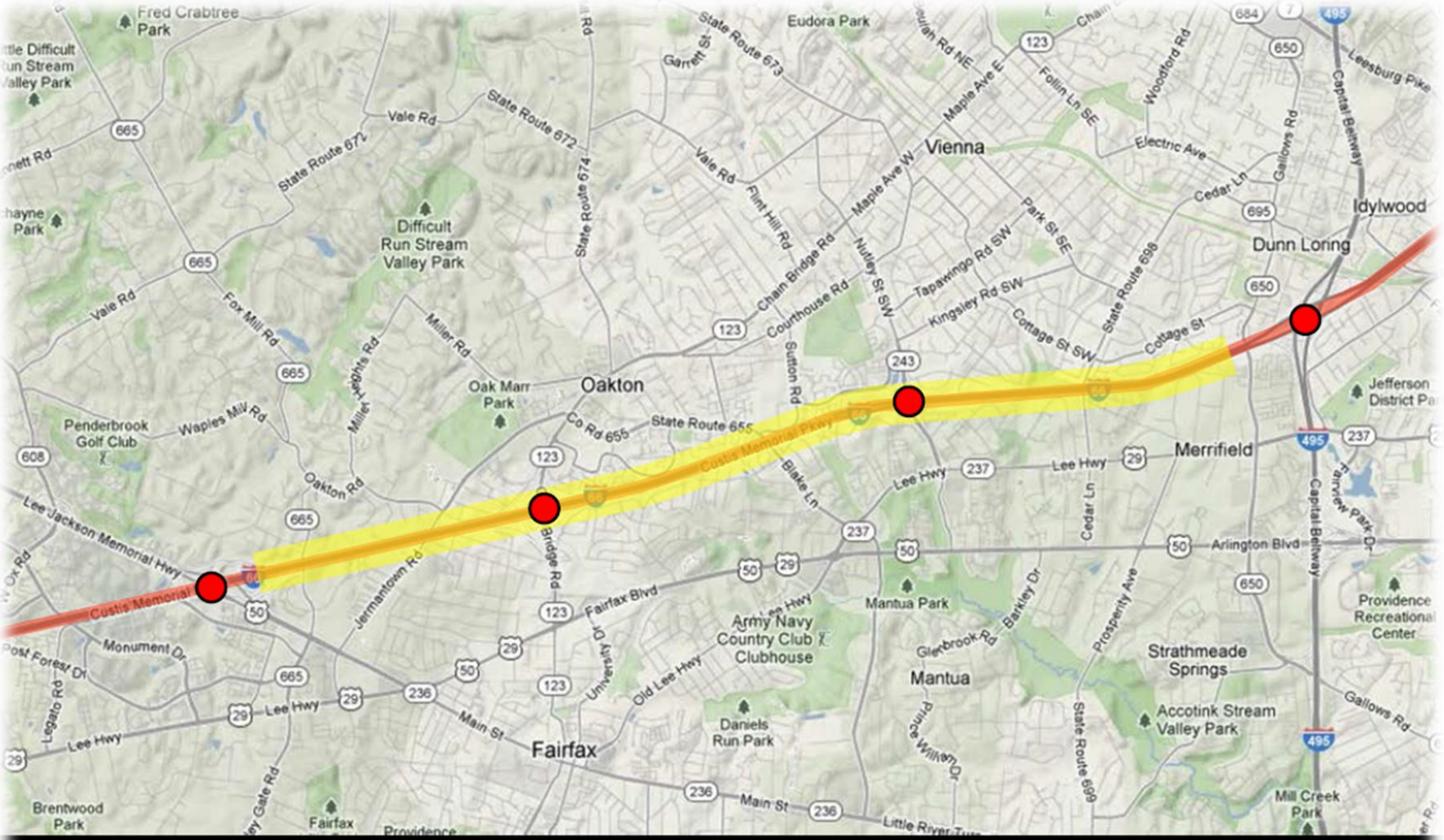
I-66 Shoulder Travel Lane History

- 1964: This segment of I-66 first constructed as a 4-lane divided freeway
- April 1993: Widened to 6 lanes. Left lane reserved for HOV-2, shoulder upgraded for use as a travel lane during peak periods.
  - 6:30 – 9:00 AM eastbound
  - 4:00 – 6:30 PM westbound
- August 1993: HOV and Shoulder Lane hours extended:
  - 5:30 – 9:30 AM eastbound
  - 3:00 – 7:00 PM westbound
- 1999: Shoulder Lane hours extended:
  - 5:30 – 10:00 AM eastbound
  - 3:00 – 8:00 PM westbound
- August 2008: Shoulder Lane hours extended and incidents
  - 5:30 – 11:00 AM eastbound
  - 2:00 – 8:00 PM westbound
- HOV Hours remain unchanged since August 1993

