



SEQ

**SEQUENTIAL FLASHING WARNING LIGHT SYSTEM**



## What is A.I.I.?

### AASHTO Innovation Initiative (A.I.I.)

#### Dedicated to sharing...

- High payoff,
- Market-ready technologies

#### Accelerating adoption of innovation among...

- Peers in U.S. transportation agencies



Why SEQ?  
Why now?

Due to highway congestion, nighttime work is increasing.

So the goals for SEQ are to:

- ❖ Enhance the nighttime work zone visibility of merging tapers, especially on interstate projects.
- ❖ Increase driver awareness.
- ❖ Reduce speeds toward speed limit compliance.
- ❖ Maximize traffic flow through the merging taper.

## Users say...

The SEQ lights are seen from a greater distance alerting the drivers to merge earlier, which provided a much safer taper area. We had no incidents and several motorists let us know that they really liked the SEQ lights.

--John Elliott, Senior Construction Inspector, MoDOT

# Presentation Agenda

- ▶ Oklahoma DOT piloted in 2010
- ▶ Missouri DOT piloted in 2010-2011
- ▶ Findings of the University of Missouri-Columbia Study
- ▶ Future Use of Sequential Flashing Warning Lights



# Oklahoma DOT



Kristie Drury, P.E.  
Oklahoma Turnpike Authority

2009 MUTCD includes sequential flashing warning lights as an option.



- **Option:** A series of sequential flashing warning lights may be placed on channelizing devices that form a merging taper in order to increase driver detection and recognition of the merging taper.

## 2009 MUTCD includes sequential flashing warning lights as an option.



- ▶ **Standard:** If a series of sequential flashing warning lights is used, the successive flashing of the lights shall occur from the upstream end of the merging taper to the downstream end of the merging taper in order to identify the desired vehicle path.

Each flashing warning light in the sequence shall be flashed at a rate of not less than 55 or more than 75 times per minute.



# Oklahoma DOT

- ▶ Oklahoma's practice is to place SEQ equipment at the taper of the work zone where the workers are present.
- ▶ ODOT finds it important to specify in plans that the sequential lights move as the work zone moves.

# Oklahoma DOT

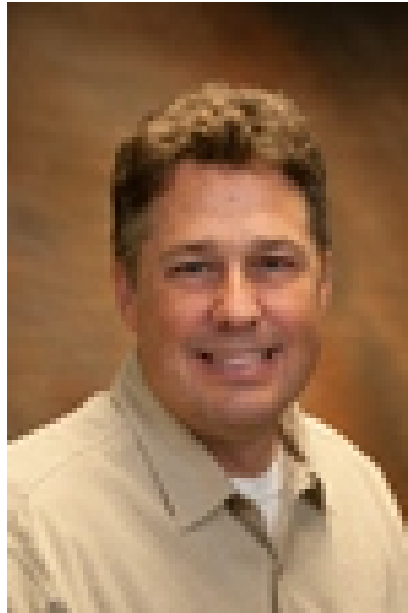
- ▶ **Oklahoma Turnpike Authority** uses 900' taper lengths. One sequential zone involves two sets of sequential lights at that length.
- ▶ **Oklahoma** practice has been to place sequential lights on drums. Some suppliers now want to use them on Direction Indicator Barricade (DIB). This option is being approved.

# Users say...

I feel they are a much better alternative than standard drums with lights. They guide the traffic through the taper even after they pass the first drum...a lot like landing strip lights guiding a plane to the runway.

--Jimmie D. Marshall, Jacobs Engineering Group Inc./Oklahoma

# Missouri MoDOT



Dan Smith, P.E.  
Missouri Department of Transportation

# Missouri DOT

- ▶ MoDOT piloted the sequential lights on I-44 nighttime maintenance project. Twenty sequential lights were used on shoulder and merging taper.
- ▶ MoDOT expanded the pilot program by purchasing a set of 20 SEQ lights for every district.
- ▶ MoDOT initiated a study to evaluate the effectiveness of SEQ.

# Users say...



The SEQ lights immediately got the drivers' attention to move over before fully entering the work space.

--Brady Watson, Senior Construction Technician, MoDOT

# MoDOT I-44 Interstate Video

<http://youtu.be/oD3NtNKV9xY>

# Users say...

The SEQ lights clearly define the merging taper for nighttime work, especially on higher speed roadways.

