

**Orange Marking
MUTCD Experimentation in Indiana
Project#: SPR-4642**

Joe Bruno and Michael Williamson

March 14, 2023

Overview

- Literature Review
- Orange Striping Sites
- Public Opinion Survey
- Autonomous Vehicles
- Lane Position
- MUTCD and FHWA

Previous or Current Orange Marking Projects

- **Completed**
 - Wisconsin
 - Kentucky
- **Underway**
 - Texas
 - California
 - Michigan



Wisconsin DOT

- Pavement markings tapes
 - Pictured: yellow, white, orange after 3.5 months in field
- Some issues caused by low cost temporary markings
 - Higher quality provides better results



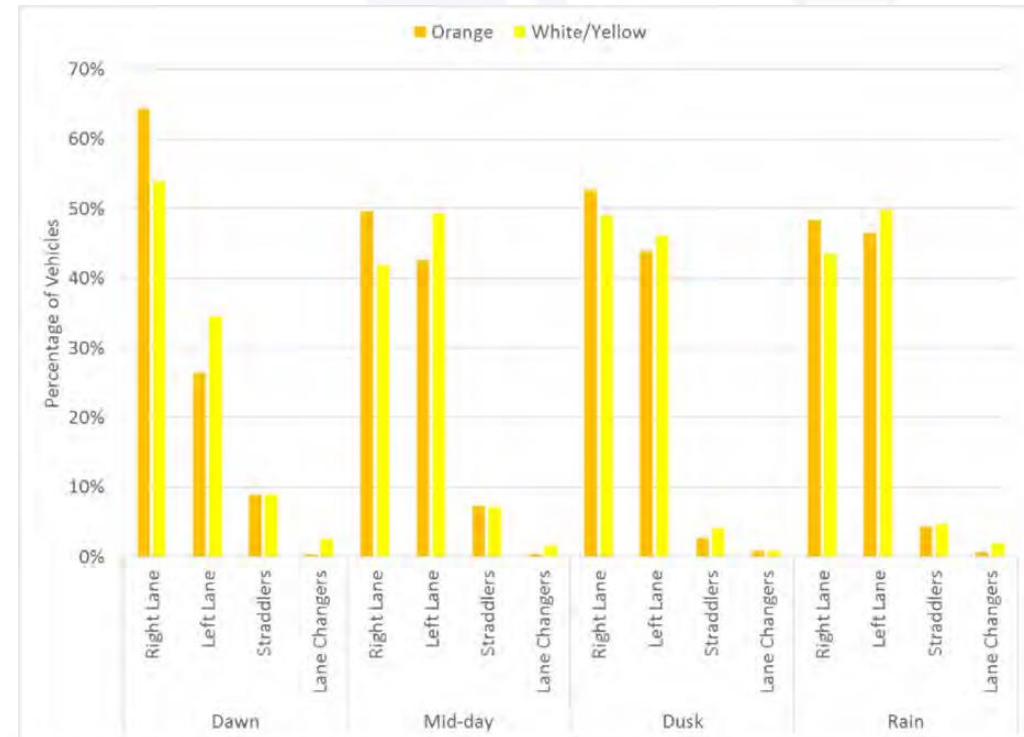
Source: WisDOT

Wisconsin DOT

- Painted pavement markings
 - Several tested
 - Problems with durability
- Retroreflectivity issues
 - Low retroreflectivity at installation
 - Bead retention problems
 - Fade resistance problems
- Lighting issues
 - Sodium bulbs turn orange to yellow at night
 - Changed to LED lighting

Wisconsin DOT

- Vehicle lane distributions for two lane sections
- Evaluated video one hour recordings
 - Time periods
 - Dawn, mid-day (base), dusk, and rain
 - Right lane
 - Left lane
 - Straddler
 - Lane changers



Source: WisDOT

Wisconsin Findings

- Speed Effect
 - Spot speeds
 - 2 mph increase with orange markings
- Survey on public opinion
 - Daytime
 - Orange
 - Nighttime
 - White (better retroreflectivity)
 - Rain
 - White (better visibility)

Kentucky DOT

- Materials tested
 - Waterborne paint
 - Spray thermoplastic
 - High-build paint
 - Various bead packages

Kentucky DOT

- Waterborne paint (15 mil thickness)
 - Poor retroreflectivity
 - Range: 51 and 132 mcd/lx/m²
 - Did not hold beads
 - Wore off within 100 days

- Spray Thermoplastic (60 to 75 mils)
 - Larger bead package
 - Brighter than 15 mils paint
 - Did not meet retroreflectivity thresholds
 - 136 mcd/lx/m² (Shortly after installation)
 - 80 mcd/lx/m² (75-100 days old)
 - 75 mcd/lx/m² (300-375 days old)

Kentucky DOT

- Waterborne paints (30 mils)
 - Higher bead package
 - Brighter at night
 - Highest levels of retroreflectivity
 - 40 days old: 220 mcd/lx/m²
 - 100 days old: 179 mcd/lx/m²
 - 160 days old: 209 mcd/lx/m²

Kentucky DOT

- Speed effect
 - Before/After with one year of data
 - Daytime
 - 0.5 mph average increase with orange markings
 - Nighttime
 - 1 mph average increase with orange markings
 - Overall average speeds 65.8 mph in 55 mph workzone

Kentucky DOT

- Public Opinion Survey
 - Online survey available on DOT website
 - Open for 50 days
 - 233 responses
 - Drivers preferred orange markings in both daytime and nighttime
- Survey comments
 - Positive
 - More aware of workzones
 - Easier to see
 - Negative
 - Hard to see in wet and nighttime conditions
 - Markings were confusing

INDOT/JTRP Research

- Build on past studies
 - Wisconsin
 - Kentucky
- Test new produces and configurations
 - Seeking improved results
- Seek public opinion
 - Ensure acceptance

Study Sites

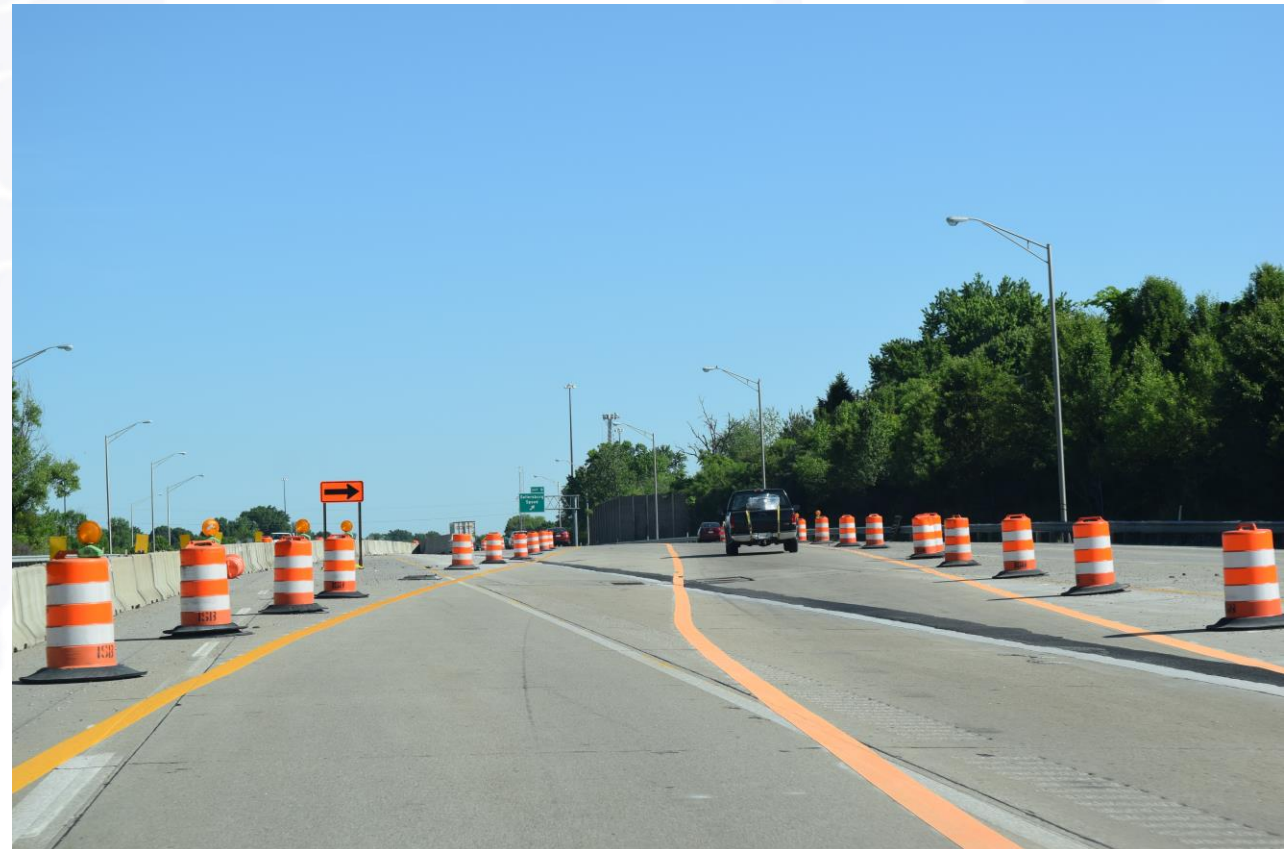
- Sellersburg, Indiana
 - I-65 near Exit 7
- Roseland, Indiana
 - I-80/90 (Indiana Toll Road) near Exit 77
- Lebanon, Indiana
 - I-65 near US 52 Exit

