Smarter Work Zones
Webinar Series

Webinar #4: Smarter Work Zones Technology Showcase – Queue Warning Systems

Todd Peterson, Gerald (Jerry) Ullman, Ted Nemsky, and Chris Brookes

October 26, 2015
1:00-2:30pm EDT

Efficiency through technology and collaboration

U.S. Department of Transportation
Federal Highway Administration
Smarter Work Zones

INTRODUCTION AND TODAY’S SPEAKERS
Today’s Speakers

Todd Peterson, P.E., PTOE
Transportation Specialist
FHWA Office of Operations

Gerald (Jerry) Ullman, Ph.D., P.E.
Senior Research Engineer
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District 8 Construction Engineer
Illinois Department of Transportation

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Work Zone Delivery Engineer
Michigan Department of Transportation
Smarter Work Zones Webinar Series

• This is the fourth in a series of bi-weekly SWZ webinars
• Topics based on what matters most to you!
• Webinars include:
  – Previously Recorded:
    • Webinar #1: A Comprehensive Overview of the SWZ Initiative (9/9/2015)
      – https://www.workzonesafety.org/swz/project_coordination/training
    • Webinar #2: Implementing Technology Application Solutions (9/29/2015)
      – https://www.workzonesafety.org/swz/technology_application/training
    • Webinar #3: SWZ Corridor-Based Project Coordination (10/15/15)
      – https://www.workzonesafety.org/swz/project_coordination/training
  – Coming Up:

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<th>November</th>
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<th>Webinar Content</th>
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<tr>
<td>11/2</td>
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<td>Webinar #5: SWZ Program-Based Coordination</td>
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<td>11/12</td>
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<td>Webinar #6: TA Case Studies: Variable Speed Limit and Dynamic Merge</td>
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<td>December</td>
<td>12/2</td>
<td>Webinar #7: Work Zone Project Coordination Guide and Examples</td>
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<tr>
<td>12/15</td>
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<td>Webinar #8: TA/PC Showcase: Corridor Traffic Management</td>
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For additional information go to:
https://www.workzonesafety.org/SWZ/main
Purpose of Today’s Webinar

Provide an overview of Queue Warning Systems (QWS) and discuss real-world examples of QWS that have been used to reduce the number and severity of rear-end crashes.

Topics include:

1. SWZ Technology Application Initiative
   - Show how the SWZ Technology Application initiative can be used by agencies to enhance their current work zone management practices

2. Queue Warning System Examples
   - Provide real-world examples of the successful use of Queue Warning Systems, which result in:
     - Reduction in the number and severity of rear-end crashes
     - Alerting drivers to stopped or slowed traffic
Smarter Work Zones
TECHNOLOGY APPLICATION INITIATIVE
What are Smarter Work Zones (SWZ)?

*Innovative strategies designed to optimize work zone safety and mobility*

- Policies and practices used to incrementally and continuously improve WZ operations
- Tools to reduce WZ crashes and delays
- Tools to enhance WZ management strategies
Two Identified SWZ Initiatives:

Project Coordination

Coordination within a single project and/or among multiple projects within a corridor, network, or region, and possibly across agency jurisdictions

Technology Application

Deployment of Intelligent Transportation Systems (ITS) for dynamic management of work zone traffic impacts, such as queue and speed management

Today’s Focus of Discussion
Technology Application – What is it?

Deployment of ITS for dynamic management of work zone traffic impacts, such as queue and speed management to provide actionable information to drivers and traffic managers.

Capabilities include:

- Improving driver awareness
- Providing dynamic and actionable guidance to drivers
- Enhancing tools for on-site traffic management

Source: FHWA
SWZ Technology Application Goals:

Goal 1A

By December 2016, 35 State DOTs have implemented business processes for work zone ITS technologies as identified in the Work Zone ITS Implementation Guide

• What does this mean?
  – Well-documented agency policies and processes to streamline consideration and use of work zone ITS technologies to minimize traffic impacts
SWZ Technology Application Goals:

Goal 1B

By December 2016, 35 State DOTs have utilized at least one work zone ITS technology application for dynamic management of work zone impacts

• What does this mean?
  – Consideration of the six step process explained in the WZ ITS implementation guide to plan and implement ITS strategies
  – Identify and use ITS strategies such as speed and/or queue management on at least one project for dynamic management of work zone impacts
Smarter Work Zones
Queue Warning Systems
Queue Warning Systems

