UCF Innovative Wrong-Way Driving Research and Countermeasure Evaluations

By

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Outline

- Wrong-Way Driving (WWD) Background and WWD Data Universe.
- Deployment and Evaluation of Advanced WWD Countermeasures in Florida: Rectangular Flashing Beacon (RFB) and Light Emitting Diode (LED) Wrong Way Signs.
- Professor Al-Deek's New and Innovative WWD Hotspot Segment Modeling and Countermeasure Optimization Approach.
- Application of Professor Al-Deek's Approach to Florida Limited Access Facilities.
- Summary and Conclusions.

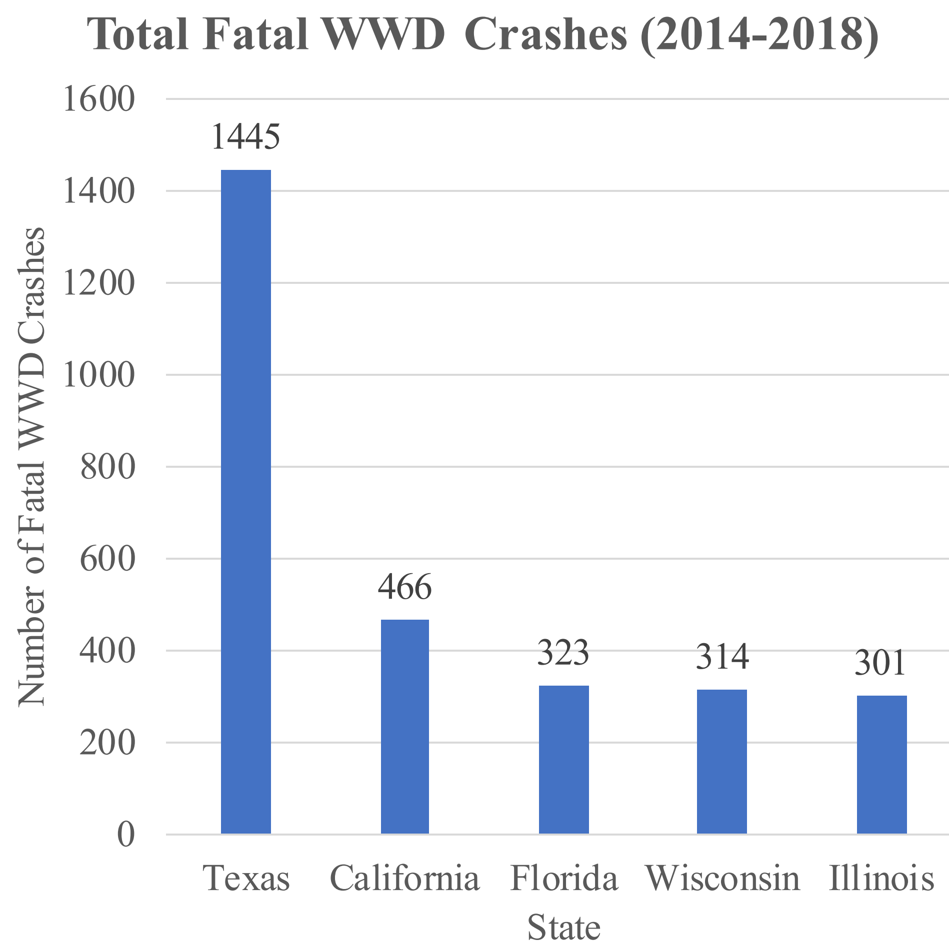
Leading Factors For Wrong-Way Driving (WWD)

- Drivers under the influence of alcohol/drugs.
- Suicidal drivers (e.g., Florida and Texas).
- Unintentional (confused and elderly) drivers.
- Intentional WW drivers (trying to save time and/or toll money).
- Other (unknown) factors.