Sellersburg Visual Inspection

Driver view approaching workzone



Driver view in workzone



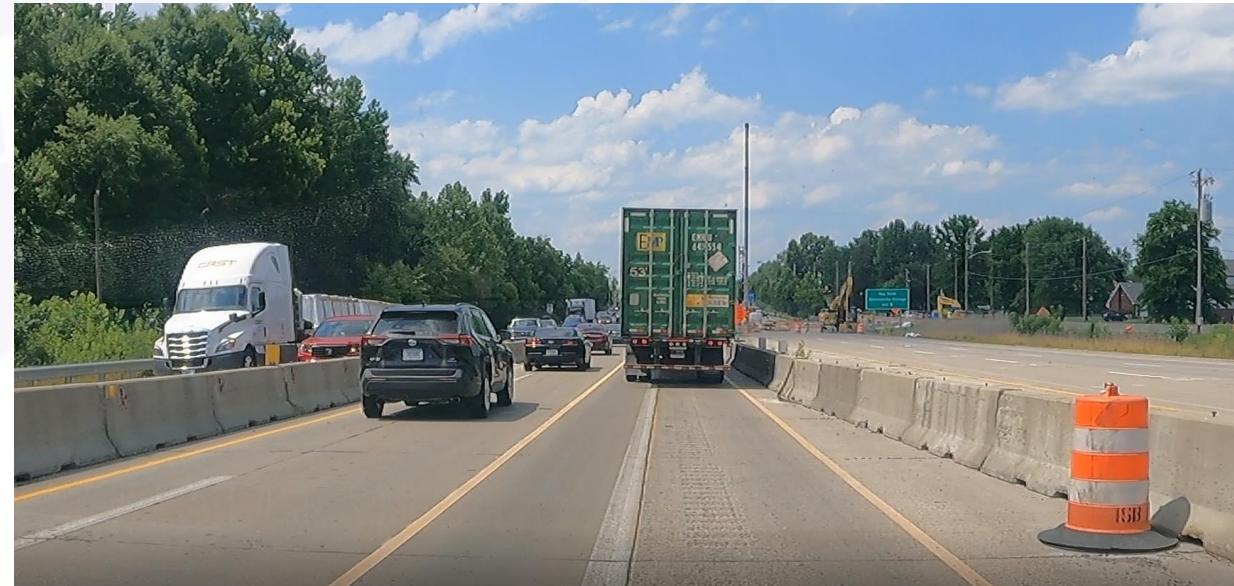
Sellersburg Visual Inspection

- Orange tape faded
- Still noticeably different

Approximately one month in field



Approximately two months in field



Sellersburg Visual Inspection

- Transition point between two months and two week old tape



Sellersburg Visual Inspection

- Driver view at night no lighting in area
 - 2 weeks in field
 - Strip appears off-white
 - 2 months in field
 - Strip appears white

Driver view 2 weeks in field



Driver view 2 months in field



Lebanon Visual Inspection

- Driver view daytime
 - Orange paint
 - Orange bead package
 - Complements other striping
- Driver view at night
 - Orange in color
 - Very visible



Lebanon Safety Benefit I-65 and US 52

- Before



- After



Lebanon Safety Benefit

- Before Crashes
 - 3 crashes
- After Crashes
 - None-reported



Orange Striping Recommendations

- Paints
 - Paint with orange bead package best option
- Tapes
 - Tape acceptable for short term use
 - Improvements to tape are needed



Public Opinion Survey

- Past surveys on orange markings
vs
- Indiana survey



Web-based Surveys

- Pros

- Convenience
- Accessibility
- Respondent privacy
- Saves time

- Cons

- No personal connection
- Chance of survey fraud
- Sampling issues
- Response bias
- Unanswered questions

Design of Wisconsin DOT public opinion surveys

- Pros:

- Short to prevent Survey Fatigue
- Survey sent via email
- Emails obtained from lists:
 - Drivers who signed up for electronic newsletters about the project
 - Employees at the Milwaukee Regional Medical Center near project

- Cons:

- Survey can be completed by those who did not drive through

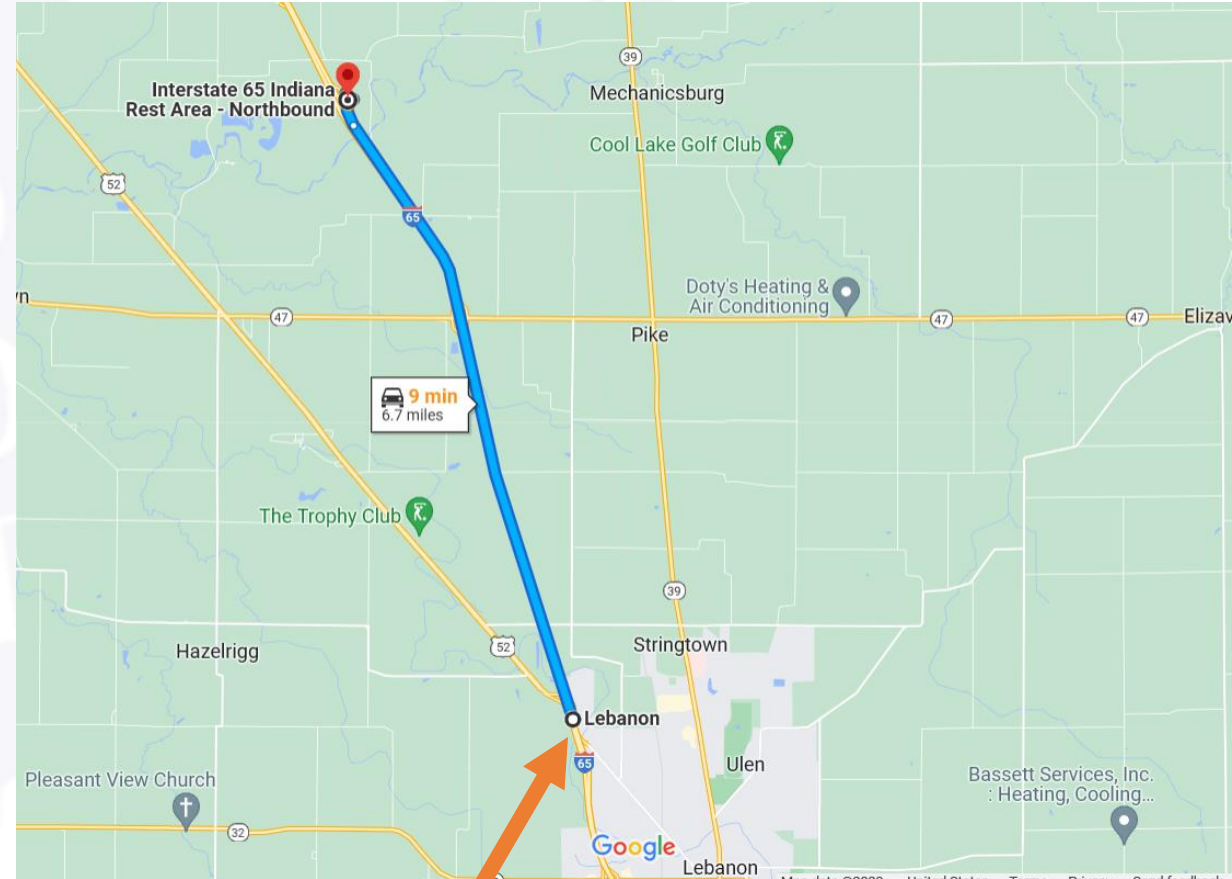
Results of Wisconsin DOT public opinion surveys