- Used to alert drivers to traffic conditions (e.g., stopped traffic, slowing traffic) ahead
- Reduce the number and severity of rear-end crashes
- Avoid drivers being surprised by stopped or slowing traffic
Queue Warning System Components

- Sensors
- Portable Changeable Message Signs (PCMS)
- Cameras
- Rumble Strips
1. Texas DOT – I-35, Central Texas
2. Illinois DOT – I-55 (I-70 to IL 140)
Example #1: I-35 Construction Corridor

- $2.1 billion effort
- 17 sections
- 96 miles
- Multiple projects active at one time
- 70k -110k ADT
- ~ 66% through traffic
- > 75% trucks at night
I-35 Construction Traveler Information System Components

- Real-time queue warning
- Lane and road closure information
- Current travel time information
- Expected construction delay information
- Volume and spot speed data
- Traffic cameras at high incident locations
- Dynamic message signs
User Needs Analysis

• Travelers
  – Many long-distance travelers
  – Normally uncongested, especially at night
  – Nighttime lane closures would create queues in some cases
  – Queues would be unexpected

• Contractors/TxDOT
  – Aggressive construction schedule
  – Equipment in ROW would adversely affect progress
  – Lane closures infrequent at any one location
  – Not all lane closures will create queues
Concept of Operations

• A highly-portable end-of-queue warning system
  – Deploy at each lane closure where queue is expected, pick up when lane closure is done
  – Scale deployment to queue expectations
System Design Needs

1. Method of identifying when and where lane closures will occur
2. Method for quickly assessing queue potential and expected maximum length
3. Determine optimum queue detection and warning configuration
4. Method for increasing likelihood of motorist receiving queue warning information
Identifying When and Where Lane Closures will Occur
Assessing Potential for Queues (1 of 2)

• Simple input-output analysis used
  – Real-time volume data at some locations
  – Assumed hourly distributions of AADT values
  – Estimates of work zone capacity (HCM, sample counts)

• Process automated to occur whenever a lane closure is entered or modified
Assessing Potential for Queues (2 of 2)

Closure Impact Assessment Report

Construction on I-35
Northbound
Full-Lane Closure
From: At Thomas Arnold Rd, Bell (Mile Marker: 284.0)
To: At FM 2484, Bell (Mile Marker: 286.0)
As of 10/16/2015

Closure ID: 3615
Last Modified: 10/16/2015 3:52:18 PM by d-borchartl@tamu.edu
Planned Start Time: 10/21/2015 07:00 PM
Planned End Time: 10/22/2015 07:00 AM
Duration: Nightly
Number of Main Lanes: 2
Lane(s) Closed: Left Lane; Right Lane
Closure Length: 2.0 mi.

Date: Wednesday, 10/21/2015
Maximum Queue Length
• Expected: 0.9 mi.
• Worse Case*: 2.7 mi.

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Expected Queue (mi)</th>
<th>Expected Delay (mm/veh)</th>
<th>Worse Case* Queue (mi)</th>
<th>Worse Case* Delay (mm/veh)</th>
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<tbody>
<tr>
<td>07:00 PM</td>
<td>08:00 PM</td>
<td>0.8</td>
<td>5.9</td>
<td>1.5</td>
<td>11.5</td>
</tr>
<tr>
<td>08:00 PM</td>
<td>09:00 PM</td>
<td>0.9</td>
<td>6.7</td>
<td>2.4</td>
<td>17.2</td>
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<tr>
<td>09:00 PM</td>
<td>10:00 PM</td>
<td>0.6</td>
<td>5.0</td>
<td>2.7</td>
<td>19.9</td>
</tr>
<tr>
<td>10:00 PM</td>
<td>11:00 PM</td>
<td>0.0</td>
<td>0.0</td>
<td>2.5</td>
<td>19.5</td>
</tr>
<tr>
<td>11:00 PM</td>
<td>12:00 AM</td>
<td>0.0</td>
<td>0.0</td>
<td>1.8</td>
<td>15.3</td>
</tr>
<tr>
<td>12:00 AM</td>
<td>01:00 AM</td>
<td>0.0</td>
<td>0.0</td>
<td>1.0</td>
<td>9.1</td>
</tr>
<tr>
<td>01:00 AM</td>
<td>02:00 AM</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>02:00 AM</td>
<td>03:00 AM</td>
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<td>0.0</td>
<td>0.0</td>
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</tr>
<tr>
<td>03:00 AM</td>
<td>04:00 AM</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>04:00 AM</td>
<td>05:00 AM</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>05:00 AM</td>
<td>06:00 AM</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>06:00 AM</td>
<td>07:00 AM</td>
<td>0.7</td>
<td>5.2</td>
<td>1.5</td>
<td>10.6</td>
</tr>
</tbody>
</table>