--Tim Ackert, Senior Construction Inspector, MoDOT



# COST-BENEFIT ANALYSIS OF SEQUENTIAL WARNING LIGHTS IN NIGHTTIME WORK ZONE TAPERS

June 8, 2011

Report to the Smart Work Zone Deployment Initiative



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<http://www.intrans.iastate.edu/smartwz/projects/details.cfm?projectID=88>

# University of MO-Columbia Study

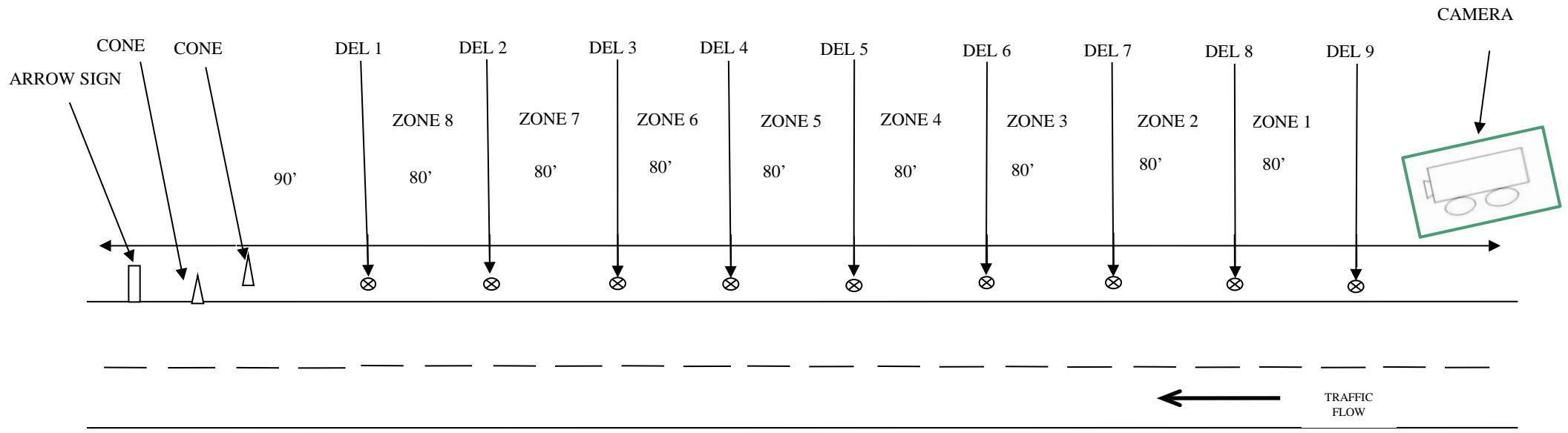
The MU Study included one urban and two rural interstate projects:

- ❖ Rural speed limit decreased from 70 to 60 mph.
- ❖ Urban speed limit remained the same.
- ❖ Video and Radar data were collected.

# University of MO-Columbia Study

Study included one urban and two rural interstate projects:

- ❖ A data collection time of three hours was used (90 minutes with & without lights).
- ❖ Data was collected from a point 730-feet upstream of the taper to the merging taper.
- ❖ The data collection area was divided into 8 zones as shown on next slide.



N ↑  
ALL DELINEATORS ARE SPACED 80 FEET APART.

Findings were reported in the following categories:

- ❖ Total vehicles
- ❖ Passenger cars
- ❖ Trucks
- ❖ Rural work zone
- ❖ Urban work zone