Survey 1	Survey 2
<p>Did the orange markings increase your awareness of being in a work zone?</p> <p>Yes: 51%</p> <p>No: 49%</p>	<p>Did the fluorescent orange markings increase your awareness of being in a work zone?</p> <p>Yes: 80%</p> <p>No: 20%</p>
<p>Did the orange markings seem more visible than the white pavement markings?</p> <p>Yes: 56%</p> <p>No: 44%</p>	<p>Do you feel the fluorescent orange is more visible than the white?</p> <p>Yes: 83%</p> <p>No: 17%</p>
<p>What is your opinion of the orange markings?</p> <p>Excellent: 12%</p> <p>Very Good: 16%</p> <p>Good: 15%</p> <p>Needs some improvement: 30%</p> <p>Needs a lot of improvement: 27%</p>	<p>Did the fluorescent orange help you drive safely through the work zone?</p> <p>Excellent: 16%</p> <p>Very Good: 33%</p> <p>Good: 25%</p> <p>Needs some improvement: 18%</p> <p>Needs a lot of improvement: 5%</p> <p>I didn't notice: 3%</p>
	<p>Which color would you prefer to be used in a construction zone?</p> <p>Fluorescent Orange: 80%</p> <p>Orange: 5%</p> <p>White: 15%</p>

Source: (Shaw, et al., 2018)

Survey Approach

- Site Lebanon, Indiana
- Northbound rest area I-65
- Approximately 6.7 miles
- Web-based
- Short and to the point
 - Six questions
 - Identify public opinion
- Flyers placed in rest area
 - Doors
 - Vending area



Work Zone

Survey Flyer



ACTIVELY LOOKING FOR YOUR FEEDBACK ON ORANGE STRIPING IN WORK ZONES

Provide your valuable input

- Scan the QR code with your phone to participate.
- The survey is anonymous.
- No personal data will be retained or used.
- The survey will take approximately 2 minutes.



Help us improve the safety of our roadways!

Survey Results

- Open for 4 weeks
- 6 questions
- 53 responses

The screenshot shows the XM survey editor interface for a survey titled "Orange Pavement Markings". The interface is divided into a left sidebar for editing and a main content area for the survey questions.

Left Sidebar (Editing Options):

- Edit question**
- Question type:** Multiple choice (selected)
- Answer type:** Allow one answer (selected), Allow multiple answers
- Choices:** Number of choices: 2 (with minus and plus buttons), Use suggested choices:
- Format:** List (selected), Alignment: Vertical (selected)

Main Content Area:

- Tools dropdown, Saved Nov 2, 2022 at 9:27 AM, Published status.
- Search, Preview, and Publish buttons.
- ExpertReview score: Great (with a lightbulb icon).
- Default Question Block containing:
 - Start button (checkbox).
 - Skip to button (with a purple icon) and a condition: "End of Survey if No Is Selected".
 - Text content:

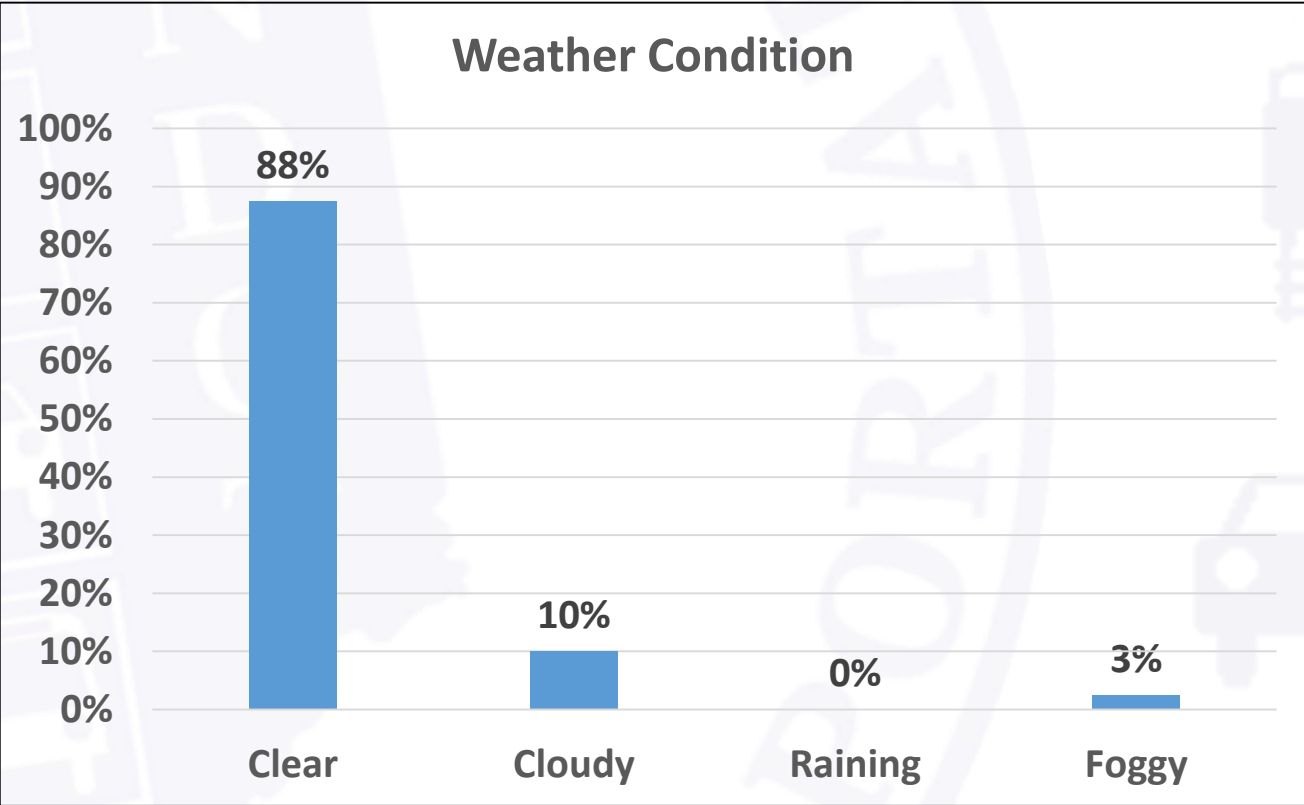
You are being invited to participate in a research study. This study aims to find out public opinion on orange striping in work zones. The way you can help me answer the question is by answering the questions in this anonymous survey, which should take you about two minutes.

Some reasons you might want to participate in this research are provide valuable information to engineers for safer design of work zones. Some reasons you might not want to participate in this research are very slight risk of a breach of confidentiality.

