

# CUTR

CENTER for URBAN  
TRANSPORTATION  
RESEARCH

## Evaluation on Impact of Red RRFB Implementation at Freeway Off-Ramps on Driving Behaviors Along Adjacent Arterials



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# Outline

- Background on Wrong-Way Driving (WWD)
- Project Motivation
- FDOT Initiatives
- Project Objectives
- Methodology and Data Collection
- Results and Findings
- Conclusions and Future Work

# Background on Wrong-Way Driving

- Approximately 350 nationwide fatalities occur per year as a result of WWD (NTSB). A majority of these cases involve:

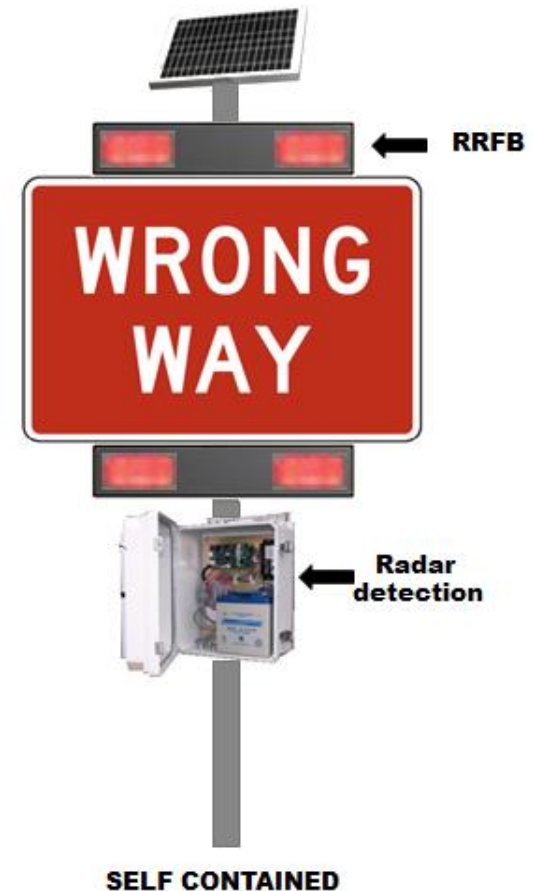
Contributing factors for wrong-way crashes (Recreated and modified from Zhou et al., 2012)

Categories	Description
Traffic violation	<ul style="list-style-type: none"> <li>Driving under the influence (DUI)</li> <li>Intentional reckless driving</li> <li>Suicide</li> </ul>
Inattention	<ul style="list-style-type: none"> <li>Falling asleep at the wheel</li> <li>Carelessness, absent-mindedness, distraction</li> <li>Inattention to informational signposts</li> </ul>
Impaired judgment	<ul style="list-style-type: none"> <li>Physical illness</li> <li>Older driver</li> <li>Drivers with psychiatric problems</li> </ul>
Insufficient knowledge	<ul style="list-style-type: none"> <li>Lack of understanding of how to use the highway</li> <li>Unfamiliar with the infrastructure</li> </ul>
Infrastructure development	<ul style="list-style-type: none"> <li>Insufficient lighting</li> <li>Insufficient field of view</li> <li>Heavy vegetation</li> </ul>



# Project Motivation

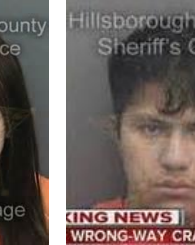
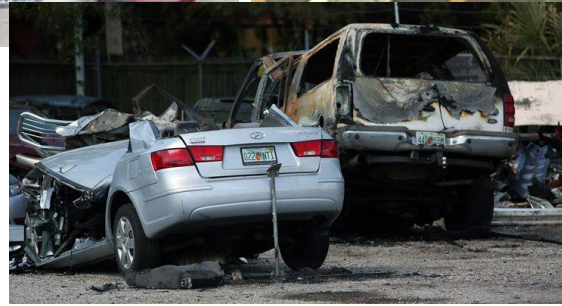
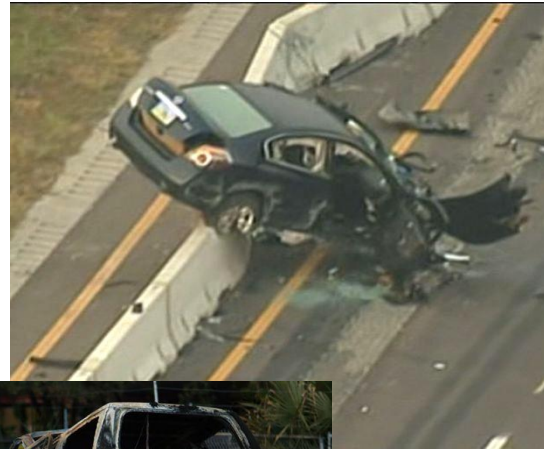
- Significant increase of WWD related fatalities in Florida during the year 2014.
- Yellow Rectangular Rapid Flashing Beacons (RRFBs) are very effective to alert drivers to yield to pedestrians crossing streets.
- However, the impacts of red RRFBs mounted on “WRONG WAY” signs on driving behaviors on adjacent arterial roadways was unknown.