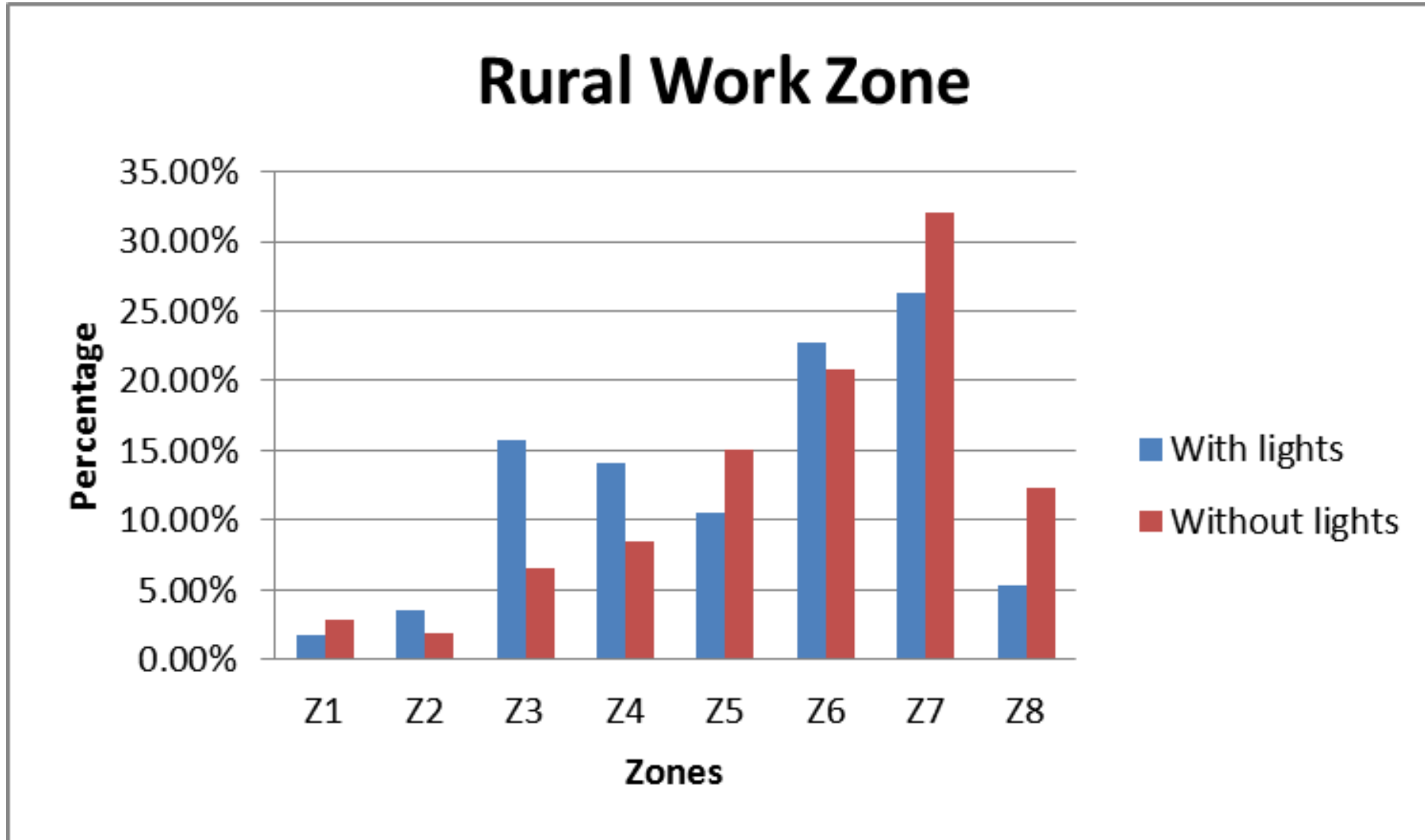
<b>85<sup>th</sup> Percentile Speed &amp; Mean Speed</b>				
	With Lights 85 <sup>th</sup> (mph)	Without Lights 85 <sup>th</sup> (mph)	With Lights Mean (mph)	Without Lights Mean (mph)
Total Vehicles	62	63	55.55	57.76
Passenger Cars	63	64	56.50	58.7
Trucks	60	61	53.80	56.30
Rural Work Zones	63	63	57.65	58.43
Urban Work Zones	60	62	53.09	56.24

Speed Reduction with SEQ Lights

Speed Limit Compliance Rate		
	With Lights (%)	Without Lights (%)
Total Vehicles	78.1	71.4
Passenger Cars	73.1	65.2
Trucks	87.3	80.9
Rural Work Zones	69.0	68.3
Urban Work Zones	88.8	78.4