The choice to participate or not is yours; participation is entirely voluntary. You also can choose to answer or not answer any question you like, and to exit the survey if you wish to stop participating. No one will know whether you participated or not. Participants

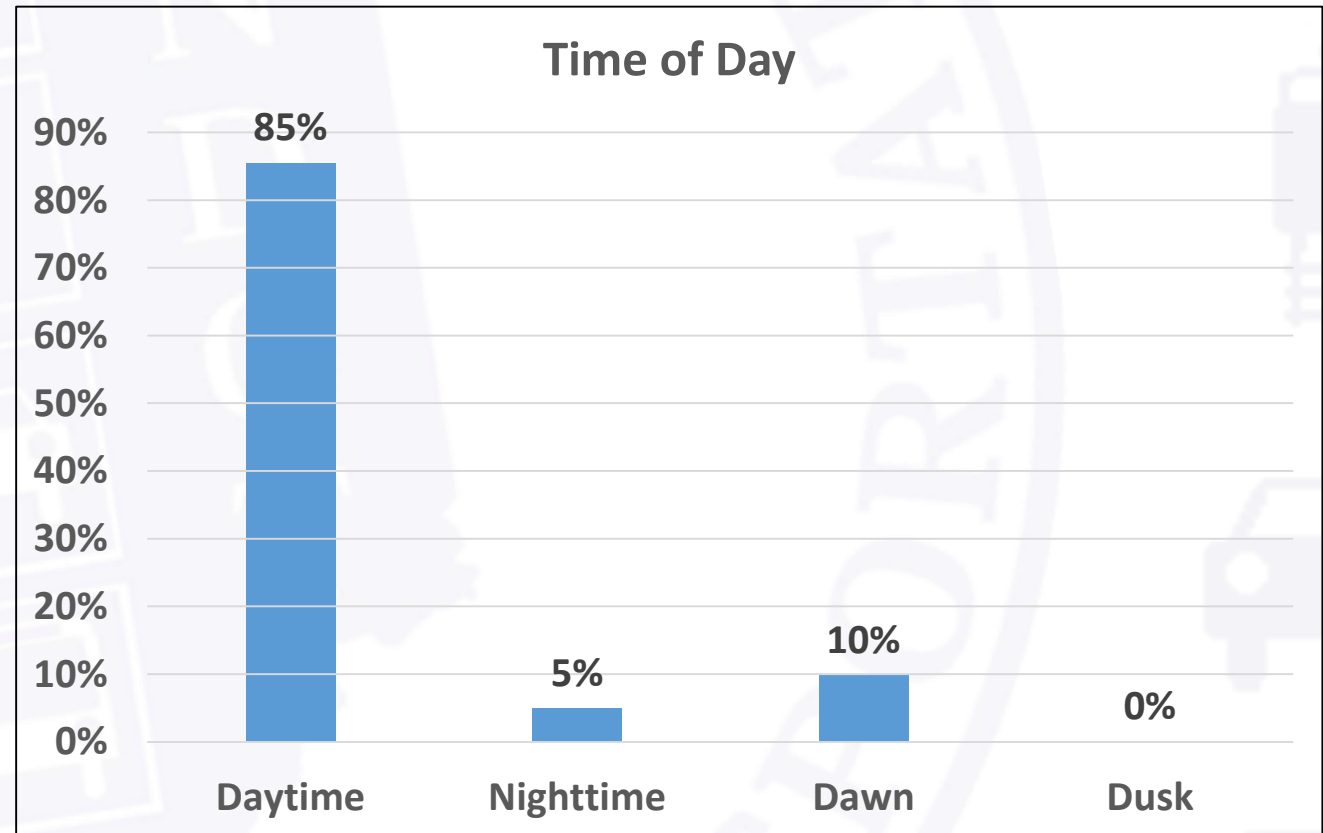
What was the weather condition when you drove through the work zone ?

Weather Condition	Count
Clear	87.50%
Cloudy	10.00%
Raining	0.00%
Foggy	2.50%



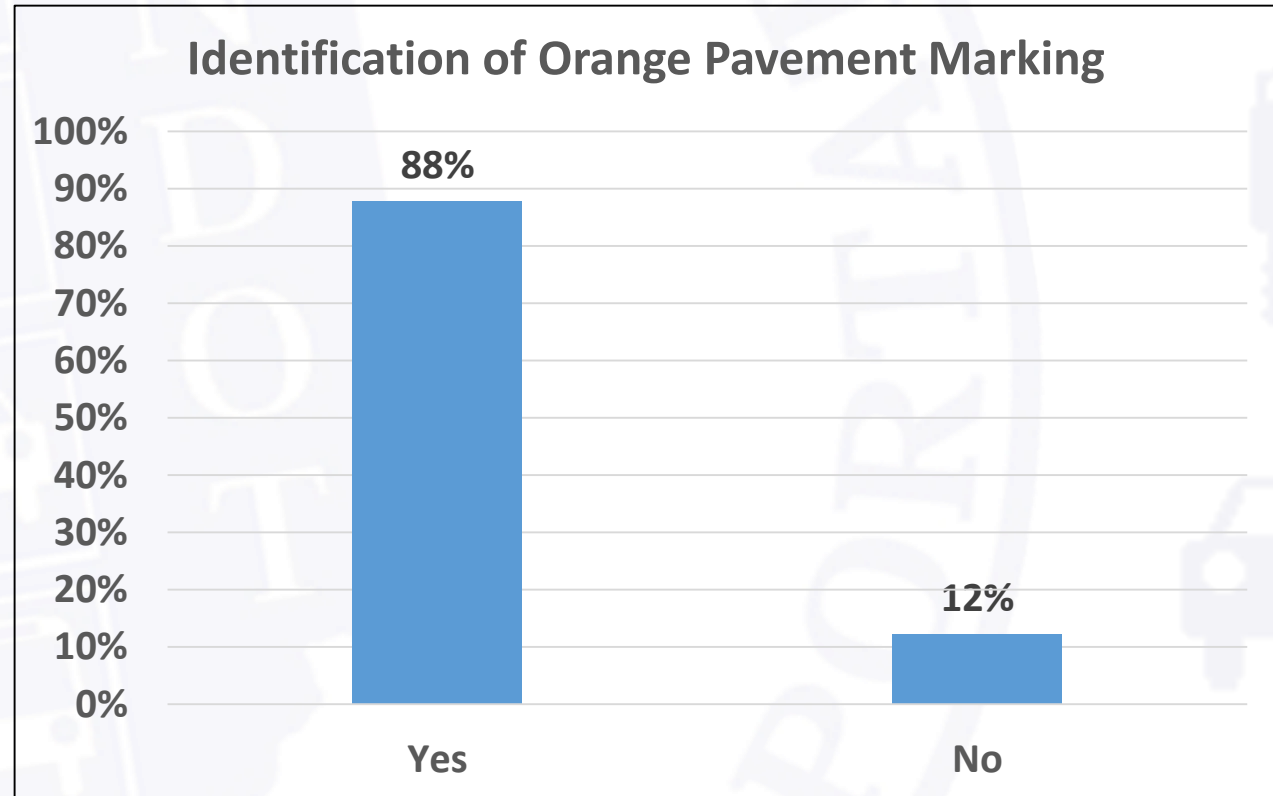
What time of day did you drive through the work zone?