Red RRFBs mounted on “WRONG WAY” sign  
(Revised from WUSE, 2015)

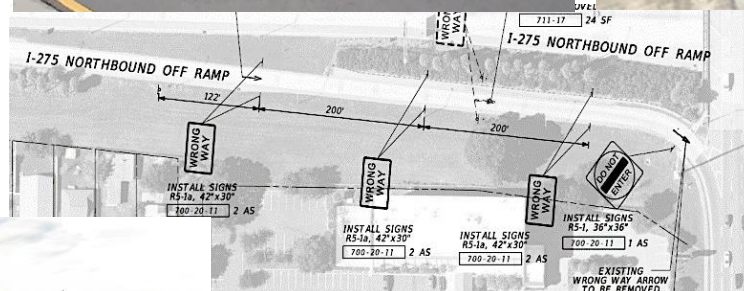
# Project Motivation (cont'd)

Tampa Bay Wrong-Way Driving Crashes from 2014 and 2015



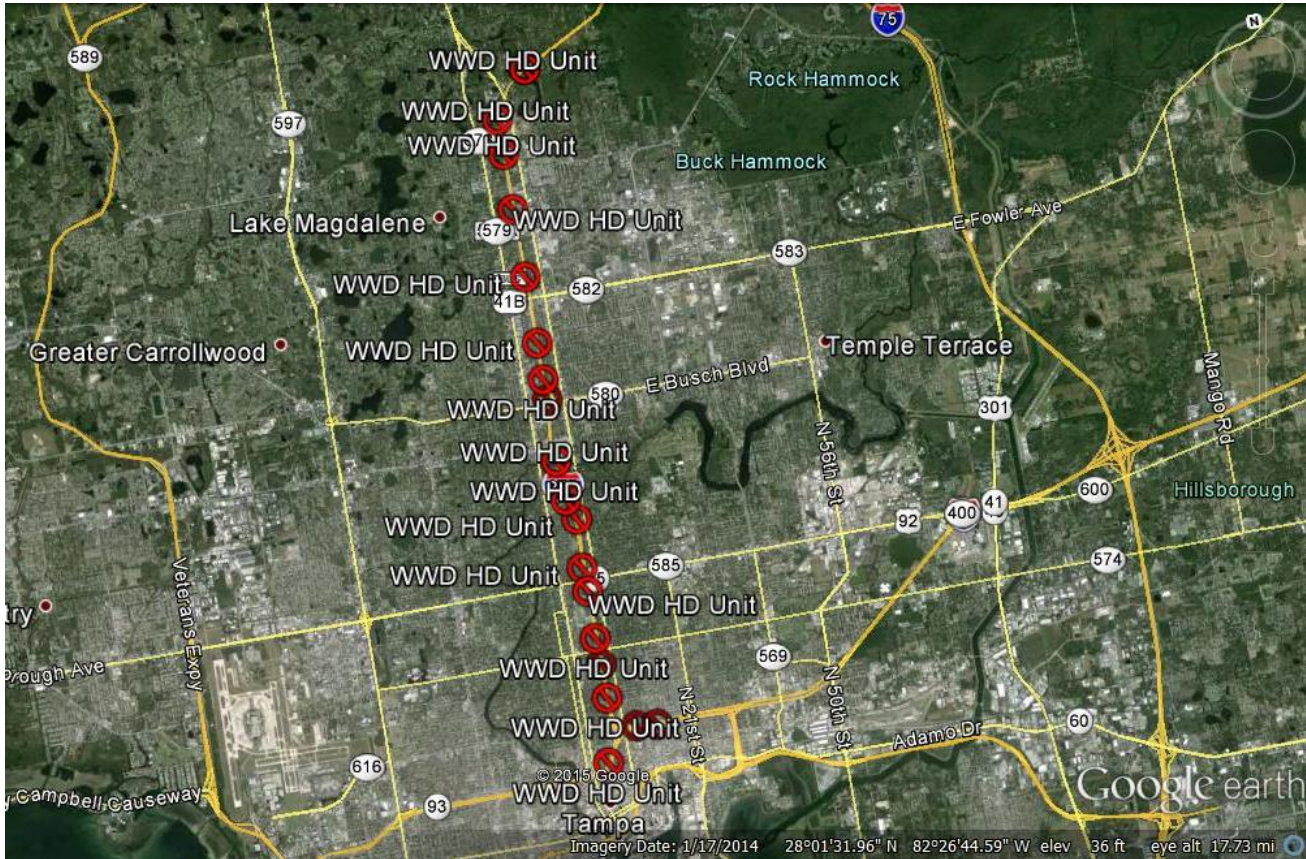
# FDOT Initiatives

Installation of Wrong-Way Driving Signing, Pavement Markings and RRFBs



# FDOT Initiatives (cont'd)

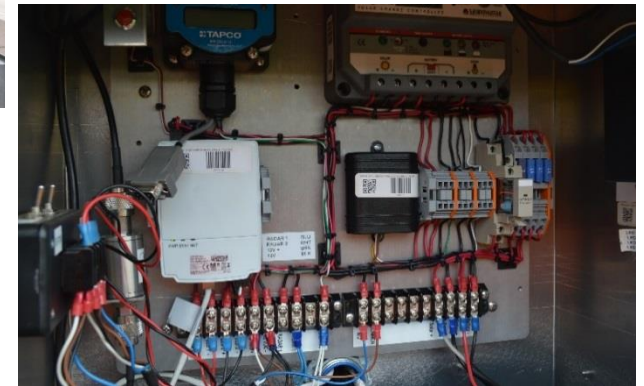
## Wrong-Way Driving Sensor Experimental Deployments at I-275 Main Lanes