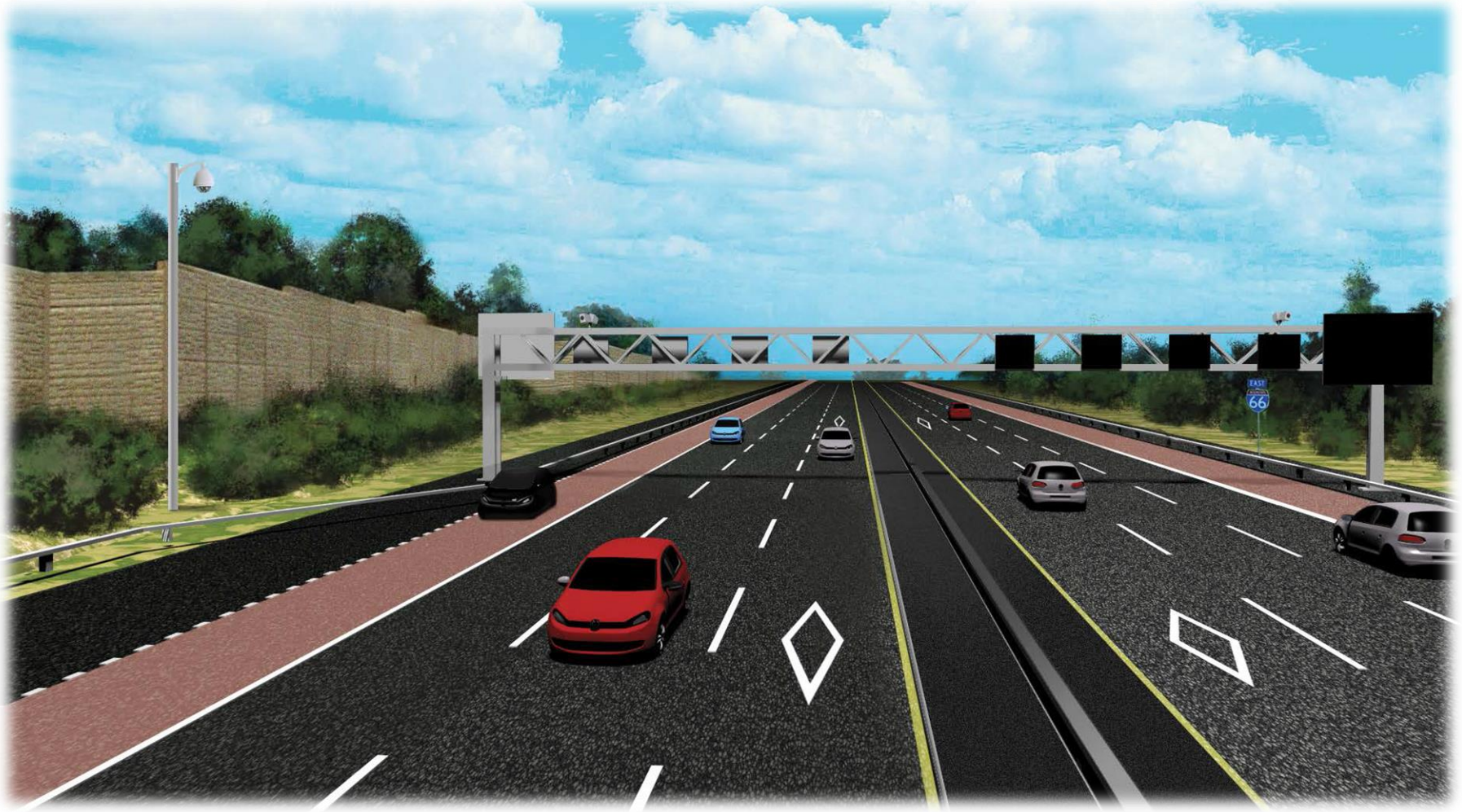
I-66 Shoulder Lane Boundaries



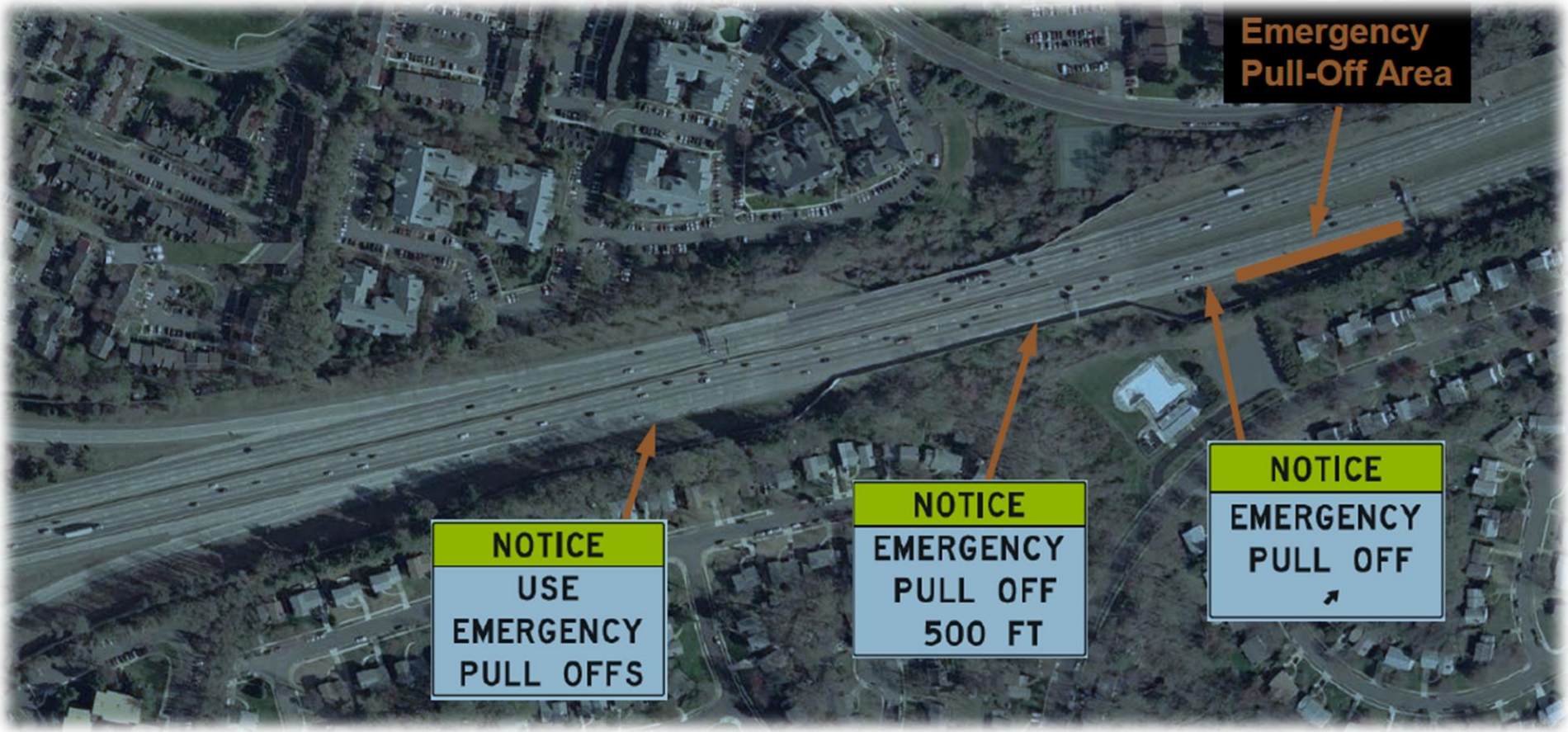
I-66 Shoulder Lane Limits



I-66 Shoulder Lane Cross Section

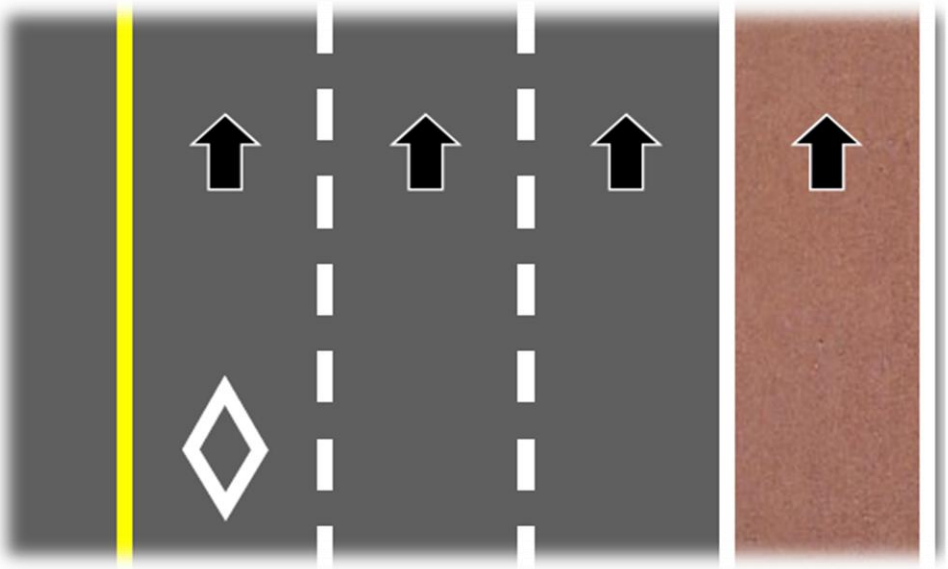


I-66 Shoulder Emergency Pull-Off Typical



Shoulder Lane Control Signs

Shoulder Lane Control Signs



Shoulder Lane Control Signs

Shoulder Lane Control Signs

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Shoulder Lane Control Signs

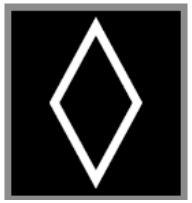
Lane Control Signs

Yellow Merge Arrow: Used to start shifting traffic away from lane when there is debris, stopped vehicle(s), encroachment, or when people are close to edge of travel way

Red X: Used keep traffic away from blocked lane at scene of an incident, debris or encroachment

Green Arrow: Used to signify that the lane is open to traffic beyond a blockage point

Lane Control Signs



HOV Diamond: Used to display HOV Diamond during restriction hours

Lower Advisory Speed: Used as slow down warning to traffic approaching congestion, an incident, debris, encroachment or blockage

Speed Limit: Used to signify resumption of normal traffic flow beyond a blockage point