Lack of detection leaves police scrambling

WWD Crash Information

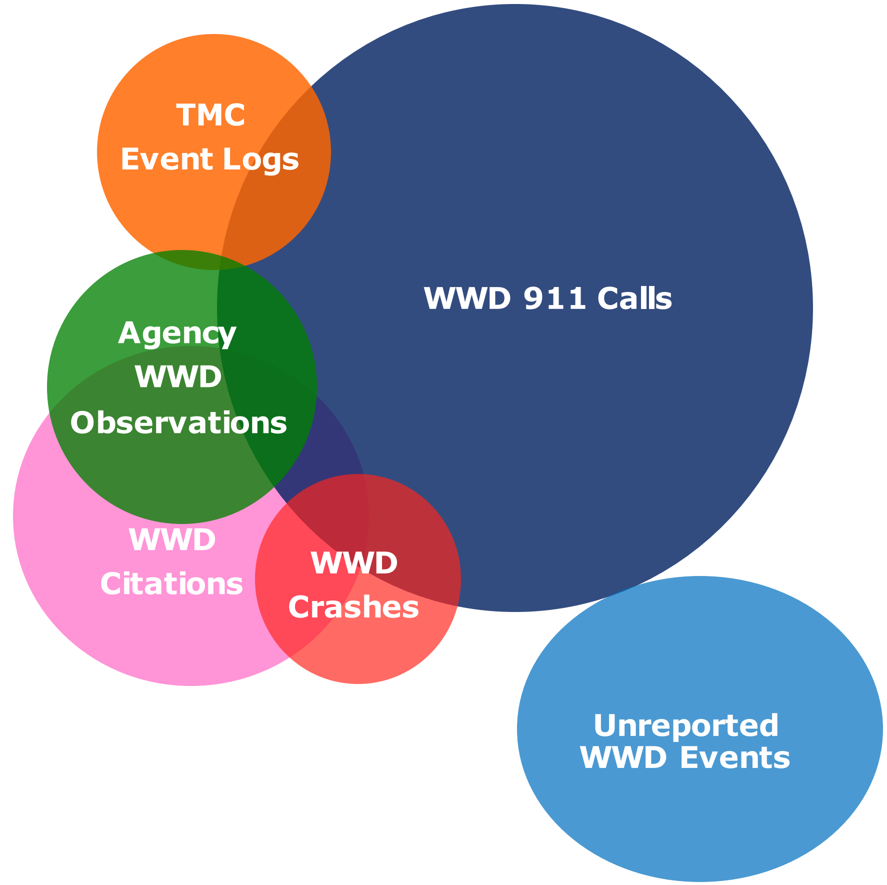
- WWD crashes make up about 3% of crashes on high-speed divided highways, but often result in fatalities or serious injuries (NTSB, 2012).
- Percentage of fatal crashes in US caused by WWD increased from 2.92% in 2014 to 3.69% in 2018 (NHTSA).
- Florida was the state with the third highest amount of fatal WWD crashes (323) from 2014-2018 (NHTSA).



Data from Fatality Analysis Reporting System (FARS), NHTSA

Professor Al-Deek Innovative Research Approach: The WWD Data Universe

- Previous research has mainly focused on WWD crashes in evaluating countermeasures to stop WWD.
- However, WWD crashes are only a small portion of the problem.
- Al-Deek's innovative and holistic research approach considers WWD crashes, citations, 911 calls, traffic management center (TMC) logs, agency observations, and unreported WWD events, which all comprise the WWD data universe.