# FDOT Initiatives (cont'd)

Wrong-Way Driving Sensor Experimental Deployments at I-275 Off-Ramps



# Project Objectives

The objectives of this research are:

- To investigate the perception of the motoring public regarding the most informing and effective red RRFBs mounted on “WRONG WAY” signs at selected freeway off-ramps to reduce WWD.
- To measure the impacts of active red RRFBs on driving behaviors on adjacent arterials by observing three specific behaviors:
  - Sudden deceleration
  - Sudden stop
  - Sudden lane changing
- To measure effectiveness of red RRFBs installed at off-ramps and microwave sensors installed along the Interstate 275 mainline on reducing wrong-way driving via crash analysis before and after the implementation.

# Methodology and Data Collection

Overview of the methodology used for this project:

<b>“Before” red RRFB Implementation</b>	<b>“After” red RRFB Implementation</b>
<ul style="list-style-type: none"><li>• Conduct public opinion survey to determine the most informing and effective RRFB combination.</li><li>• Installation of red RRFBs.</li><li>• Obtain video recordings of driving behaviors on adjacent arterials as baseline (“before”) data.</li></ul>	<ul style="list-style-type: none"><li>• Using the most effective RRFB combination obtained from survey, record their effects on adjacent traffic by:<ul style="list-style-type: none"><li>• Manual triggering of red RRFBs.</li><li>• WWD vehicular triggering of RRFBs.</li></ul></li><li>• Perform statistical analysis to compare before and after data.</li><li>• Determine if red RRFBs have adverse effects on driving behaviors on the adjacent arterial.</li></ul>

# Methodology and Data Collection (cont'd)

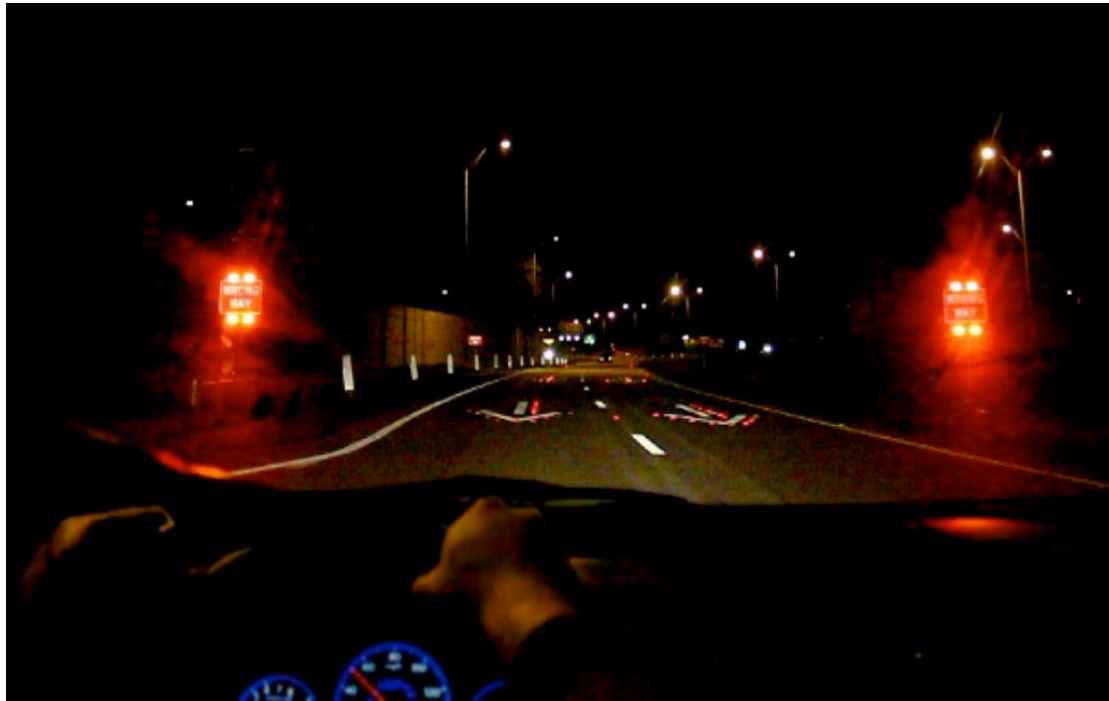
“Before” (baseline) data collection involved obtaining recorded video footage of baseline driving behaviors on adjacent arterials for the selected off-ramps.