I-66 Shoulder Lane Usage

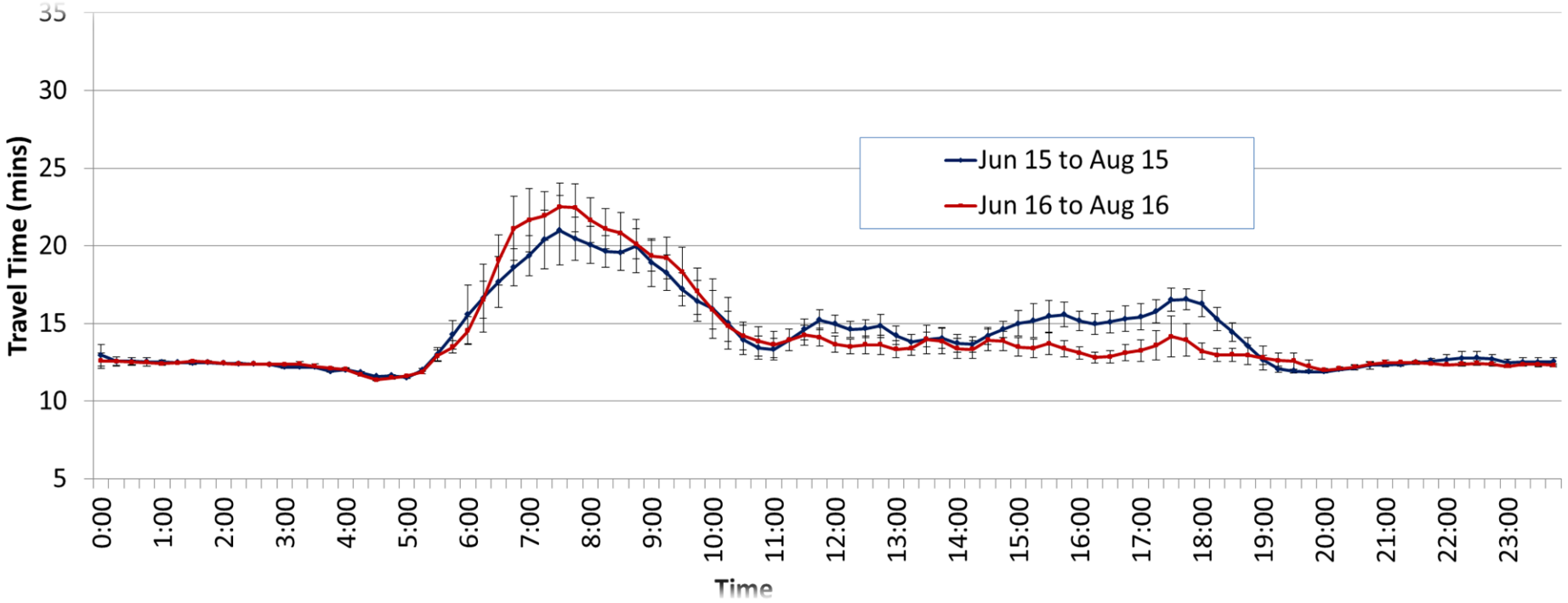
- Before ATM, shoulders on I-66 from US 50 to I-495 were open to travel on a fixed schedule:
  - EB: 5:30-11:00 AM weekdays only
  - WB: 2:00-8:00 PM weekdays only
- After ATM, shoulders were also opened as needed based on traffic congestion.
- Average daily duration of shoulder lane sign activation since opening September 2015:

HSR Utilization in Hours (Average Hours of Operation/Day per Gantry)

Direction	Average Day	Before-ATM	After-ATM
Eastbound	Weekday	5.5	10.2
	Weekend	N/A	7.2
Westbound	Weekday	6	8.4
	Weekend	N/A	7.8

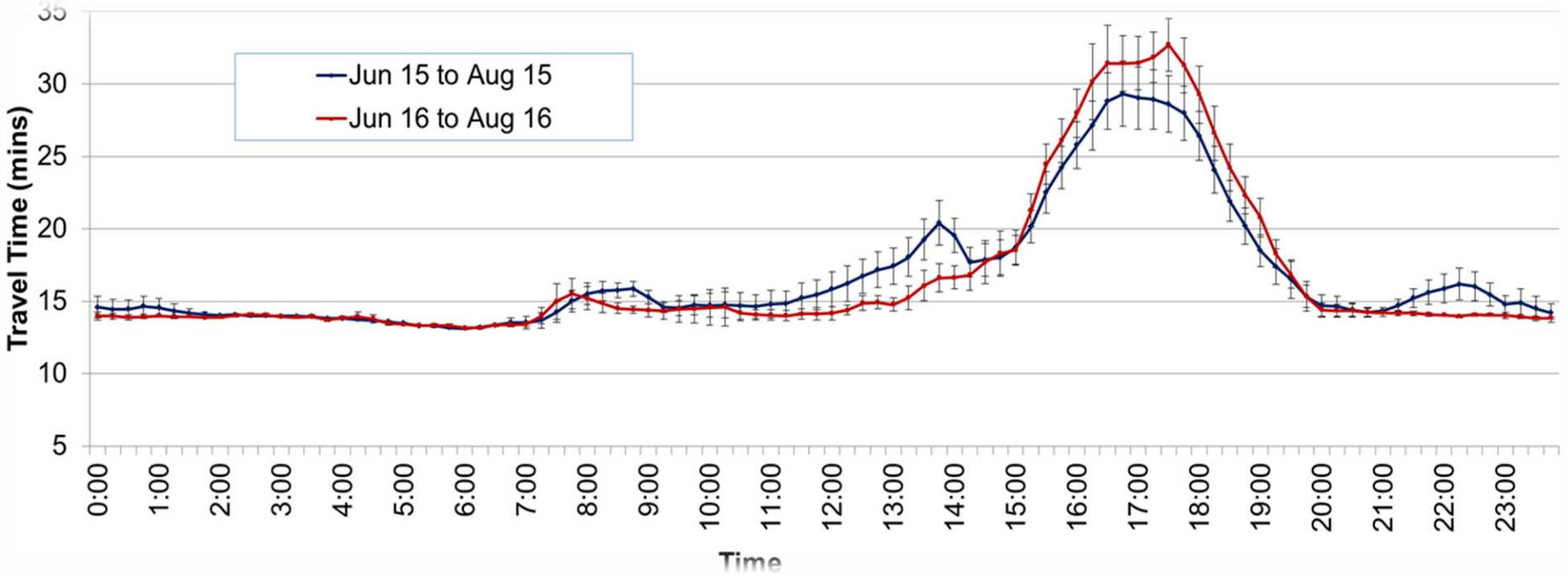
2014-2015 vs. 2015-2016 Average EB Weekday Travel Times