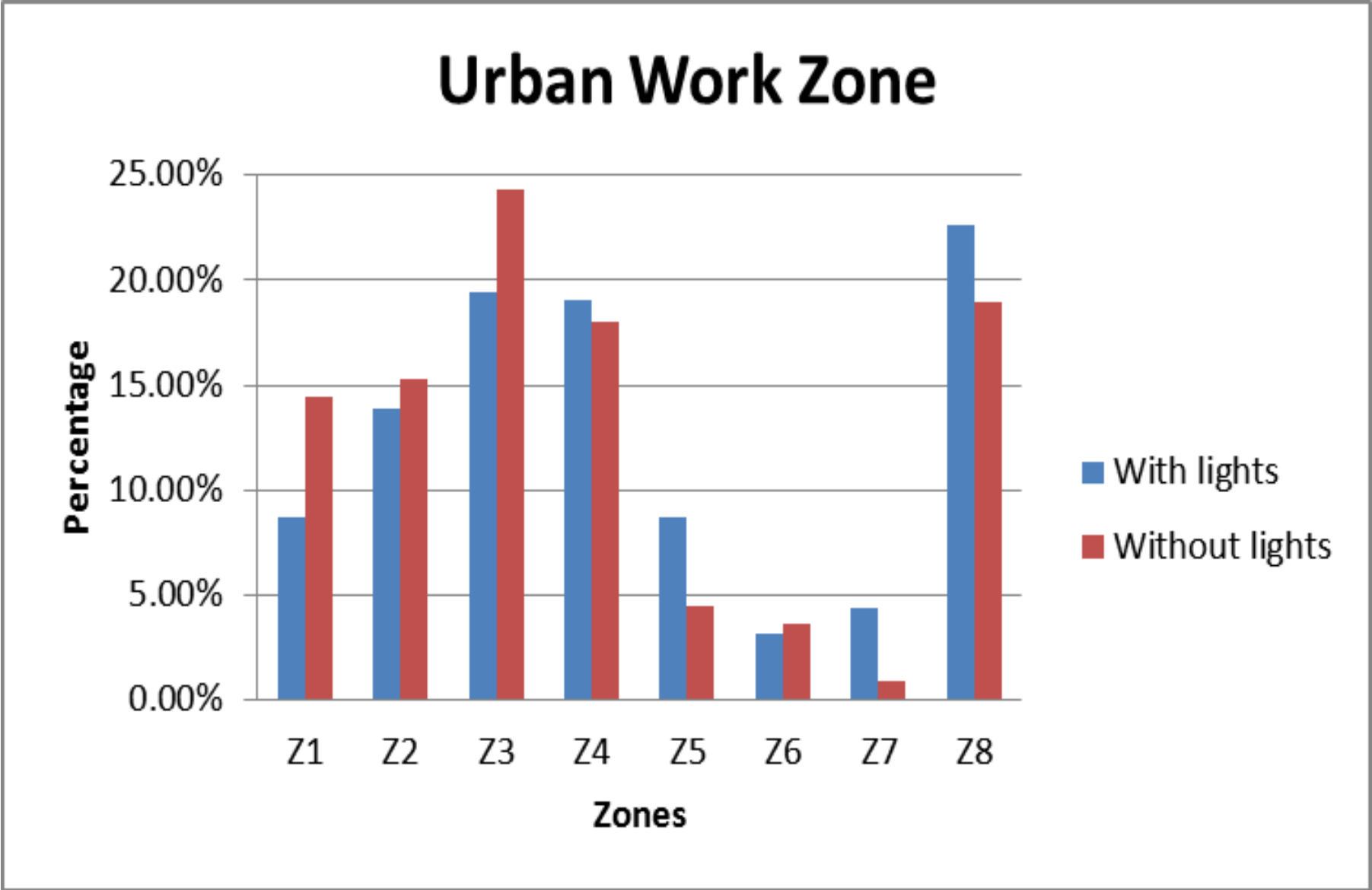
Increased Compliance

# Merging Percentage

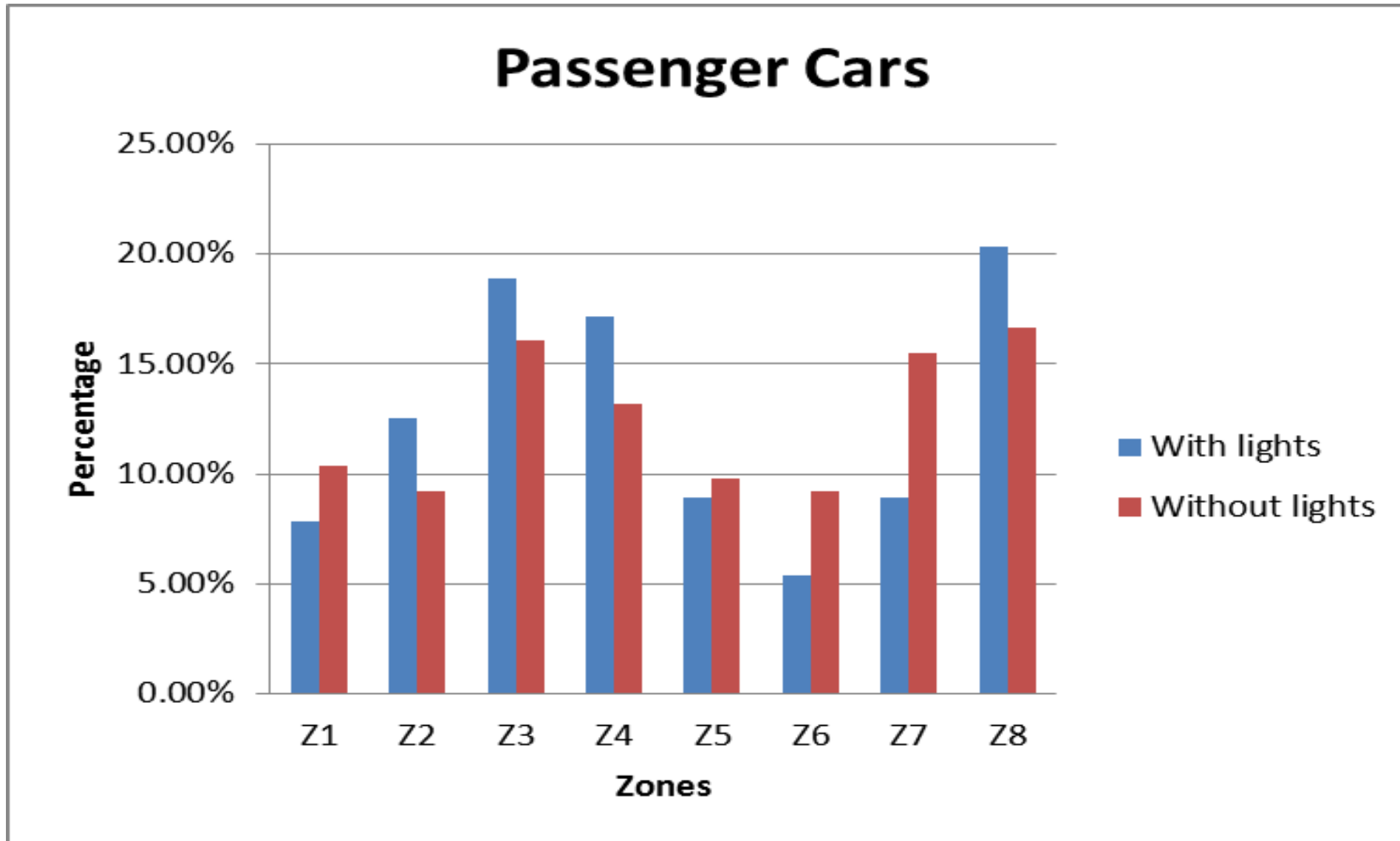




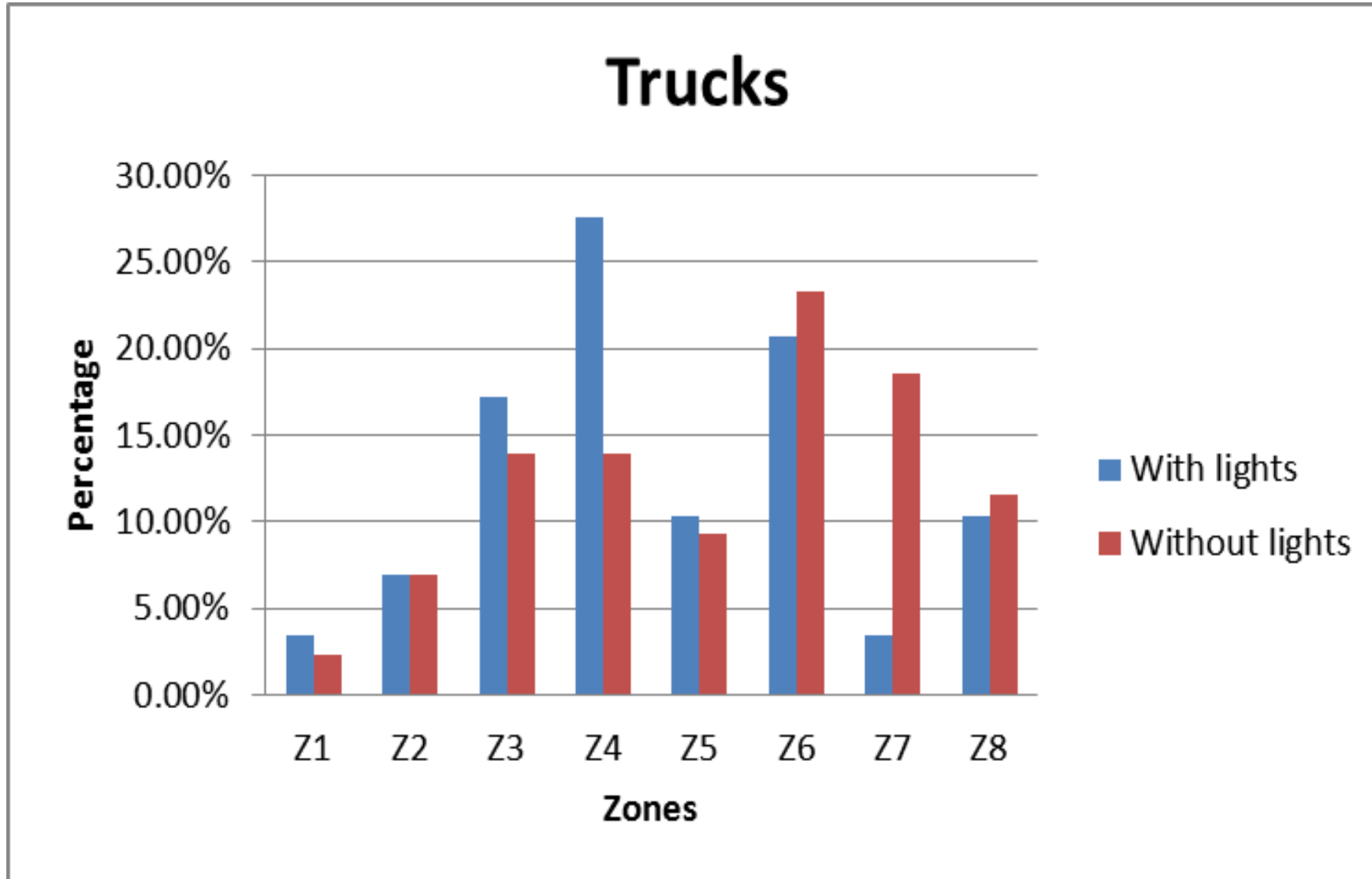
# Merging Percentage



# Merging Percentage

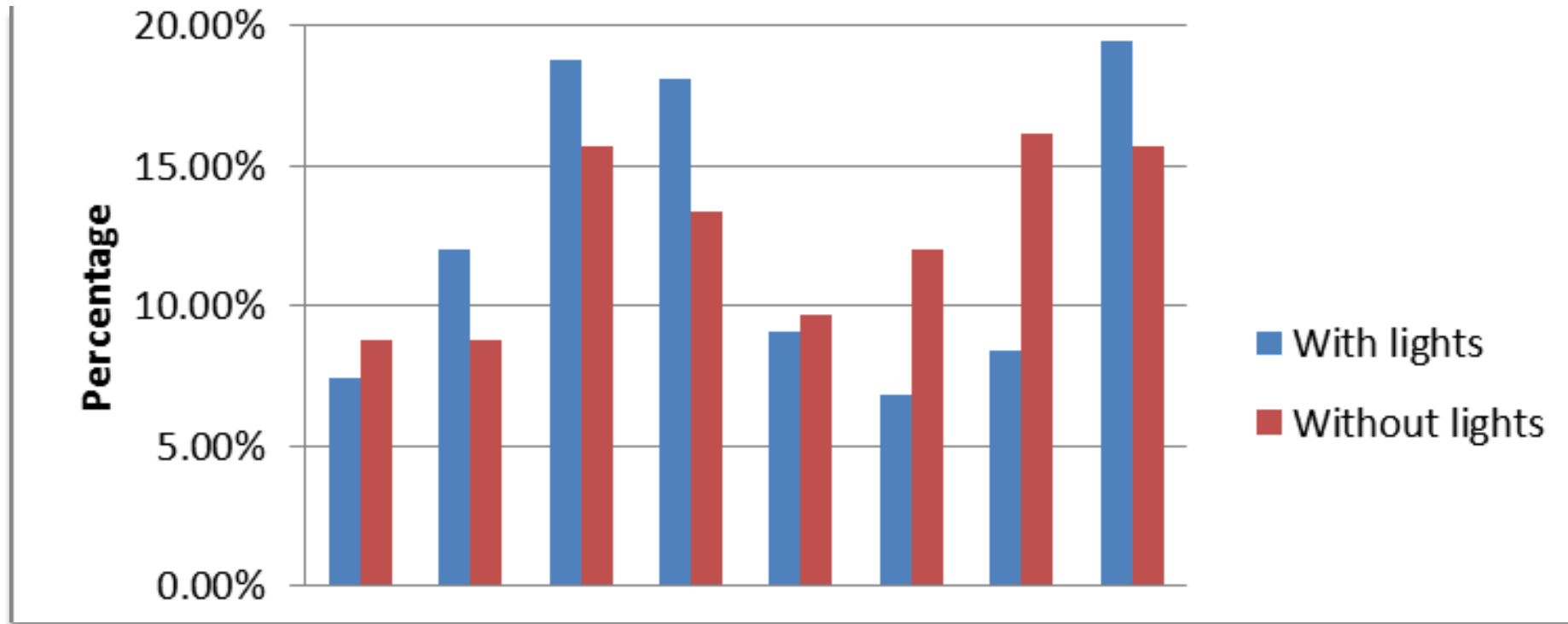


# Merging Percentage



# Merging Percentage

28



Overall Performance

# Benefit/Cost

The following resources were used to calculate benefits:

- ▶ Missouri work zone fatal & injury data for freeways/major highways
- ▶ Nilsson Power Model (quantitative relationship between crashes and speed)
- ▶ Costs of Crashes (User Benefit Analysis for Highways, AASHTO)