Video camera footage of Bearss Avenue and Interstate 275 off-ramp

# Methodology and Data Collection (cont'd)

Following red RRFB installation and baseline data collection, a public opinion survey was conducted to evaluate public perception of WWD and to investigate the flashing red RRFB combination that participants found as the “most informing and effective”.



# Methodology and Data Collection (cont'd)

Shorter version of the video shown to public opinion survey participants.



# Methodology and Data Collection (cont'd)



The public opinion survey targeted three age groups:

- 16-29
- 30-59
- 60+



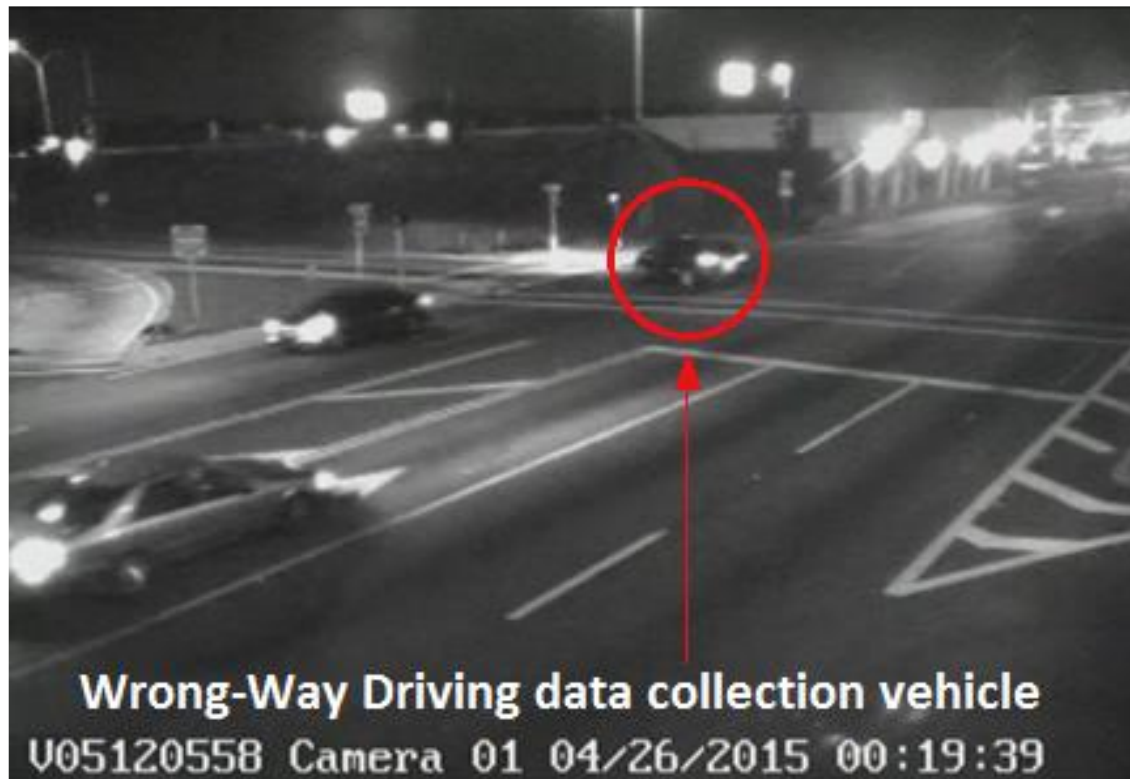
# Methodology and Data Collection (cont'd)

- “After” study started after the installation of red RRFBs at six select I-275 off-ramps (Fowler, Fletcher, and Bearss Avenues northbound and southbound off-ramps).
- Implementation of the “most informing and effective” RRFB combination to be tested in the field.
- Two methods used:
  - Manual triggering of red RRFBs
  - WWD vehicular triggering
- Behaviors were recorded both on camera and manually by the CUTR research team.



# Methodology and Data Collection (cont'd)

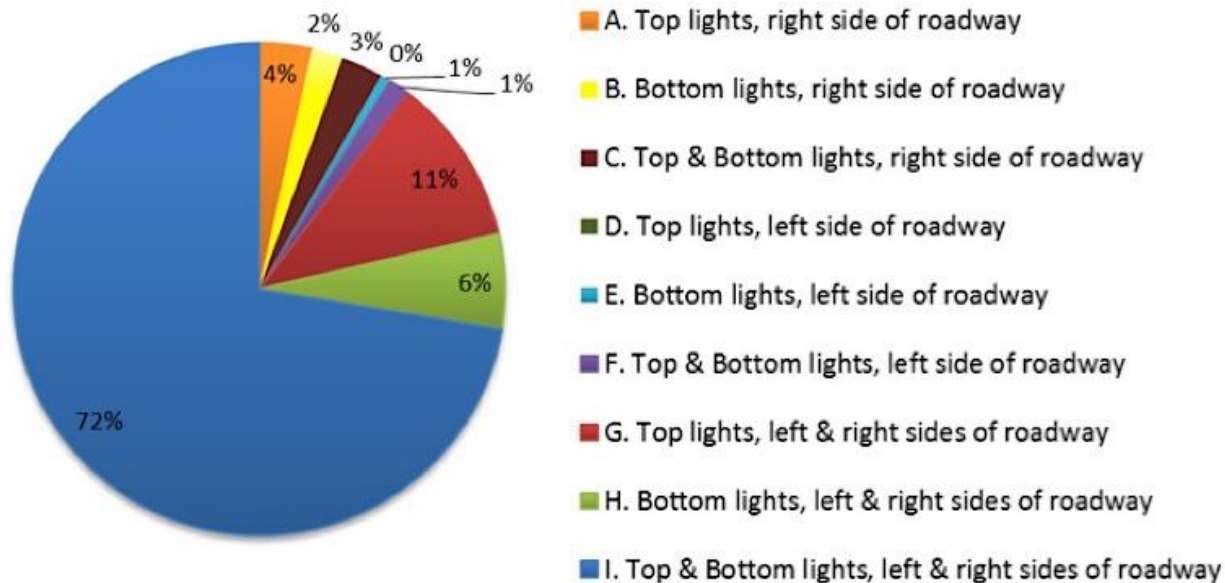
Video camera footage of WWD vehicular triggering of red RRFBs.