Time Period	Oct 2014 - Aug 2015	Oct 2015 - Aug 2016	Change	Statistically Significant?
AM Peak (5:30AM - 11AM)	17.6 min	18.6 min	+1.0 (+5.9%)	Yes
Midday (11AM - 2PM)	13.9 min	13.4 min	-0.5 (-4.1%)	Yes
PM Peak (2PM - 8PM)	14.6 min	13.3 min	-1.3 (-9.1%)	Yes



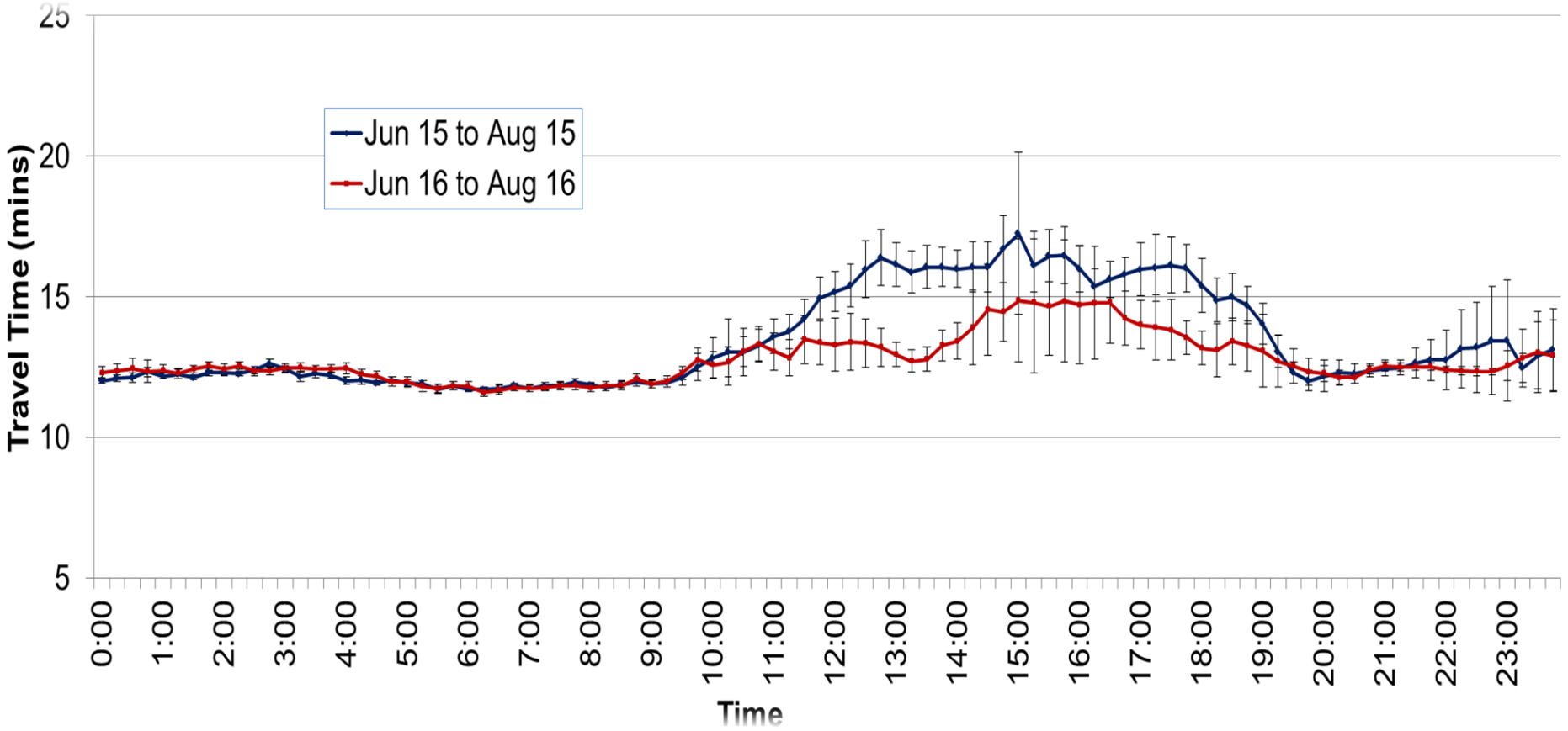
2014-2015 vs. 2015-2016 Average WB Weekday Travel Times