* Worse case analyses are based on volumes 10% higher than expected and a work zone capacity 10% lower than expected.
Queue Warning System Configuration (1 of 3)

• Simulation analyses performed to evaluate:
  – Sensor spacing
  – Sensor location
  – System update frequency
  – Logic thresholds for queue detection
Queue Warning System Configuration (2 of 3)

PCMS Operations Rules: Deployment Plan 1 (Max Design Queue ≤ 3.5 Miles)

PCMS Message

<table>
<thead>
<tr>
<th>Last 5-Minute Average Speed V (mph)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>ROAD WORK AHEAD</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
</tr>
<tr>
<td>SLOW TRAFFIC 3 MILES</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
</tr>
<tr>
<td>SLOW TRAFFIC 2 MILES</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
</tr>
<tr>
<td>SLOW TRAFFIC 1 MILE</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
</tr>
<tr>
<td>SLOW TRAFFIC AHEAD</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
<td>V &gt; 55 OR V = 0.0</td>
</tr>
<tr>
<td>STOPPED TRAFFIC 3 MILES</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
</tr>
<tr>
<td>STOPPED TRAFFIC 2 MILES</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
</tr>
<tr>
<td>STOPPED TRAFFIC 1 MILE</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
</tr>
<tr>
<td>STOPPED TRAFFIC AHEAD</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
<td>V &gt; 40 OR V = 0.0</td>
</tr>
<tr>
<td>0.0 ≤ V ≤ 40</td>
<td>Any value</td>
<td>Any value</td>
<td>Any value</td>
<td>Any value</td>
</tr>
<tr>
<td>STOPPED TRAFFIC AHEAD</td>
<td>Any value</td>
<td>Any value</td>
<td>Any value</td>
<td>Any value</td>
</tr>
</tbody>
</table>

Note: Location of the sensors and the PCMS can be adjusted slightly based on site conditions (e.g., location, other static signing, overpasses, etc.).
Queue Warning System Configuration (3 of 3)
Procurement

- Indirect purchase through construction contracts
- Original plan: bid on a per-deployment basis
- Switched to mobilization plus a per-night deployment bid
- First systems change ordered into existing contracts, included in latter projects as bid items
Deployment and Evaluation

- Began use in 2013 (300+ deployments to date)
- Systems shared between contractors (several used same temporary traffic control subcontractor)
Effectiveness of System

• Across approximately 200 deployment nights:
  – Total crashes reduced 18 to 45% when deployed
  – Crash cost reductions between $6,600 and $10,000/night
For More Information:

Gerald (Jerry) Ullman, Ph.D., P.E.
Texas A&M Transportation Institute
G-Ullman@tti.tamu.edu

Questions?
Example #2: Illinois DOT

- Background Information

**Carnage on I-57**

**AT LEAST TWO DIE IN FIERY, SEVEN-VEHICLE CRASH**

July 16, 2010 1:00 am • BY STEPHEN RICKERL, THE SOUTHERN

A seven-vehicle fiery crash on Interstate 57 on Thursday afternoon claimed the lives of two people, caused a third victim to be airlifted to a hospital and closed the highway for about five hours.

Two other crash victims were taken to Franklin Hospital in Benton after the crash just after 2 p.m. in Franklin County just north of West Frankfort.

Hazmat teams were called out, as four of the vehicles involved were semitrailers, two carrying loads of asphalt and another carrying a load of vehicle batteries. Fuel and vehicle batteries were exploding in the fire, challenging firefighters to keep the fire in check.

Trooper David Sneed of Illinois State Police District 13 said
Example #2: Illinois DOT – I-55 (I-70 to IL 140)

- Madison County, Illinois
- 30 miles of bi-directional mainline interstate on I-55
- Rubblizing, resurfacing, and bridge work
- Nov. 2010 – June 2012

Pavement Patching, Resurfacing & Bridge Rehabilitation
$10.4 Million
ADT = 26,700

Rubbllization and Resurfacing
$42.3 Million
ADT = 27,300

Bridge Replacement and SPUD Interchange Reconstruction
$23.5 Million
ADT = 36,500
I-55 (I-70 to IL-140) Project Directives

• Two directives for this project after end-of-queue accident
  – Reduce risk of accident like on I-57
  – Better inform traveling public about delays and help with options to minimize delays
Smart Traffic Monitoring Special Provision Requirements