# Public Opinion Survey Results

- The majority of public survey participants favored the RRFB combination with flashing top and bottom RRFBs on both sides of the roadway.

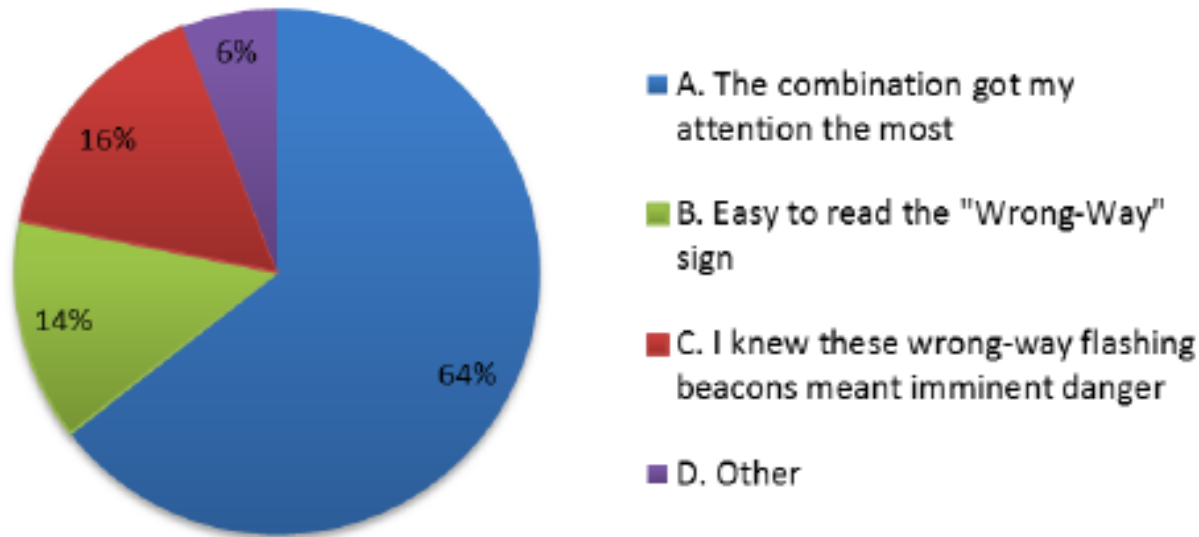
I-275 at Fowler Avenue "Long and Wide Off-Ramp"



# Public Opinion Survey Results (cont'd)

- Why was this combination selected as the most effective and informing by the public?

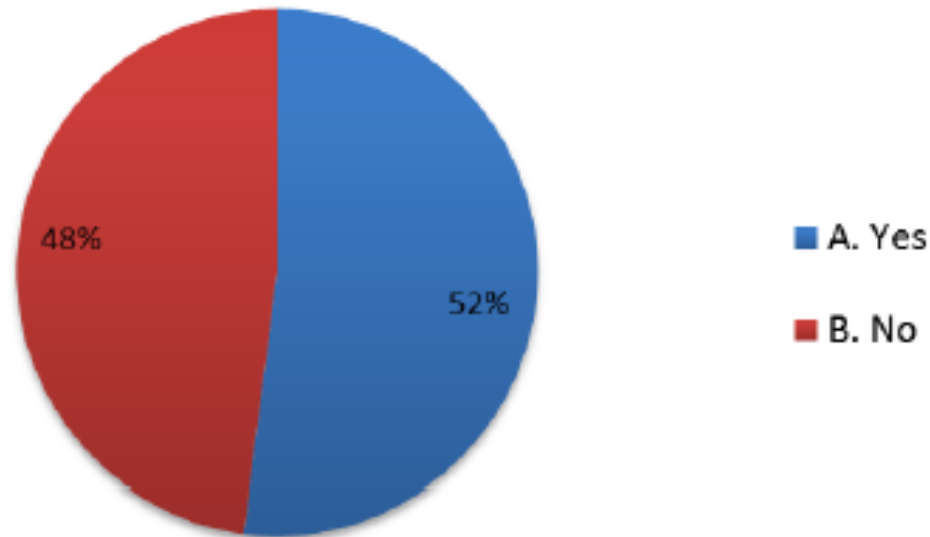
## I-275 at Fowler Avenue "Long and Wide Off-Ramp"



# Public Opinion Survey Results (cont'd)

- Did the public know immediately that these were WWD warning signs?