Time Period	Oct 2014 - Aug 2015	Oct 2015 – Aug 2016	Change	Statistically Significant?
AM Peak (5:30AM - 11AM)	13.2 min	12.8 min	-0.4 (-3.6%)	Yes
Midday (11AM - 2PM)	14.4 min	13.2 min	-1.2 (-8.8%)	Yes
PM Peak (2PM - 8PM)	21.9 min	22.7 min	+0.8 (+3.7%)	Yes



2014-2015 vs. 2015-2016 Average EB Weekend Travel Times

Time Period	Oct 2014 - Aug 2015	Oct 2015 - Aug 2016	Change	Statistically Significant?
Daytime Peak (10AM - 8PM)	14.9 min	13.3 min	-1.6 (-11.0%)	Yes



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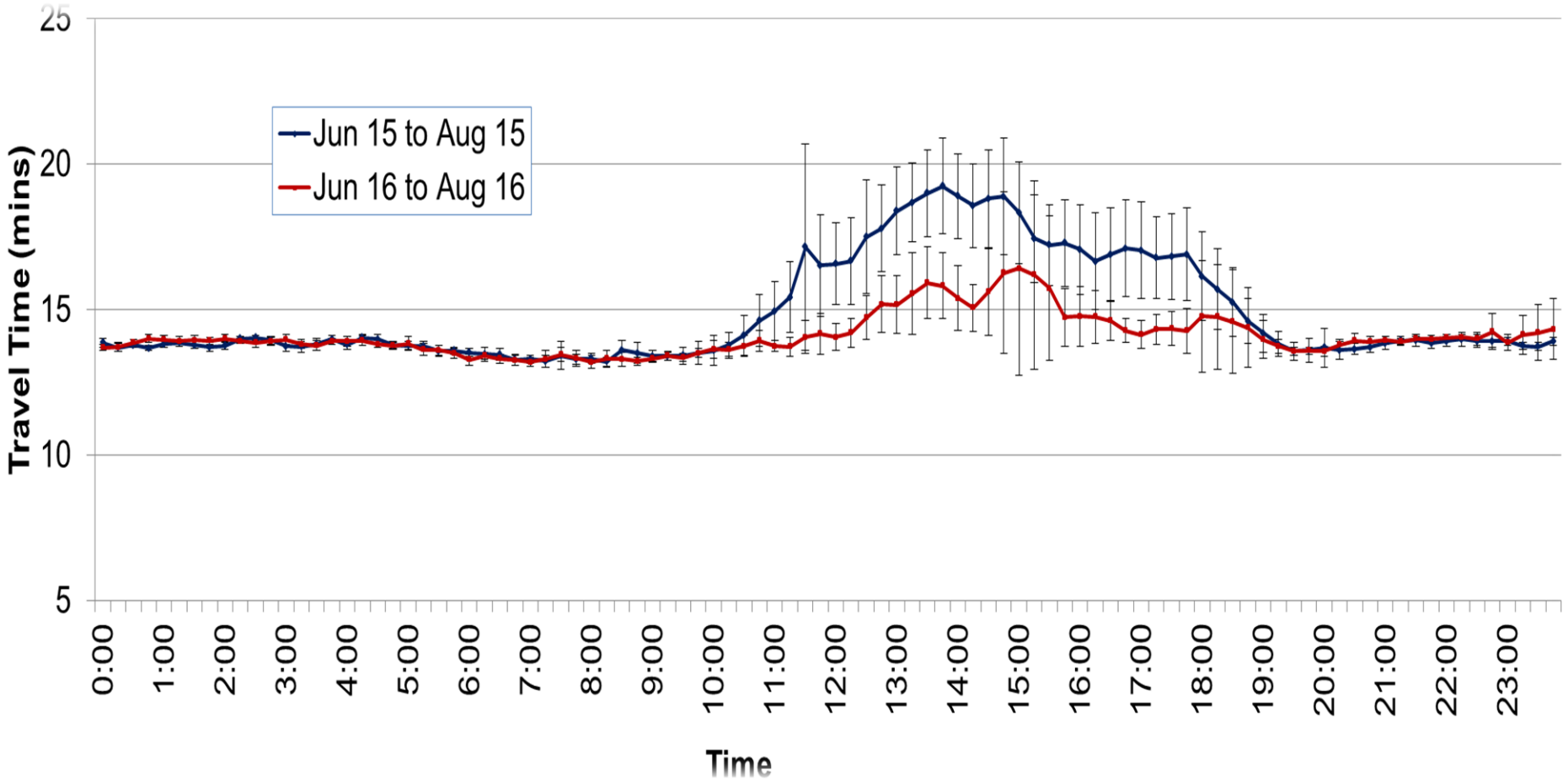
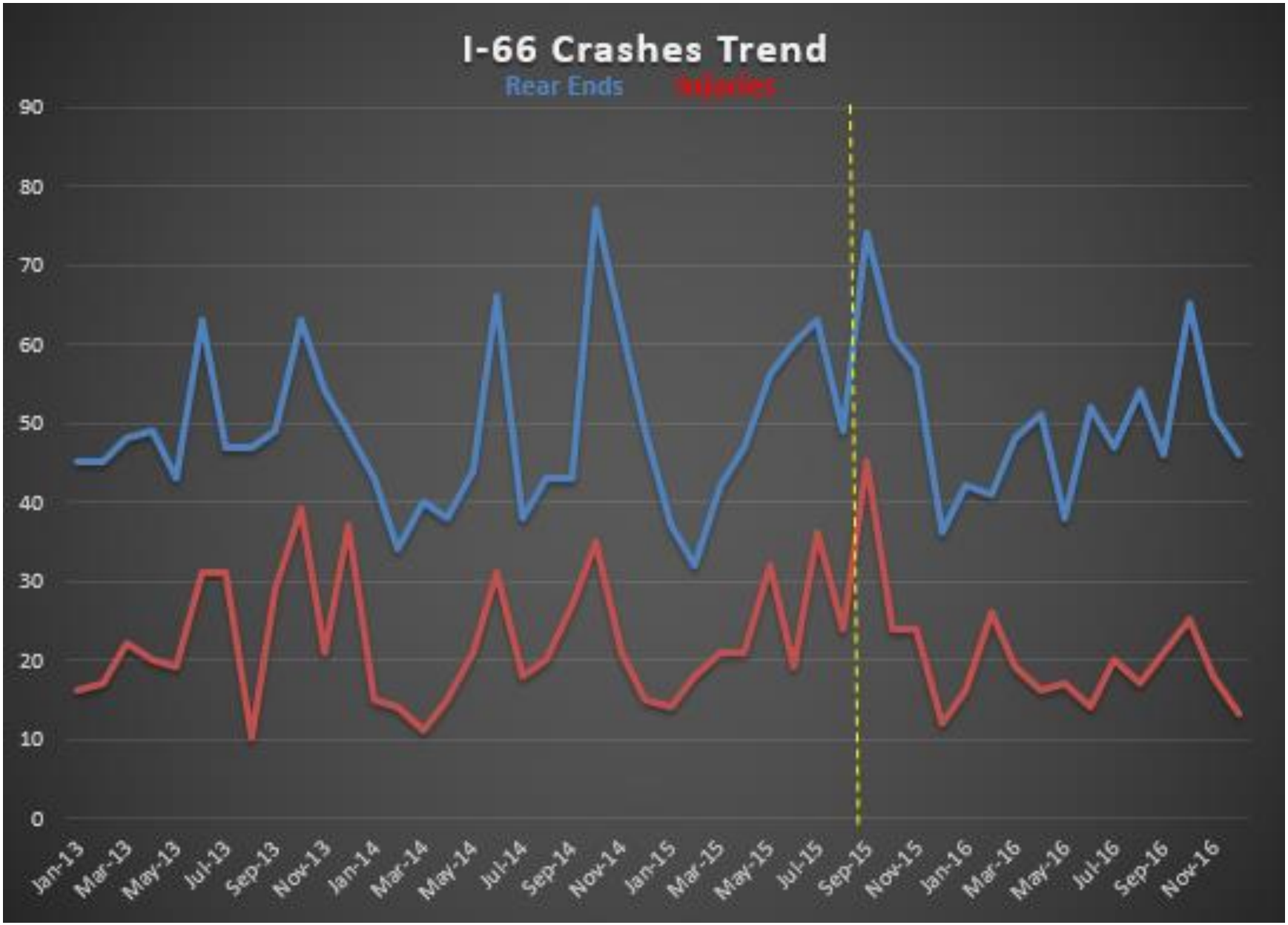