# Benefit/Cost

The following costs were used:

- ▶ SEQ light cost per unit (\$104/light)
- ▶ Power cost (batteries)
- ▶ Based on 1,968 nighttime work zones deployed in 2010
  - Number of nights per work zone (average 7.6 nights)
  - Maximum 109 nighttime work zones
- ▶ Labor costs (2 workers, 20 SEQ lights, 30 min. install, 30 min. remove)
  - Scenario 1—install/remove SEQ lights every night
  - Scenario 2—install remove SEQ lights at beginning/end of project

# Benefit/Cost Ratio

Total Benefits: \$3.65 million

Total Cost:

- ❖ Scenario 1--\$705,008
- ❖ Scenario 2--\$341,580

Benefit/Cost Ratio ranged from 5 to 10

## Users say...

Safety is the primary reason I like SEQ lights. The SEQ lights alert drivers about closed lanes better than an arrow board. Drivers tend to get over sooner and not wait until the last minute to merge. Also, the SEQ lights were very rarely hit by traffic, which means less maintenance.

--John Casey, Senior Construction Inspector, MoDOT



# Summary of the Report

- ▶ SEQ lights appear to be an effective tool for improving driver awareness of the work zone merging taper.
- ▶ SEQ lights was shown to be most effective with trucks and rural work zones as compared to passenger cars and urban work zones.
- ▶ Most measures of performance supported this conclusion as speeds were reduced and early merging increased.

# Summary of the Report

- ▶ A small percentage of aggressive drivers caused an increase in speed variability and late merges.
- ▶ No operational or synchronization problems were observed in the lab or in the field.
- ▶ **Benefit/Cost** ratio of the SEQ lights ranged from **5 to 10**, depending on labor costs.

# Users say...



The cost to benefit ratio of the SEQ lights was noteworthy and their continued use is highly encouraged!