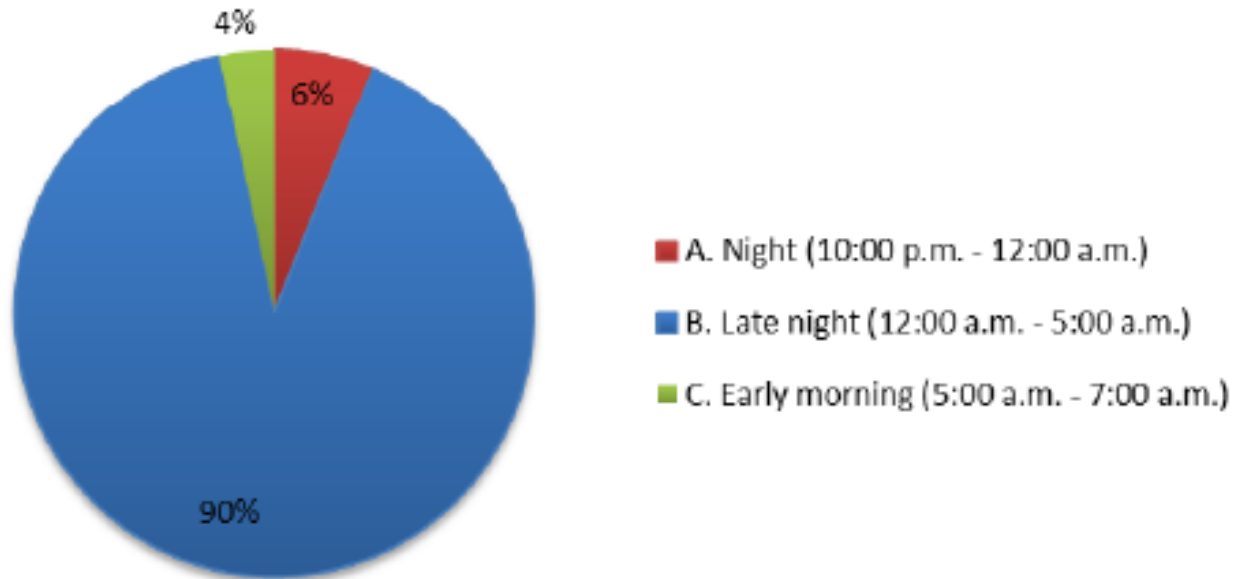
I-275 at Fowler Avenue "Long and Wide Off-Ramp"



# Public Opinion Survey Results (cont'd)

- Time of day the public expects WWD to occur?

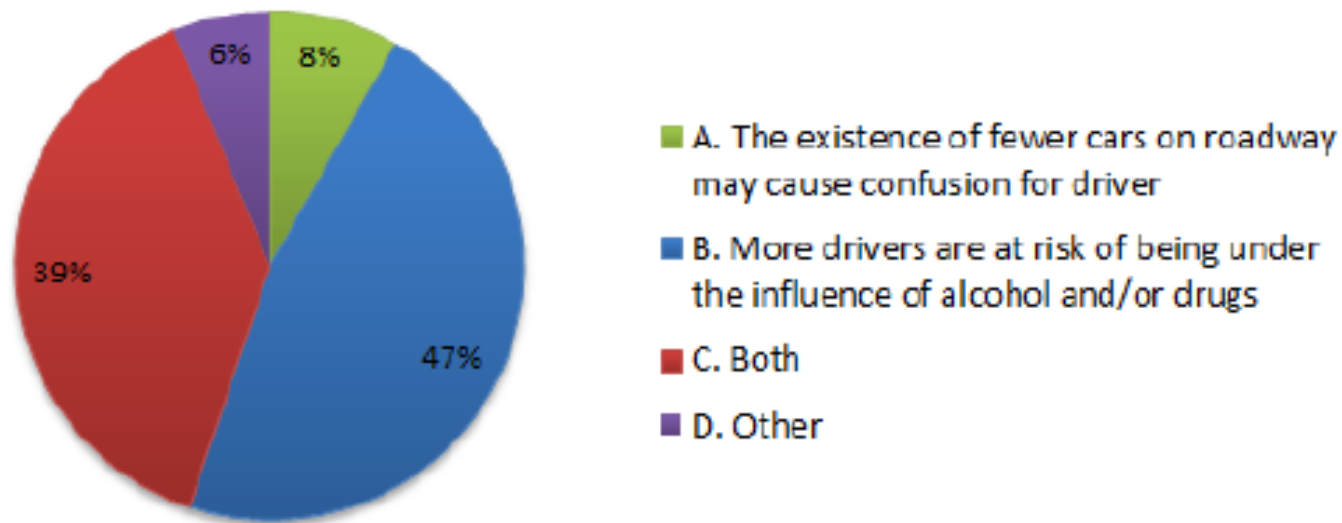
## I-275 at Fowler Avenue "Long and Wide Off-Ramp"



# Public Opinion Survey Results (cont'd)

- Why does the public think nighttime has the most likelihood of WWD?