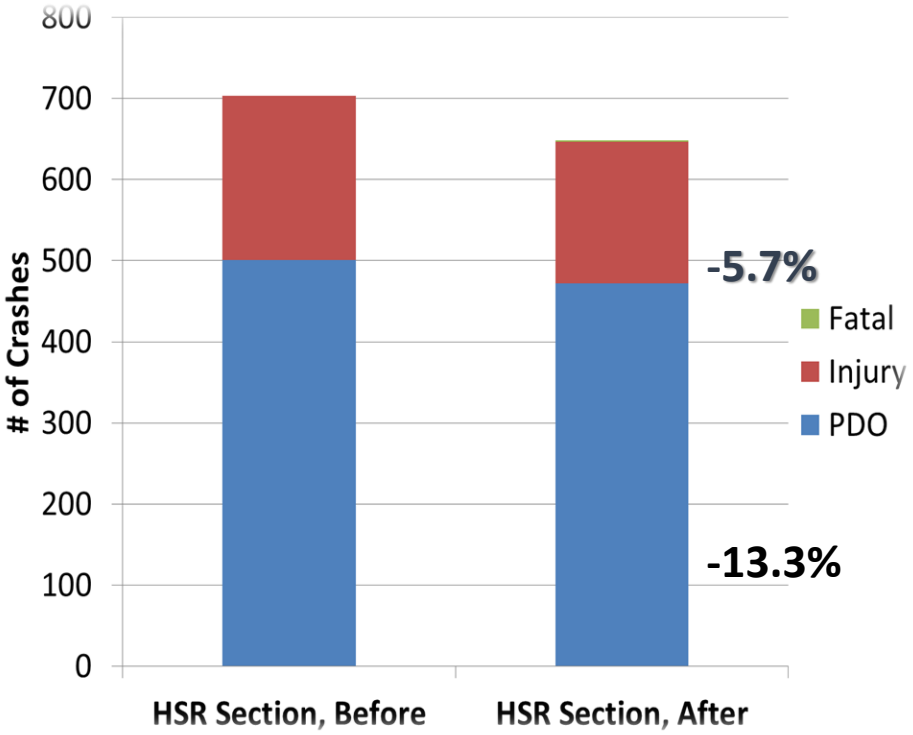
I-66 HSR 2013-2016 Crash Trend

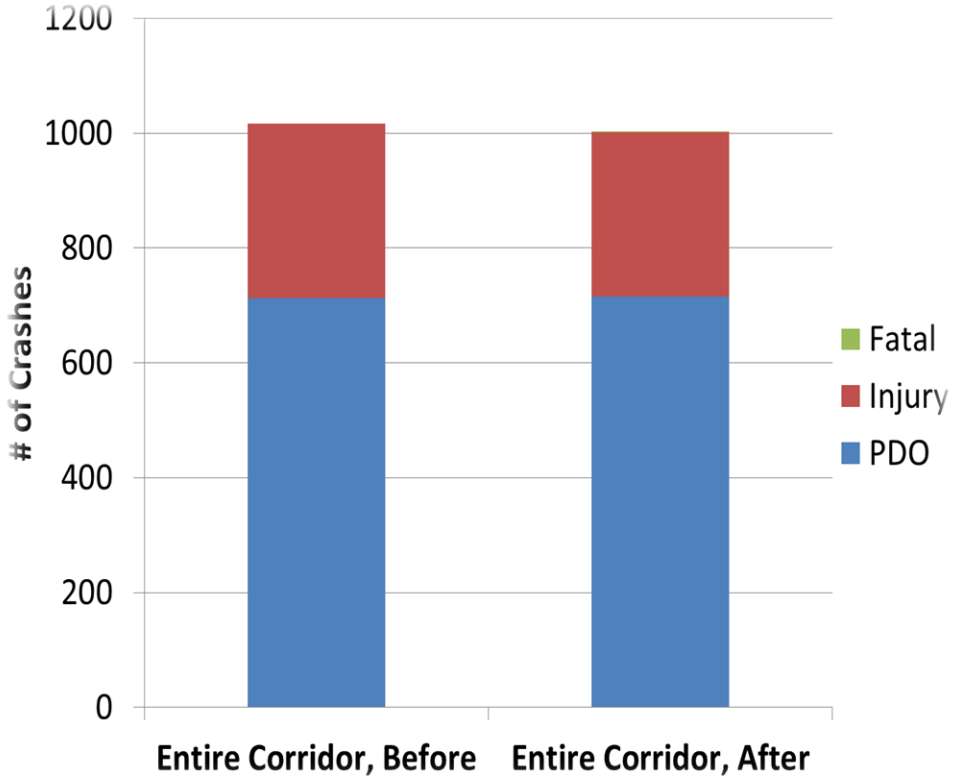


Before-After Crash Data 1st Year

HSR segment only:

- 8% reduction overall
- 13% reduction in rear end crashes
- 6 % reduction in injury crashes





Corridor all segments:

- No significant change along entire corridor
- More data needed to reach firm conclusions

Crash Modifications Factors

EB results for all segments
HSR Segment Results

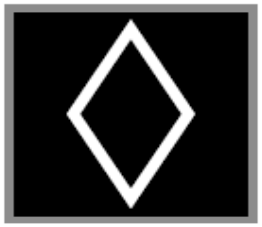
No	Crash Type	CMF	Std. Error	% Red	Stat. Sig.
	All Severity Crashes				
1	Total Crashes	0.75	0.065	25	3.8***
2	Multiple Vehicle	0.71	0.066	29	4.4***
3	Rear End crashes	0.69	0.071	31	4.3***
	Fatal and Injury Crashes				
4	Total Fatal/Injury	0.69	0.107	31	2.9***
5	Multiple Vehicle	0.59	0.103	41	4.0***
6	Rear End crashes	0.61	0.112	39	3.5***

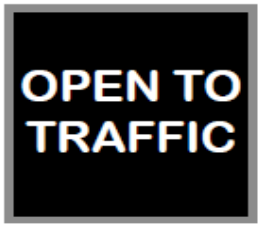
Significant at 95% confidence level ***

Contacts

Project page on VDOT website

www.virginiadot.org/projects/northernvirginia/I-66_atms.asp





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Today's Participants

- Jim Hunt, *Federal Highway Administration,* jim.hunt@dot.gov
- Greg Jones, *Federal Highway Administration,* gregm.jones@dot.gov
- Pete Jenior, *Kittelson & Associates, Inc.,* pjenior@kittelson.com
- Kamal Suliman, *Virginia Department of Transportation,* Kamal.Suliman@VDOT.Virginia.gov

KITTELSON & ASSOCIATES

Similar Event

- NOCoE Webinar: Maximizing Capacity: New Applications for Full-Time and On-Demand Hard Shoulder Running
- https://transportationops.org/ondemand-learning/webinar-maximizing-capacity-new-applications-full-time-and-demand-hard-should

Get Involved with TRB

- Getting involved is free!
- Join a Standing Committee (http://bit.ly/2jYRrF6)
  - AFB10 (Geometric Design)
- Become a Friend of a Committee (http://bit.ly/TRBcommittees)
  - Networking opportunities
  - May provide a path to become a Standing Committee member
- For more information: www.mytrb.org
  - Create your account
  - Update your profile

97th TRB Annual Meeting: January 7-11, 2018

Take Part in the *Careers in Motion* Networking Fair

http://bit.ly/CareersInMotionFair