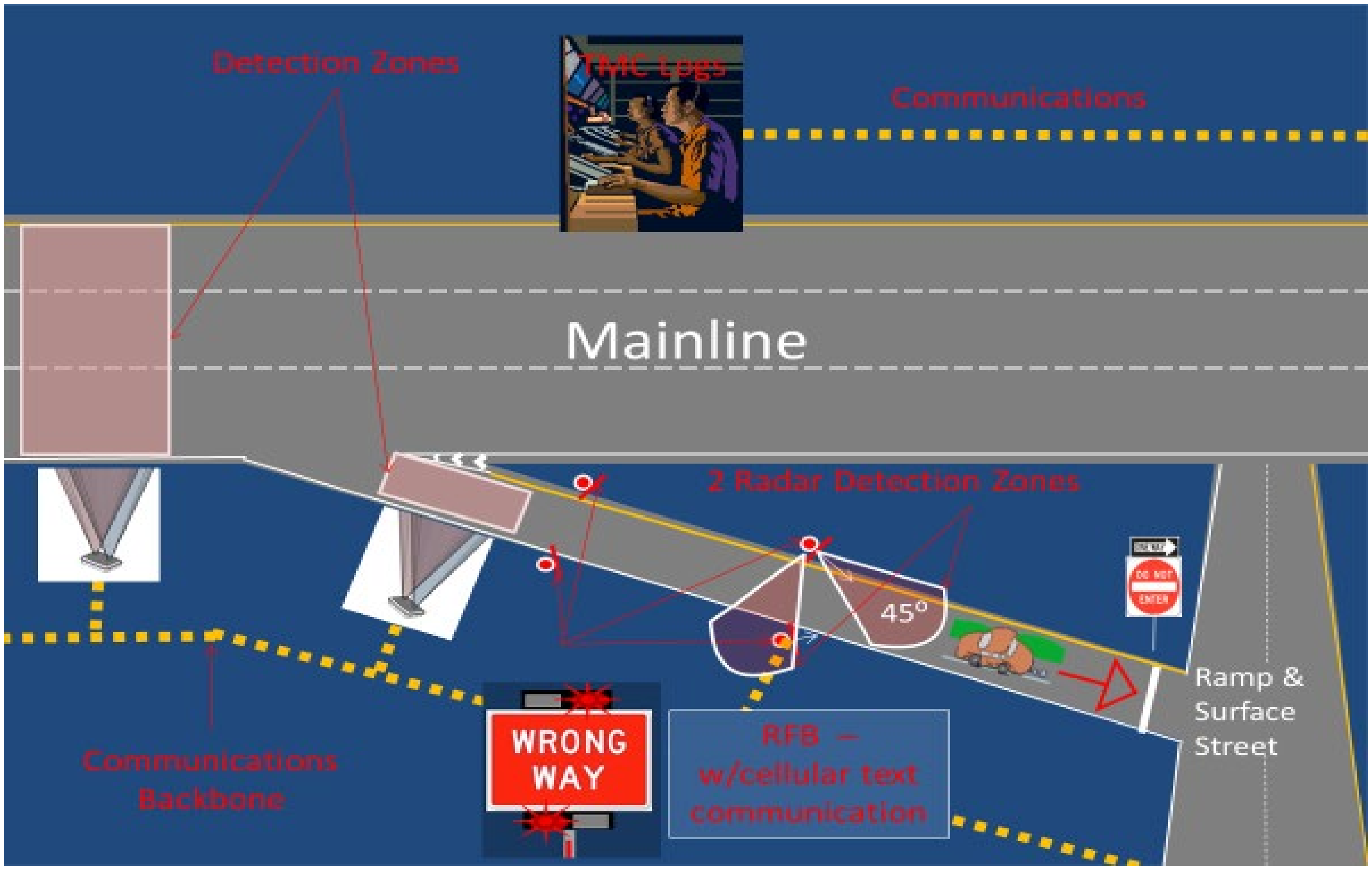
Source: Al-Deek et al., 2013

UCF/CFX Solution in Florida: Innovative WWD Enhanced Countermeasures

Approved UCF/CFX Concept for Testing (FHWA) - Double Red RFB on "Wrong Way" Sign

UCF/CFX Solution in Florida: Innovative WWD Enhanced Countermeasures

UCF/CFX Conceptual Setup of RFBs and WWD Detection

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Continuing Evaluation of Advanced WWD Countermeasures

- Focus on two Florida regions where advanced WWD countermeasures have been implemented:
  - Central Florida: Wrong Way signs equipped with Rectangular Flashing Beacons (RFBs), cameras, and detectors deployed at toll road exit ramps operated by Central Florida Expressway Authority (CFX) and Florida’s Turnpike Enterprise (FTE).
  - South Florida: Wrong Way signs equipped with Light Emitting Diodes (LEDs), cameras, and detectors deployed at toll road exit ramps operated by FTE.

Florida WWD Countermeasures in Action

Video showing LED Wrong Way signs used in South Florida from viewpoint of wrong-way driver.