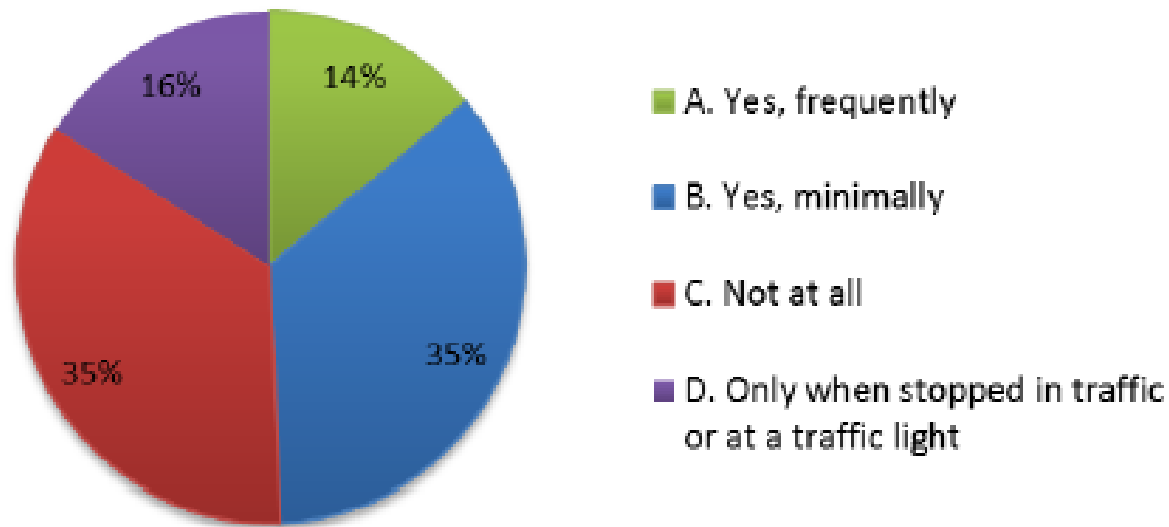
## I-275 at Fowler Avenue "Long and Wide Off-Ramp"



# Public Opinion Survey Results (cont'd)

- Does the public talk, text or use their other smartphone functions while driving?

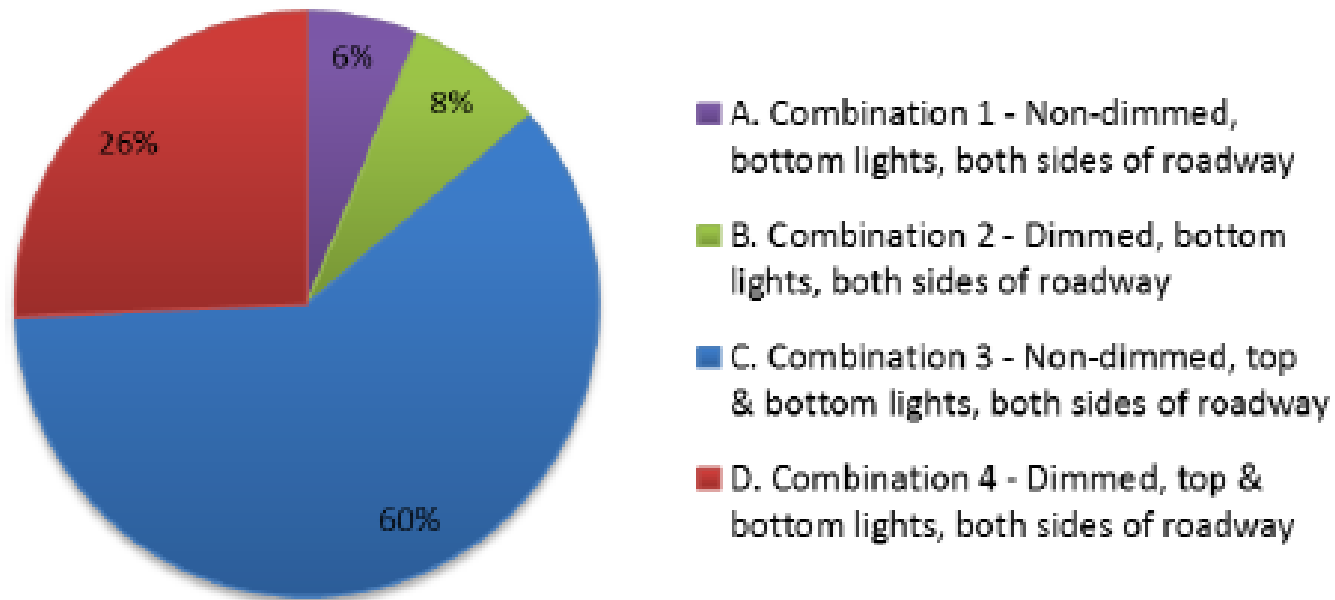
## I-275 at Fowler Avenue "Long and Wide Off-Ramp"



# Public Opinion Survey Results (cont'd)

- Dimmed red RRFB lights vs. non-dimmed?