--Matt Daulton, Senior Construction Inspector MoDOT

# MoDOT US 60 Video

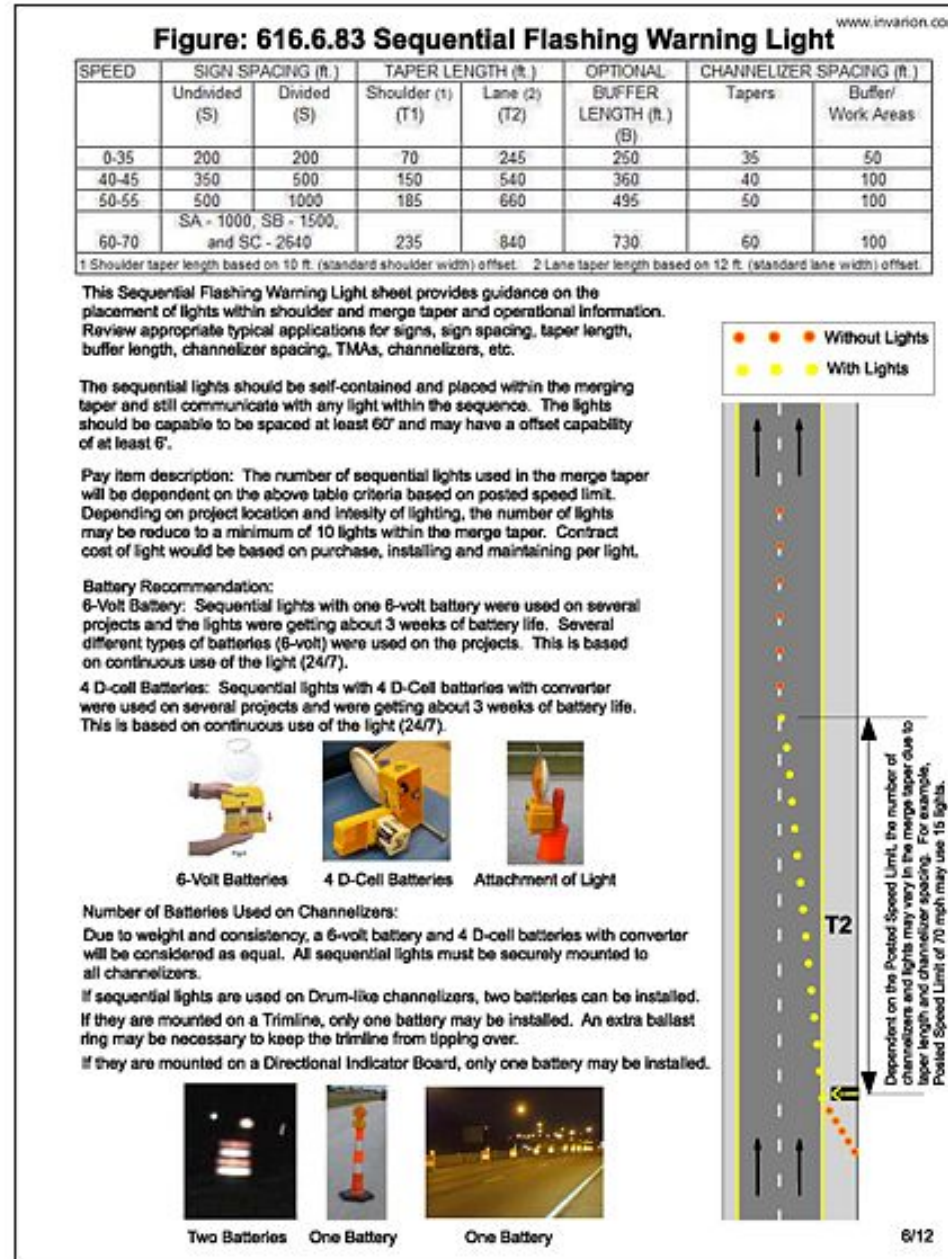
<http://youtu.be/C3LyRxlgpxY>

# Future Use of Sequential Flashing Warning Lights

- ❖ MoDOT has successfully deployed sequential lighting on nighttime interstate construction and maintenance projects.
- ❖ MoDOT has developed a formal policy for the use of SEQ lights on nighttime interstate projects.
- ❖ Oklahoma's future use.

# MoDOT Engineering Policy

[http://epg.modot.org/index.php?title=616.6\\_Temporary\\_Traffic\\_Control\\_Zone\\_Devices\\_%28MUTCD\\_6F%29#Fig.616.6.83\\_Sequential\\_Flashing\\_Warning\\_Light](http://epg.modot.org/index.php?title=616.6_Temporary_Traffic_Control_Zone_Devices_%28MUTCD_6F%29#Fig.616.6.83_Sequential_Flashing_Warning_Light)



## Users say...



The SEQ lights were amazing; we didn't have one incident and we received a number of positive comments from area residents.

--Kevin Schuette, Construction Inspector, MoDOT

# Users say...

Well in advance of the taper, motorists can see the path they need to take to get around the closure. We had ZERO incidents during nighttime bridge work with the SEQ lights.

--Jason Williams, P.E., Transportation Project Manager, MoDOT



# Questions?

[aii.transportation.org](http://aii.transportation.org)

Select Sequential Flashing Warning Lights for Work Zones

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Thank you.