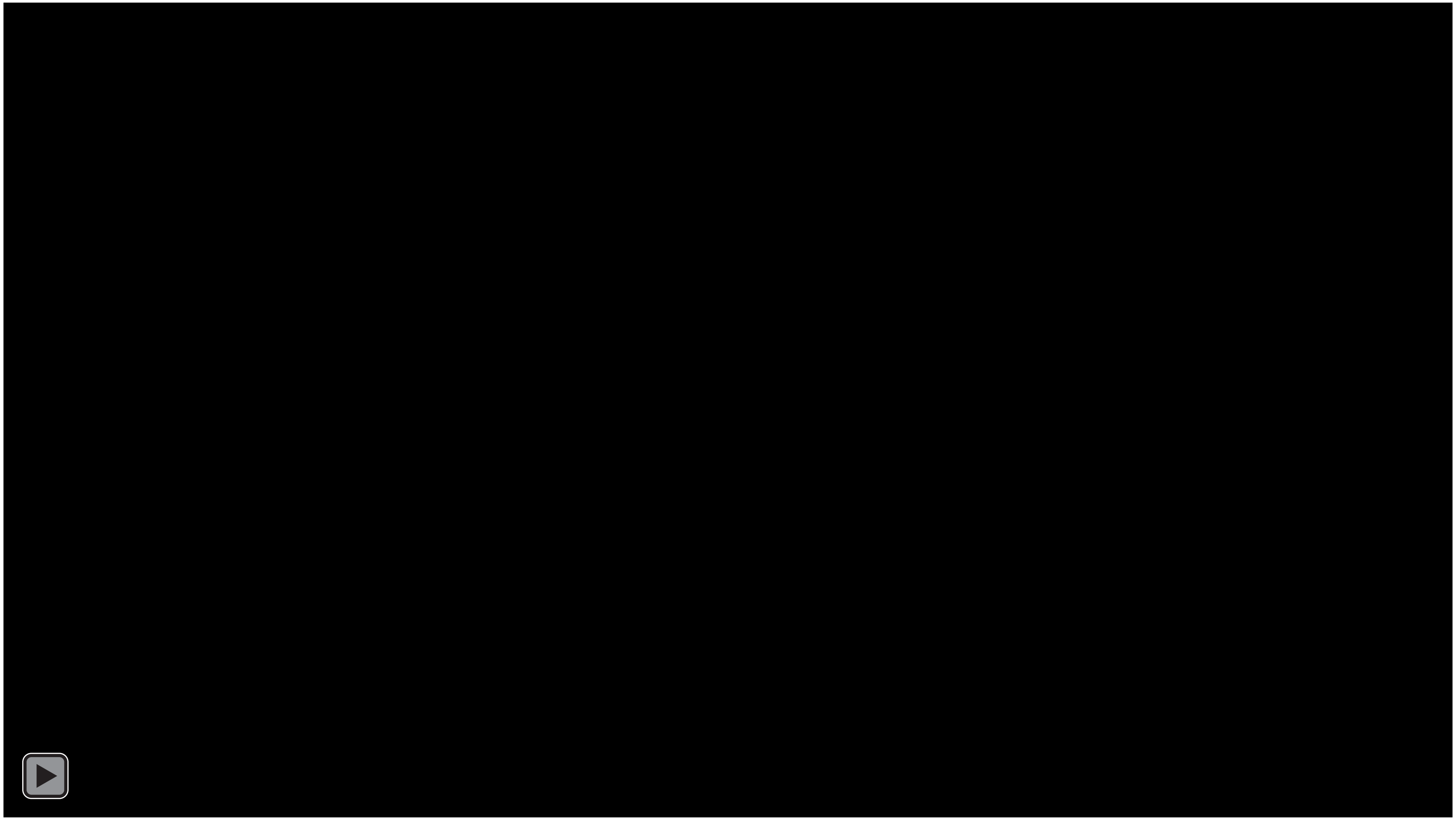
Source: Florida’s Turnpike Enterprise

Video showing CFX RFB Wrong Way signs used in Central Florida from viewpoint of wrong-way driver.

Source: Central Florida Expressway Authority

- UCF surveyed 1800 drivers and 247 Florida Highway Patrol (FHP) officers regarding these WWD countermeasures.
  - 74% of drivers and 71% of FHP officers preferred the RFBs over the LEDs.
  - The RFBs were mainly preferred due to the additional set of signs and better flashing.