Time Zone	Count
Daytime	85.37%
Night-time	4.88%
Dawn	9.76%
Dusk	0.00%



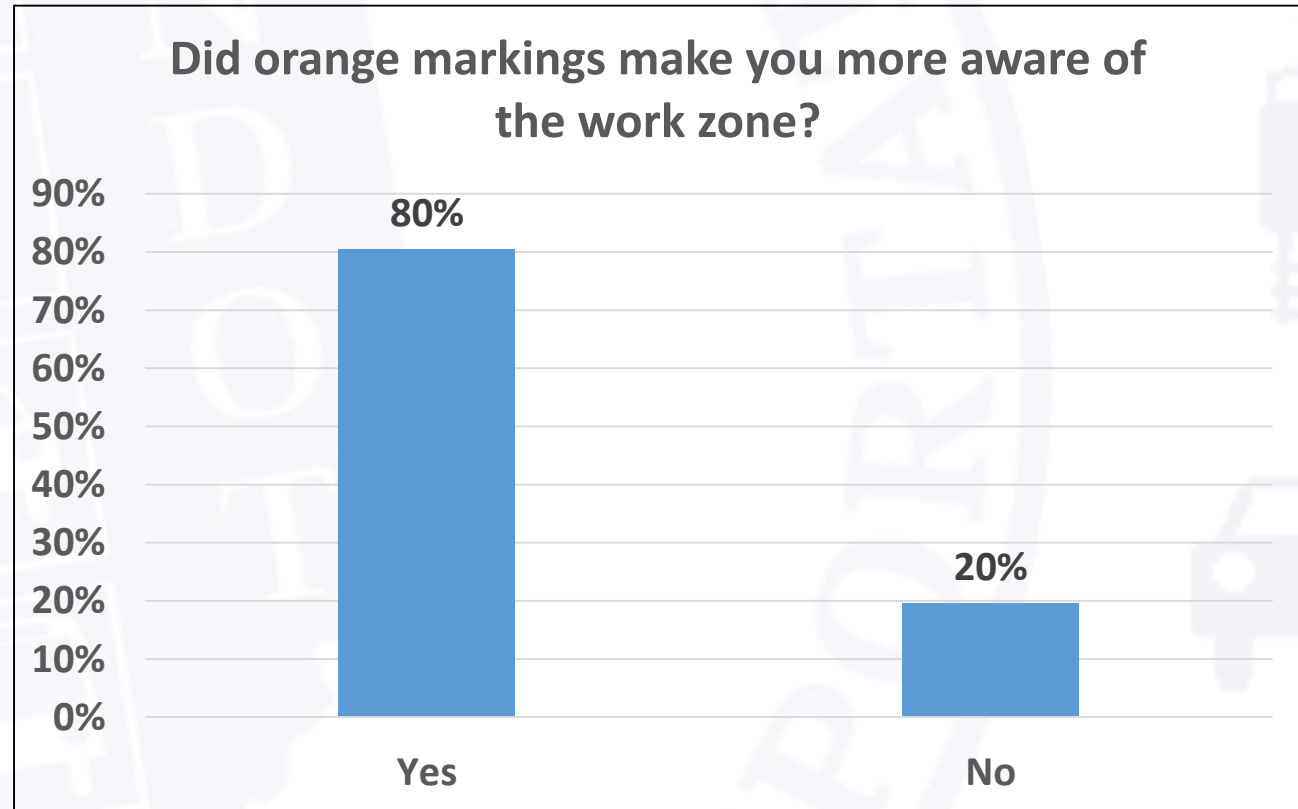
Did you notice the orange pavement markings in the work zone?

Notice Orange	Count
Yes	87.80%
No	12.20%



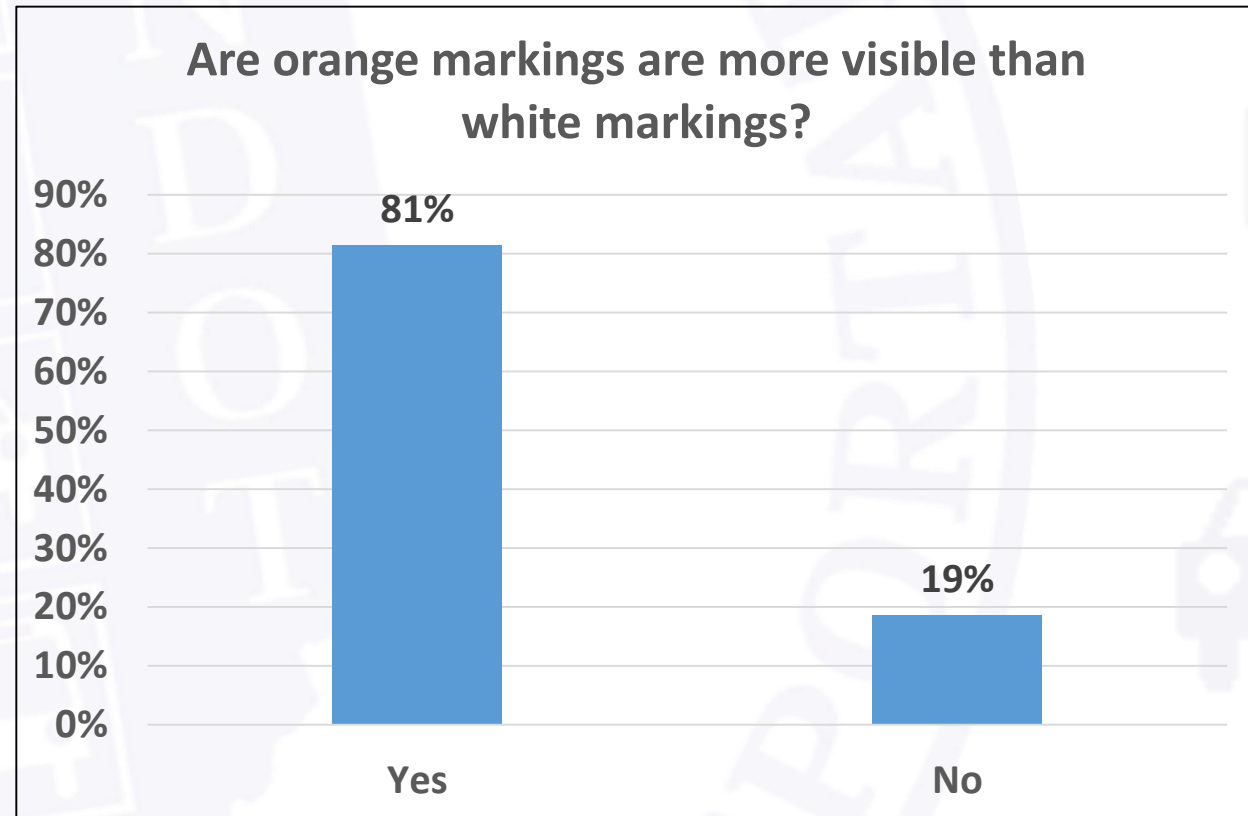
Did the orange markings make you more aware of the work zone?

more aware of the work zone	Count
Yes	80.49%
No	19.51%



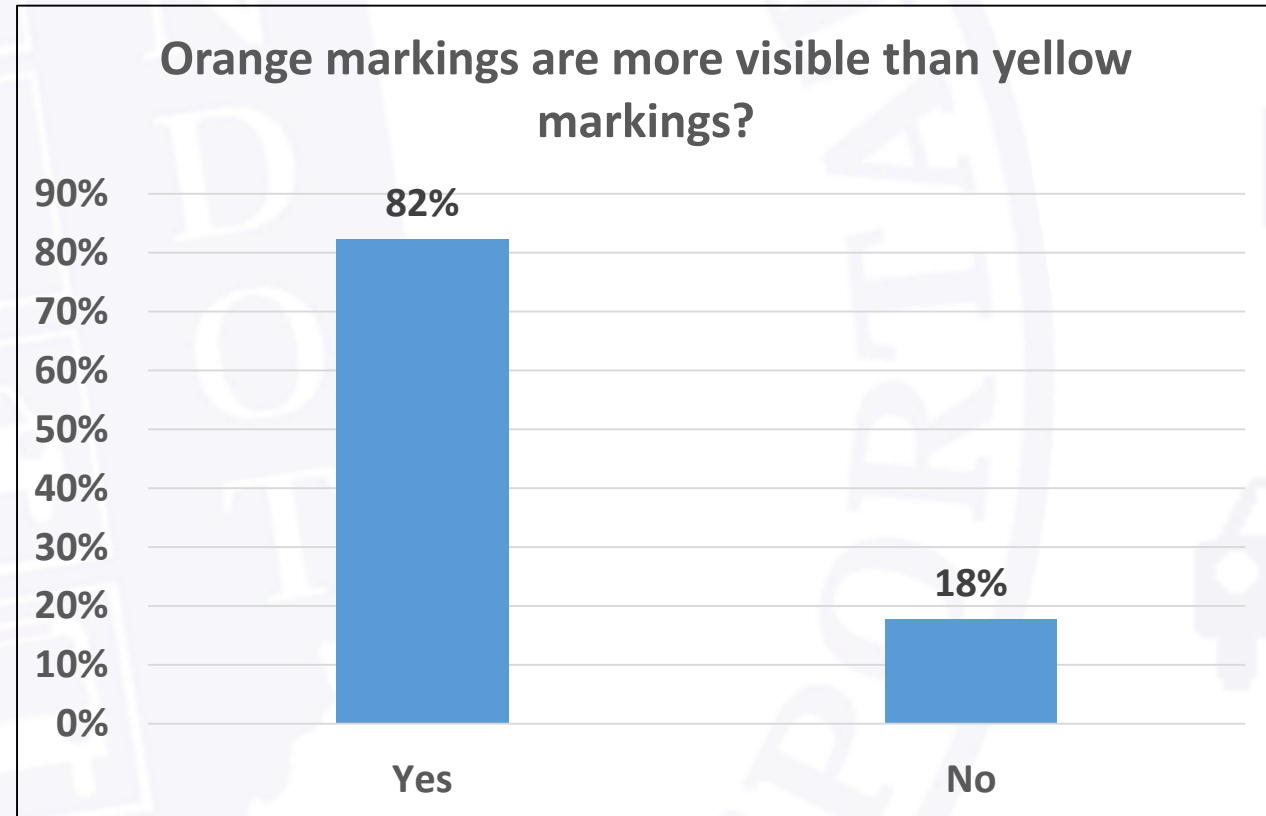
Do you feel orange markings are more visible than white markings?