## I-275 at Fowler Avenue "Long and Wide Off-Ramp"

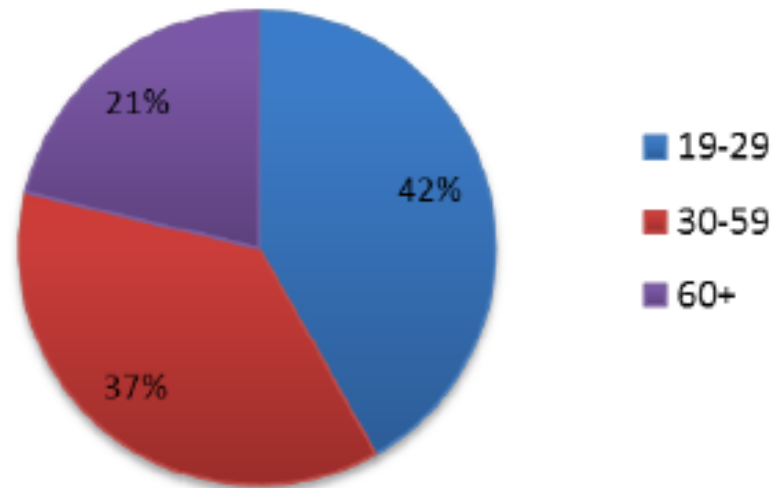




# Public Opinion Survey Results (cont'd)

- Age split of general public who answered the survey.
- Results did not show significant differences between age groups.

Age: I-275 at Fowler Avenue  
"Long and Wide Off-Ramp"



# “Before and “After” Analysis Results

Date/Time Period	Total Number of Vehicles	Sudden Deceleration	Sudden Stops	Sudden Lane Changing
January 9-10, 2015 11pm-1am	1,392	0	0	0
January 10, 2015 1am-4am	461	0	0	1
January 10-11, 2015 11pm-1am	1,390	0	0	0
January 11, 2015 1am-4am	465	2	1	1

Sample results from “Before” Study – I-275 & Bearss Avenue Northbound Off-Ramp

Date/Time Period	Manual vs. WWD Vehicle Triggering	Total Number of Vehicles	Sudden Deceleration	Sudden Stops	Sudden Lane Changing
April 24-25, 2015 11pm-1am	WWD vehicle-triggered RRFBS	902	1	0	0
April 25, 2015 1am-4am	WWD vehicle-triggered RRFBS	470	0	0	0
May 15-16, 2015 11pm-1am	Manually-triggered RRFBS	858	0	0	0
May 16, 2015 1am-4am	Manually-triggered RRFBS	477	0	0	0

Sample results from “After” Study – I-275 & Bearss Avenue Northbound Off-Ramp

# Statistical Testing

- Statistical testing of both “before” and “after” data two-tailed t-tests were performed to check for statistical significance of red RRFB implementation effects.
  - $H_0$ : The implementation of red RRFBs does not have a negative impact on the adjacent arterial driving behaviors when compared to the before-implementation driving behaviors data on the same adjacent arterial.
- These t-tests were performed to a 95% CI.

# Statistical Testing Results

- The absolute value of all t-calculated values were found to be less than the t-critical value obtained from the t-distribution critical values table at 95% CI.
- Failed to reject the null hypothesis.
- The implementation of the red RRFBs has no impact on the driving behaviors on the adjacent arterial to the off-ramp.

# Conclusions and Future Work

- 69.5% of public survey participants selected the combination of placing “WRONG WAY” signs on both the left and right sides of an interstate off-ramp with red RRFBs activated at the top and bottom.
- 58% of the participants selected non-dimmed flashing red RRFBs over the dimmed option.
- The implementation of red RRFBs can effectively alert wrong-way drivers while not adversely impacting driver behaviors on adjacent arterials.
- The effectiveness of red RRFBs on the reduction of wrong-way crashes will be investigated via a before-and-after crash data analysis.

# Conclusions and Future Work (cont'd)

- CUTR to evaluate red RRFB locations' vehicle detection data within a three year period, beginning February 2015
- CUTR to evaluate the use of 18 microwave sensors for wrong-way detection on I-275 between Bearss Ave. and I-4 interchange within a three year period on I-275, beginning October 2015
- FDOT to install 7 additional wrong-way driving sensors and 900 MHz wireless transmitters for exit ramps along I-4, I-175, I-275, and I-375
- FDOT to restore the 3 legacy wrong-way driving sensors to operational status
- FDOT to create a District Seven wrong-way driving sensors deployment map

# Conclusions and Future Work (cont'd)

- FDOT to prepare systems engineering-related documentation for wrong-way driving sensors deployments
- FDOT to develop CPR practices for wrong-way driving education and enforcement
- FDOT to develop proposed District Seven regional wrong-way driving countermeasures strategic plan for arterials
- FDOT to retrofit wrong-way driving sensors on remaining District Seven interchanges and main lanes on case-by-case basis

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