RFB Testing by Central Florida Expressway Authority (CFX) at SR 408 and Chickasaw Trail



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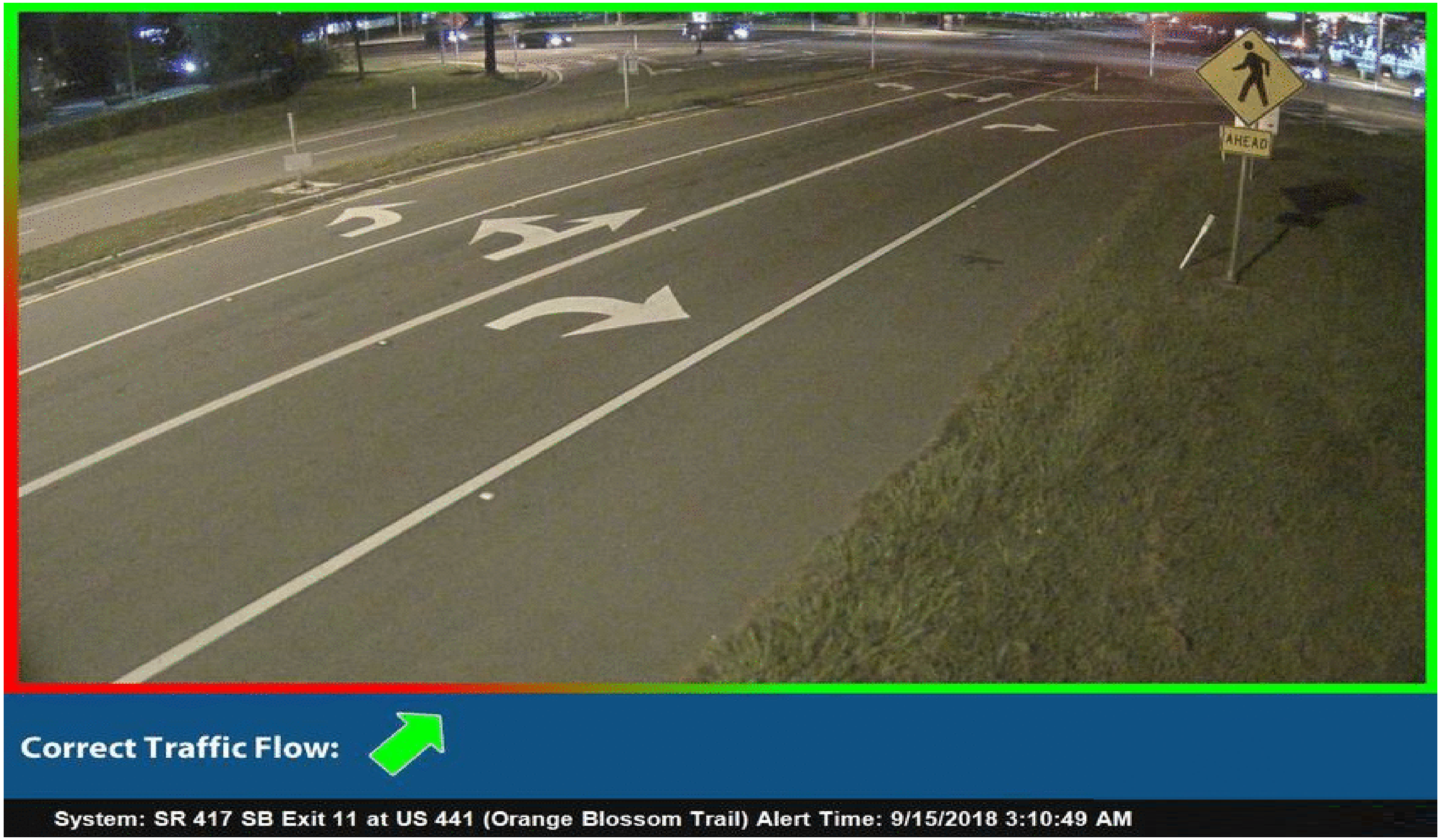
WWD Turn Around at CFX RFB Site



Similar images captured at FTE RFB and LED sites.

WWD Turn Around at CFX RFB Site

Images from second and third cameras only available at CFX RFB sites.