more visible than white markings	Count
Yes	81.40%
No	18.60%



Do you feel orange markings are more visible than yellow markings?

more visible than yellow markings	Count
Yes	82.22%
No	17.78%



Key Survey Outcomes

- Good public acceptance
- Public more aware of workzone
- Increased visibility of striping



Orange Pavement Marking Detection

- Lane Detection System Testing
 - Concern about orange strip detection
 - 4 major brands
 - Tested commercially available cars



Orange Pavement Markings

- Examples of Striping



Orange Pavement Markings

- Examples of Ghost Striping



Ghost Striping

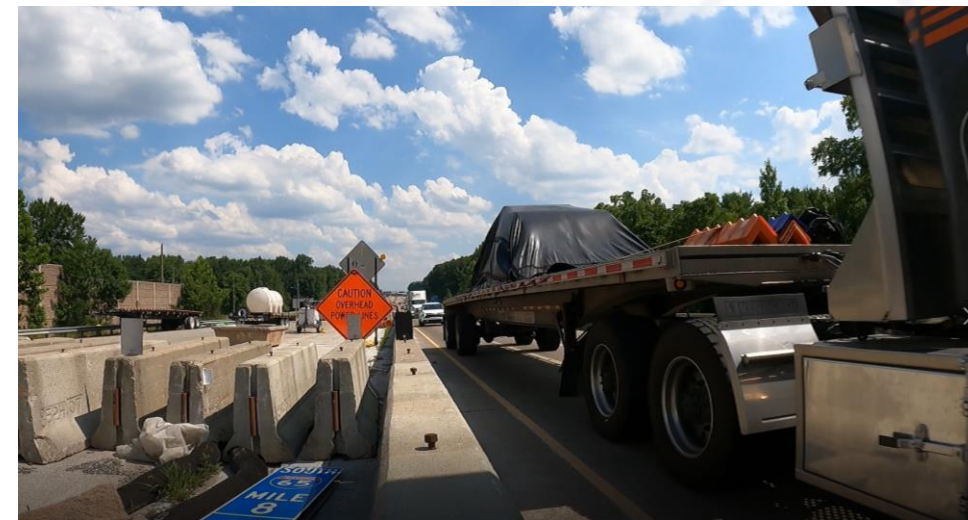
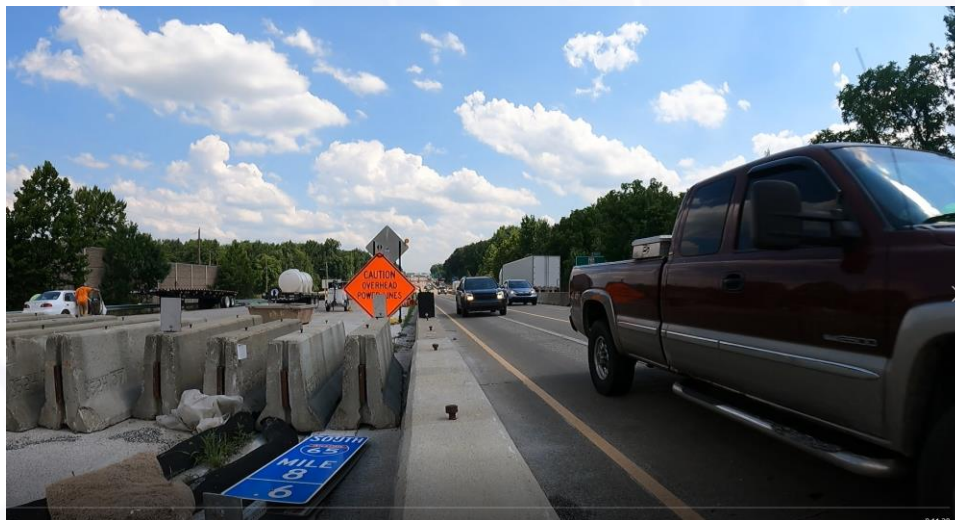
Orange Pavement Markings

- Lane Detection System Testing Results

Strip Tested	Detection	
	Rate	Description
Yellow	100%	Detection at line
White	100%	Detection at line on good striping, delay detection on worn striping
Orange	100%	Detection at line
Ghost Markings	0%	No detection even when grooving had remnants of striping

Lane Choice and Position

- Video recording of lane position
- Analyzed each video



Sellersburg Lane Choice and Position

- Video recording straight section
- During evening peak hours
- Observational method
- Identify lane choice
 - Left vs right
- Identified lane positions
 - Left
 - Center
 - Right



Sellersburg Lane Choice

PM Peak Hours (approx. 2 hours)	
Lane Choice	Sellersburg
Left	55.51%
Right	44.46%
Straddlers	0.00%
Lane Changers	0.03%



Sellersburg Lane Position

Summary of Report

Video Set	Left lane of Highway			Right lane of Highway		
	Left	Center	Right	Left	Center	Right
Set - 1	21%	57%	22%	42%	40%	18%
Set - 2	28%	55%	17%	34%	50%	16%
Set - 3	27%	51%	22%	30%	53%	17%
Set - 4	29%	51%	20%	40%	43%	17%
Set - 5	35%	47%	18%	29%	50%	21%
Set - 6	26%	50%	25%	25%	52%	23%
Set - 7	24%	46%	30%	29%	53%	18%
Average	27%	51%	22%	33%	49%	19%



Lebanon Lane Choice and Position

- Video at gore
- Crash history at gore
- During evening peak hours
- Observational method
- Identify lane choice
 - Left vs right
- Identified lane positions
 - Left
 - Center
 - Right



Lebanon Lane Choice

PM Peak Hours (approx. 2 hours)	
Lane Choice	Lebanon
Left	64.38%
Right	35.40%
Straddlers	0.00%
Lane Changers	0.23%



Lebanon Lane Position

Summary of Report

Video Set	Left lane of Highway			Right lane of Highway			Exit Lane of Highway		
	Left	Center	Right	Left	Center	Right	Left	Center	Right
Set - 1	23%	39%	39%	60%	32%	7%	3%	26%	71%
Set - 2	23%	40%	36%	52%	38%	10%	2%	21%	77%
Set - 3	32%	36%	32%	62%	32%	6%	8%	29%	64%
Set - 4	28%	45%	27%	61%	33%	6%	11%	26%	63%
Set - 5	27%	46%	28%	73%	24%	3%	2%	21%	77%
Average	27%	41%	32%	62%	32%	6%	5%	25%	70%