• Collect real-time vehicle data
• Analyze data via control software
• Alert drivers of delay times, stopped traffic conditions, and alternate route options

Contract Plans and Special Provisions/Addendums available here:
http://eplan.dot.il.gov/desenv/091710/76C93-063/
Equipment Procurement

• Researched and interviewed several ITS Smart Work Zone companies
• Developed a Contract Special Provision and Plan Sheet Addendum
  – Allowed at least 2 bidders to meet the specification
Deployment

- 73 PCMS (1 per mile each direction and at cross roads)
- 56 Doppler Speed Sensors
- 6 mile lead in each direction
System Operation

- Drivers were alerted 1 and 2 miles upstream of any detected queue.
- Alternating “STOPPED TRAFFIC AHEAD” and “BE PREPARED TO STOP” messages were displayed when traffic slowed below 40 mph
- Provided anticipated delay times at approach to each work zone and every traffic decision point.
2010 and 2011 Construction Seasons

Pavement Patching, Resurfacing & Bridge Rehabilitation
$10.4 Million
CY 2010 & 2011

Rubblerization and Resurfacing
$42.3 Million
CY 2011

Bridge Replacement and SPUD Interchange Reconstruction
$23.5 Million
CY 2010 & 2011

Pavement Patching, Resurfacing & Bridge Rehabilitation
$9.6 Million
CY 2010

Pavement Patching, Resurfacing & Bridge Rehabilitation
$14.4 Million
CY 2010
2010 Construction Season

Pavement Patching, Resurfacing & Bridge Rehabilitation
$10.4 Million
ADT = 26,700

Smart Work Zone not utilized during 2010

Bridge Replacement and SPUD Interchange Reconstruction
$23.5 Million
ADT = 36,500

Pavement Patching, Resurfacing & Bridge Rehabilitation
$9.6 Million
ADT = 39,700
2011 Construction Season

Pavement Patching, Resurfacing & Bridge Rehabilitation
$10.4 Million
ADT = 26,700

Rubblization and Resurfacing
$42.3 Million
ADT = 27,300

Bridge Replacement and SPUD Interchange Reconstruction
$23.5 Million
ADT = 36,500

Smart Work Zone utilized on all 3 contracts in 2011
System Evaluation

- Compared 2010 and 2011 Construction Years for 5 projects along I-55
- Only looked at rear-end accidents because that is what system was setup to reduce

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
<th>Difference</th>
<th>% Change</th>
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</thead>
<tbody>
<tr>
<td>Total Miles I-55 Construction</td>
<td>19.5</td>
<td>20.2</td>
<td>+0.7</td>
<td>+3.6%</td>
</tr>
<tr>
<td>Total Lane Closure Days</td>
<td>355</td>
<td>540</td>
<td>+185</td>
<td>+52%</td>
</tr>
<tr>
<td>*Total Vehicle Exposure (ADT x Lane Closure Days)</td>
<td>13,031,750</td>
<td>16,346,800</td>
<td>+3,315,050</td>
<td>+25.4%</td>
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<tr>
<td>Property Damage Accidents</td>
<td>75</td>
<td>64</td>
<td>-11</td>
<td>-14.6%</td>
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<tr>
<td>Injury Accidents</td>
<td>18</td>
<td>16</td>
<td>-2</td>
<td>-11%</td>
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<tr>
<td>Fatalities</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Total Queuing Accidents</td>
<td>94</td>
<td>81</td>
<td>-13</td>
<td>-13.8%</td>
</tr>
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</table>

*Does not account for ADT using Alt Routes
Lessons Learned

• Develop statewide tiered special provisions that will allow for competition between all SWZ systems
• Establish guidelines for utilization of tiered SWZ systems
• Recognize that no system is perfect at this point
• Smart Work Zone costs average 2.5% of our contract costs.
• Smart Work Zones can reduce queuing type accidents
For more information:

Ted Nemsky
Illinois DOT

[email link]
Example #3: Michigan DOT – I-94 and Sargent Road

- I-94 Interchange realignment and construction
- Bridge removal and construction
- MOT required I-94 to be reduced to one lane in each direction for two weeks for bridge removal
- July 2011 – November 2012
Portable Changeable Message Sign (PCMS) and Sensor Locations
I-94 and Sargent Road Lessons Learned