Performance of CFX RFBs

- There have been 936 detected wrong-way vehicles at the CFX RFB sites through October 2021.
- 806 of these vehicles turned around (turnaround percentage of 86.1%).
- 64.4% of detections were at nighttime, with 86.6% of the nighttime detections turning around (as of October 2021).
- Next slide compares CFX RFBs with FTE RFBs and LEDs through July 2021.
  - Complete FTE data after July 2021 have not been received yet.

Performance of Florida Advanced WWD Countermeasures through July 2021

Countermeasure	CFX RFBs	FTE RFBs	FTE LEDs
Number of Sites	53	18	17
Months Active	Between 3 and 74 depending on site.	50	82
Detections	864	94	208
Turn Arounds	741 (85.8%)	61 (64.9%)	55 (26.4%)
Confirmed Mainline Entries	20 (2.3%)	5 (5.3%)	19 (9.1%)
Crashes	1 (0.12%) (non-fatal)	1 (1.1%) (non-fatal)	4 (1.9%) (1 fatal, 3 non-fatal)
Crashes/Site-Month	0.0005	0.0011	0.0029

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Benefit-Cost Evaluations of Deployed RFB and LED Countermeasures

- Life-cycle benefit-cost evaluations were conducted for the RFB and LED countermeasures currently deployed on the FTE and CFX toll road networks in Florida.
- Costs and benefits for 10-year life cycles are shown below.
- RFBs expected to prevent 10 or more WWD crashes and provide over $38 million in life-cycle savings.

Result	CFX RFBs	FTE RFBs	FTE LEDs
Life-Cycle Costs	$6,025,739	$1,082,376	$611,951
Life Cycle WWD Crash Reduction	11.26	10.00	2.95
Life Cycle Injury Savings	$45,431,143	$38,936,075	$12,741,341
Life Cycle B/C Ratio	7.54	35.97	20.82

Other Evaluations of WWD Countermeasures in Florida

(1) Newly-developed Signing And Pavement Marking (S&PM) Standards

(2) Red Rectangular Rapid Flashing Beacons (Red RRFBs)

(3) Red Flush-mount Internally Illuminated Raised Pavement Markers (IIRPMs)

(4) Detection-Triggered LED lights around "WRONG WAY" signs

(5) Detection-Triggered Blank-out signs that flash "WRONG WAY"

(6) Delineators Along Off-ramps

(7) Wigwag Flashing Beacons

- Red RRFBs were the most effective countermeasure based on results of focus groups, surveys, and driving simulator study (Lin, Ozkul, Guo, & Chen, 2018).
- Installed red flashing beacons (similar to RRFBs, but with slower flashing pattern) at six I-275 exit ramps resulted in 85% turnarounds at one site and 60% turnarounds at another site (Ozkul & Lin, 2017).

WWD Countermeasures Optimization Approach

- ITS WWD countermeasures are successful in reducing WWD, but agencies typically cannot deploy ITS countermeasures at all ramps due to high expense and limited resources.
- Need a way to determine optimal deployment locations.
- Lack of WWD crash data and uncertainty in WWD entry points makes it difficult to identify specific exits for optimal deployment.
- It is not cost-effective to deploy ITS countermeasures on every exit ramp within a corridor (blanket approach) because this wastes resources that could be used at exits with higher WWD risk.
- Prof. Al-Deek's team developed an innovative WWD countermeasures optimization approach to identify roadway segments with high WWD crash risk (WWCR) and the optimal exits for countermeasure deployment.

WWD Countermeasures Optimization Approach

- This approach considers crash and non-crash WWD events along with geometric and traffic factors to model WWCR and identify hotspot segments with high potential for WWD crashes.
  - No other research has considered all these data together.
- An optimization algorithm is then used to identify exits within the hotspot segments (hotspot exits) and outside of the hotspot segments (lone wolf exits) which will provide the most WWCR reduction for the lowest cost.
  - More WWCR reduction than simply deploying countermeasures at all hotspot exits.

Application of WWD Countermeasures Optimization Approach

- This approach has been applied to the CFX and FTE networks, as well as to all Florida limited access facilities statewide.
- Was personalized for each application.
- Results can be used by agencies when deciding where to implement ITS WWD countermeasures in the future.
- Statewide application discussed in following slides.