Base Segments Average

Summary of Report

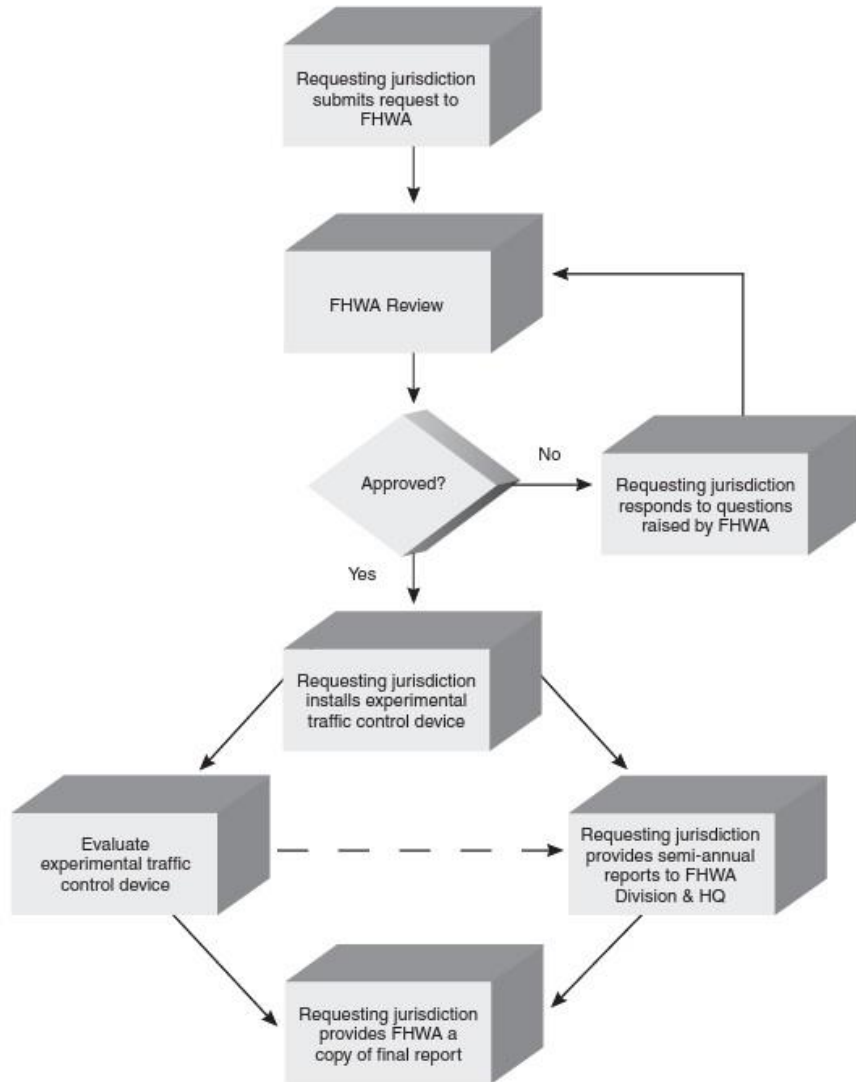
	Left lane of Highway			Right lane of Highway			Exit Lane of Highway		
	Left	Center	Right	Left	Center	Right	Left	Center	Right
Sellersburg	27%	51%	22%	33%	49%	19%	-	-	-
Lebanon	27%	41%	32%	62%	32%	6%	5%	25%	70%
Base Section	74%	24%	2%	23%	59%	18%	-	-	-

Next Steps

- Evaluate additional locations
- Analyze speed effect
- Evaluate crash reduction effect

MUTCD Experimentation (§1A.10)

Figure 1A-1. Process for Requesting and Conducting Experimentations for New Traffic Control Devices



- A request for permission to experiment includes:
 - ✓ A problem statement
 - ✓ A description of the proposed traffic control device or change
 - ✓ Legally binding statement not to patent or copyright device
 - ✓ Time period and location(s)
 - ✓ Research plan
 - ✓ Agreement to restore site after 90 days notice
 - ✓ An agreement to provide semi-annual progress reports

INDOT's Initial Experimentation Request



Kentucky Transportation Cabinet



North Texas Tollway Authority

- Based on existing research in other states
- Sent on 10/19/2021
- Orange would have replaced both white and yellow in test section
- Did not require removal of conflicting markings

Appendix A – Orange Marking USP for B-42018

SEYMOUR DISTRICT

ADDED 12/01/2021
Contract No. B -42018

ORANGE TEMPORARY PAVEMENT MARKINGS

The Standard Specifications are revised as follows:

SECTION 801, BEGIN LINE 568, INSERT AS FOLLOWS:

801.12 Temporary Pavement Marking

Temporary pavement markings shall be new materials placed in accordance with 808.04 and 808.05, *except that orange shall be used as the color for the temporary pavement markings for southbound I-65 traffic and orange temporary traffic paint shall be applied with a wet film thickness of 25 mils to 30 mils using a single bead drop with a rate of 8 to 10 lbs/gal of traffic paint.* However, when temporary markings are to be in place for 10 work days or less the dashed line pattern used on center line and lane lines may be 4 ft line segments on 40 ft centers and gore areas shall be marked by outline only and may be 5 in. wide lines. No-passing zones on all undivided two-way roadways shall be identified with signs and centerline markings. Markings shall remain clearly visible during the day and night for a minimum of 200 ft ahead of a vehicle. All temporary markings shall be maintained and replaced until they are no longer applicable.

The orange temporary pavement markings for southbound I-65 traffic shall be selected from the following manufacturers:

Paint

*Ennis-Flint, Greensboro, NC for waterborne traffic paint
Potters Industries, Malvern, PA for VisiMax WZ Orange beads*

Approved Equal

Temporary Pavement Marking Tape, Type I

Brite-Line, Denver, CO

Approved Equal

The Standard Specifications are revised as follows:

SECTION 921, BEGIN LINE 105, INSERT AS FOLLOWS:

(e) Pavement Marking Beads

A type C certification in accordance with 916 shall be provided for the pavement marking beads. *The remainder of this subsection applies to the beads for white and yellow pavement markings and does not apply to the beads for orange temporary pavement markings.*

- For location on I-65 from Exit 7 to 9 in 2022 (B-42018).
- Temporary orange markings will be used to replace the existing right edge line and lane (skip) line.
- Intent was for both removable tape and waterborne traffic paint to be used.
- Contractor elected to use just orange removable tape.

Feedback from FHWA



- Don't use orange to replace both white and yellow markings
- More detail needed on data collection
- Specify process for requesting additional locations

Approved INDOT Experimentation Request



U.S. Department
of Transportation
**Federal Highway
Administration**

1200 New Jersey Avenue, SE
Washington, D.C. 20590

May 2, 2022

In Reply Refer to:
HOTO-1

Daniel P. McCoy
Director, Traffic Engineering Division
Indiana Department of Transportation
100 North Senate Avenue
Room N758-TE
Indianapolis, Indiana 46204

Dear Mr. McCoy:

Thank you for your request to experiment with orange temporary pavement markings in work zones. Your request has been approved.

We look forward to receiving the semi-annual progress reports and your final evaluation report at the end of the study period in accordance with Item I of Paragraph 11 in Section 1A.10 of the 2009 *Manual on Uniform Traffic Control Devices for Streets and Highways*. Please submit the progress reports throughout the course of the experiment in accordance with the following schedule: August 1, for the preceding period of January through June; February 1, for the preceding period of July through December.

For recordkeeping purposes, we have assigned the following Official Ruling number and title: "6(09)-65 (E) - Temporary Orange Pavement Markings - Indiana DOT." Please refer to this number and title in future correspondence.

Thank you for your interest in improving work zone safety and operations in temporary traffic control zones. Please contact Mr. Eric Ferron at eric.ferron@dot.gov if you have any further questions concerning this matter.

Sincerely,

MARK RICHARD
KEHRLI

Mark R. Kehrl
Director, Office of Transportation
Operations

Digitally signed by
MARK RICHARD KEHRLI
Date: 2022.05.02
08:56:35 -04'00'

- Amended Request Sent on 3/30/2022
- FHWA Approval Received on 5/2/2022
- Leave Plenty of Time for Review

NextLevel
INDIANA

First Semi-Annual Progress Report

SEMI-ANNUAL PROGRESS REPORT No. 1
6(09)-65 (E) – Temporary Orange Pavement Markings - Indiana
January – June 2022

I. DESCRIPTION

Temporary orange pavement markings sign are an experimental type of temporary traffic control device used to delineate travel lanes in work zones. INDOT sent FHWA an amended request for permission to experiment on March 30, 2022 and received approval on May 2, 2022. This is the first progress report submittal for this experimentation request. The following is a summary of the experimentation progress between January 1, 2022 and June 30, 2022.