• Have a greater saturation of PCMS (both sides of the road)
• Provide a list of suggested messages for difference scenarios
  – Stopped Traffic, Slowed Traffic, and Free Flow Traffic
• Add additional cameras to make sure that the back-up location can be viewed
• Clearly define the duration of use
  – Only in use for 2 weeks on I-94
• Require email alerts to be sent out based on traffic speeds
• Temporary rumble strips to alert drivers at PCMS locations
• Call out specific pay items so that modifications can be made
  – PCMS boards
  – Sensors
  – Cameras
  – Sensor Adjustment (Stage Changes)
I-94 between US-14 and US-23

- CPM Project
- Full depth concrete patches
- Single course HMA mill and resurface
- Construction of Crash Investigation Sites
- Possible additional work depending on funding
  - Drainage structure repair and ramp repairs at Ann Arbor Saline Road and State Street
PCMS and Sensor Locations
I-94 between US-14 and US-23 – Lessons Learned

• Traffic on US-23 was more of an issue on the first weekend
• System is very easy to set up
• Took less than 2 hours to set up 9 sensors
• Traffic slowed down after reading traffic stopped ahead
• PCMS boards on both sides of roadway are major benefit to the motoring public
I-75 Reconstruction

- Complete reconstruction of 5.6 miles
- Rehabilitation of 2 bridges
- Reconstruction of 4 bridges
- 10 ramp reconstructions
- Geometric upgrades, drainage improvements, ITS equipment, etc.
- Existing – 3 lanes NB and SB
- MOT – 2 lanes NB and SB with barrier wall
Determining Need

- Project location historically had a crash rate of 7.27 per month
- Traffic volumes can be maintained in two lanes with an average delay of 3 minutes
- What happens when there is a crash, special event, or additional construction interference?
- Determined system was needed, even if it wouldn’t be used everyday
What Happened Between Design and Construction? (1 of 2)
What Happened Between Design and Construction? (2 of 2)
I-75 Reconstruction Lessons Learned

• Plan during design/scoping phase of project
  – Sensor spacing
  – Message Plan
  – Optimal Locations
    • Diversion Points
• Make sure staff understand capabilities
  – Message to location
• Option of statewide contract
  – As needed basis
• How to hand down time messages
  – Develop a statewide policy
• Determining of the system was successful
For more information:

Chris Brookes
Michigan DOT
brookesc@michigan.gov

Questions?
Smarter Work Zones

FHWA RESOURCES
SWZ Interactive Toolkit Available!

https://www.workzonesafety.org/swz/main
FHWA Work Zone ITS Implementation Guide

• Provide guidance on implementing ITS in work zones to assist public agencies, design and construction firms, and industry stakeholders

• Presented through a 6-Step Systems Engineering Approach to WZ ITS implementation

Other Resources

• Work Zone ITS Case Studies
  http://www.ops.fhwa.dot.gov/publications/fhwahop14007/

• FHWA Work Zone Mobility and Safety program website
  http://www.ops.fhwa.dot.gov/Wz/its/index.htm

• Work Zone ITS Overview Webinar

• Queue Warning Systems in Work Zones Summary of Uses and Benefits

• Innovative End-of-Queue Warning System Reduces Crashes Up to 45%
Thanks for joining us!

**Upcoming Events**

- **Webinar #5**: Smarter Work Zones – Program-Based Project Coordination
  - Monday, November 2, 2015, 1:00-2:30pm EST
  - Registration: [https://connectdot.connectsolutions.com/e40b51cfk6k/event/event_info.html](https://connectdot.connectsolutions.com/e40b51cfk6k/event/event_info.html)

- **Webinar #6**: Technology Application Case Studies: Variable Speed Limit and Dynamic Lane Merge
  - Thursday November 12, 2015, 1:00-2:30pm EST

- **Regional Peer Exchanges**

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<tr>
<th>FHWA DFS Region</th>
<th>Location</th>
<th>Dates</th>
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<tbody>
<tr>
<td>Mid-America</td>
<td>Des Moines, Iowa</td>
<td>October 22-23</td>
</tr>
<tr>
<td>North</td>
<td>Springfield, Massachusetts</td>
<td>October 28-29</td>
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<tr>
<td>South</td>
<td>Raleigh, North Carolina</td>
<td>November 5-6</td>
</tr>
<tr>
<td>West</td>
<td>Denver, Colorado</td>
<td>November 17-18</td>
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- Check The National Work Zone Safety Information Clearinghouse website for updates [https://www.workzonesafety.org/SWZ/main](https://www.workzonesafety.org/SWZ/main)

- **Questions or Comments?**
  - Jawad Paracha (FHWA Operations, WZ Team) [Jawad.Paracha@dot.gov](mailto:Jawad.Paracha@dot.gov)
For more information from our presenters:

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