II. EXPERIMENTATION PLAN

For review, INDOT's experimentation plan is to install the temporary orange pavement markings on select freeway work zones. Data collection will include checking the daytime and nighttime color, measuring retro-reflectivity, and reviewing crash data. All progress reports and the final report will be submitted by INDOT's Traffic Engineering Division.

The first implemented location, the work zone on I-65 between exits 7 and 9 in Sellersburg, (B-42018), had the temporary orange markings installed in the place of the white edge line and lane line in April of 2022. The type of material used for this installation was fluorescent orange removable tape from Brite-Line.



Figure 1 – Initial Installation of Fluorescent Orange Removable Tape

- Included Initial Findings:
 - Daytime color of fluorescent orange tape was very visible, but faded quickly.
 - Average initial retro-reflectivity of fluorescent orange tape was 1,112 mcd/m²/lux and 653 mcd/m²/lux after 3 weeks
 - Nighttime color of tape appeared white.



Request to Add Locations to the Experiment



INDIANA DEPARTMENT OF TRANSPORTATION

Driving Indiana's Economic Growth

100 North Senate Avenue
Room N758-TE
Indianapolis, Indiana 46204

PHONE: (317) 234-7949

Eric Holcomb, Governor
Michael Smith, Commissioner

August 1, 2022

FHWA Resource Center
Attn: Eric Ferron, MUTCD Team
31 Hopkins Plaza, Suite 840
Baltimore, Md. 21201

Re: 6(09)-65 (E) Temporary Orange Pavement Markings - Indiana

Dear Mr. Ferron,

The Indiana Department of Transportation (INDOT) is requesting to add two locations for its experiment with temporary orange pavement markings. INDOT received approval for the experiment on May 2, 2022 and the initial study location was on I-65 over Camp Creek between exits 7 and 9 in Clark County (B-42018). Based on the need for more data and the success of the experiment in other states, INDOT is seeking approval for two additional projects during the 2022 construction season. The following is a list of the additional locations:

- Northbound I-65 near a horizontal curve at mile marker 141.4 for an added travel lanes project in Boone County (R-41841).
- I-80/90 (Indiana Toll Road) in both directions near mile marker 76 for bridge work over the St. Joseph River in South Bend, Ind.

Both locations would use the contrast pattern shown to the right as a conspicuity enhancement to the existing temporary markings.



Please let me know if you have any questions or concerns regarding INDOT's request to add locations to the experiment.

- Added 2 Locations:
 - NB I-65 near mile marker 141.4 (R-41841) for horizontal curve by Exit 141 (US 52).
 - I-80/90 (Indiana Toll Road) near mile marker 76 by Exit 77 (SR 933)
- Both Locations Used Contrast Pattern

Second Semi-Annual Progress Report

SEMI-ANNUAL PROGRESS REPORT No. 2
6(09)-65 (E) – Temporary Orange Pavement Markings - Indiana
July – December 2022

I. DESCRIPTION

Temporary orange pavement markings sign are an experimental type of temporary traffic control device used to delineate travel lanes in work zones. INDOT sent FHWA an amended request for permission to experiment on March 30, 2022 and received approval on May 2, 2022. This is the second progress report submittal for this experimentation request. The following is a summary of the experimentation progress between July 1, 2022 and December 31, 2022.

II. EXPERIMENTATION PLAN

For review, INDOT's experimentation plan is to install the temporary orange pavement markings on select freeway work zones. Data collection will include checking the daytime and nighttime color, measuring retro-reflectivity, and reviewing crash data. All progress reports and the final report will be submitted by INDOT's Traffic Engineering Division.

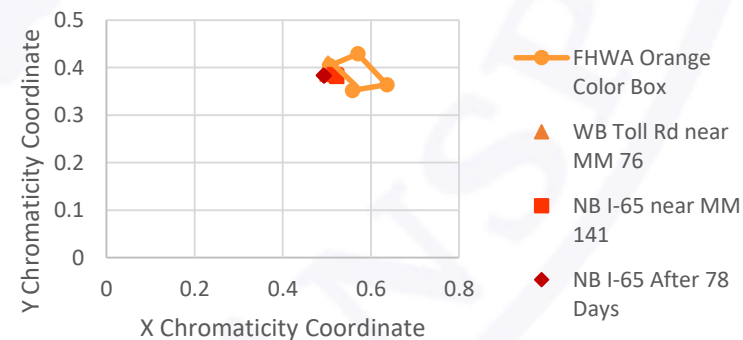
INDOT had one project during this reporting period where temporary orange markings were applied as a conspicuity enhancement to delineate a horizontal curve and interstate exit. Temporary orange markings were applied on northbound I-65 near Exit 141 in Lebanon, (R-41841), on August 9, 2022. The type of material used for this installation was orange traffic paint from PPG and orange VisiLok beads from Potters Industries.



Figure 1 – Initial Installation of Orange Traffic Paint

- Summary of Findings:
 - Initial retro-reflectivity of orange traffic paint 249 mcd/m²/lux and 98 mcd/m²/lux after 11 weeks
 - Color retention of traffic paint much better and Potters VisiMax WZ Orange Beads preserve orange color at night
 - Useful as conspicuity enhancement with favorable public response

Orange Contrast Marking Color Check



USP for Orange Contrast Temporary Markings

ORANGE CONTRAST TEMPORARY PAVEMENT MARKINGS

The Standard Specifications are revised as follows:

SECTION 801, BEGIN LINE 568, INSERT AS FOLLOWS:

801.12 Temporary Pavement Marking

Temporary pavement markings shall be new materials placed in accordance with 808.04 and 808.05, *except that orange shall be used to provide contrast to the white and yellow temporary pavement markings. Orange temporary traffic paint shall be applied with a wet film thickness of 25 mils to 30 mils using a single bead drop with a rate of 8 to 10 lbs/gal of traffic paint.* However, when temporary markings are to be in place for 10 work days or less the dashed line pattern used on center line and lane lines may be 4 ft line segments on 40 ft centers and gore areas shall be marked by outline only and may be 5 in. wide lines. No-passing zones on all undivided two-way roadways shall be identified with signs and centerline markings. Markings shall remain clearly visible during the day and night for a minimum of 200 ft ahead of a vehicle. All temporary markings shall be maintained and replaced until they are no longer applicable.

For solid lines, the orange contrast temporary pavement markings shall be the same width as the white or yellow solid line and placed on the side closer to traffic. For broken and dotted lines, the orange contrast temporary pavement markings shall be the same width and length as the white broken or dotted line and immediately follow it without reducing the gap between the white broken or dotted lines.

The orange contrast temporary pavement markings shall be selected from the following manufacturers:

Paint

*P P G Industries Inc., d/b/a Ennis-Flint, Greensboro, NC for waterborne traffic paint
Potters Industries, Malvern, PA for VisiMax WZ Orange beads*

Approved Equal

The Standard Specifications are revised as follows:

SECTION 921, BEGIN LINE 105, INSERT AS FOLLOWS:

(e) Pavement Marking Beads

A type C certification in accordance with 916 shall be provided for the pavement marking beads. *The remainder of this subsection applies to the beads for white and yellow pavement markings and does not apply to the beads for orange temporary pavement markings.*

- Wet film thickness of orange traffic paint should be between 25 to 30 mils (instead of 15 mils for standard traffic paint).
- Beads should be applied at 8 to 20 lbs/gal (instead of 6 lbs/gal).
- 10 ft orange broken line (or 3 ft orange dotted line) placed after white broken (or dotted) lines.

Questions?



Joe Bruno, P.E.

Sr. Traffic Engineer, Signals & Markings

INDOT Traffic Engineering Division

(317) 234-7949

jbruno@indot.in.gov

Dr. Michael Williamson

Associate Professor

Civil Engineering

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