WWD Countermeasures Optimization Approach Methodology

Data Collection and Preparation

- Collect and Prepare WWD Event Data
- Collect and Prepare Limited Access Roadway Data
- Combine Prepared Event and Roadway Data

Roadway Segmentation

- Determine Appropriate Segment Sizes
- Split Roadways in Segments
- Incorporate Event and Roadway Data

WWCR Modeling

- Develop Model to Predict WWD Crashes on Roadway Segments
- Identify WWD Hotspots

WWD Countermeasure Optimization

- Collect Necessary Parameters Used in Optimization Algorithm
- Determine Desired Constraints
- Apply Optimization Algorithm and Interpret Its Results

Benefit-Cost Analyses

- Determine WWD Crash and Injury Costs
- Determine Countermeasure Costs
- Estimate Life-Cycle Benefits and Costs

Data Collection and Roadway Segmentation

- WWD crash and non-crash data (citations and 911 calls) were collected for 5 years (2012-2016).
- The nearest possible or known entry point was determined for each WWD event.
- Various roadway data (interchange designs, traffic volumes, and area type) were also collected for each direction of 28 Florida interstates and toll roads.
- The studied roadways were then segmented into overlapping four-exit segments.
- WWD crashes on these roadway segments were modeled using Poisson modeling (results shown on next slide).

WWCR Segment Model and WWD Hotspots

$$Predicted\ Segment\ WWD\ Crashes = \exp[-0.793 + 0.026(Segment\ WWD\ 911\ Calls) + 0.046(Segment\ WWD\ Citations) - 0.265(Trumpet\ Interchange\ Presence) - 0.514(Slip\ Ramp\ Presence) + 0.104(Rest\ Area\ Presence) + 0.005(Crossing\ Road\ AADT)]$$

- Predicted crash values added to actual WWD crashes for each segment to obtain WWCR values.
  - WWCR values provide a better understanding of WWD risk than just considering actual crashes while considering the negative impacts of actual WWD crashes (injuries/fatalities, delays, negative media and public perception, etc.).
- The 5% of segments with highest WWCR were selected as hotspot segments.
  - Resulted in 63 hotspot segments containing 132 unique hotspot exits.

Florida Limited Access WWD Hotspot Exits

- Most hotspot exits near large urban areas (Orlando, Jacksonville, Miami, Tampa).
- I-95 SB, I-95 NB, and I-75 NB had most WWD hotspot exits.

WWD Countermeasures Optimization Algorithm

- The WWCR segment model can identify segments with high WWCR, but not individual exits in or outside of the hotspot segments.
- The WWD countermeasures optimization algorithm analyzes each exit to identify where advanced WWD countermeasures should be deployed to achieve the maximum WWCR reduction.
  - Can improve resource utilization compared to blanket deployment at all hotspot exits and identify lone wolf exits with high WWCR not located in the hotspot segments.
- Considers effectiveness and cost of deploying the countermeasures and available resources.
- Constraints can be added to the algorithm to represent various real-world scenarios.

Application of Optimization to Florida Limited Access Facilities

- Map shows hotspot exits and lone wolf exits selected by optimization.
- Optimization selected 66 hotspot exits (73 ramps) and 95 lone wolf exits (96 ramps) not in the hotspot segments.
- Exits with existing RFBs or LEDs were excluded.
- 14 roadways without hotspot segments had exits selected by the optimization.
- I-110 SB only roadway where all hotspot exits were selected by the optimization.

Comparison of Optimization and Hotspot Exits

- Deploying RFBs at all optimization exits improved total WWCR reduction by 38.4% compared to only deploying RFBs at all hotspot exits.
- 96 of the 169 ramps selected by the optimization were at lone wolf exits, resulting in improved resource utilization of 56.8%.
- These results show that deploying countermeasures at all hotspot exits is not the most effective strategy.
- Using optimization to identify best deployment locations within and outside of hotspot segments can improve WWCR reduction and allow for best utilization of resources.

Summary and Conclusions

- The RFBs and LEDs implemented in Florida have successfully reduced WWD, with the RFBs resulting in a higher turnaround percentage and fewer crashes.
- Professor Al-Deek's innovative WWD countermeasure optimization approach:
  - has been used to identify hotspot roadway segments throughout Florida.
  - was applied to CFX and FTE networks, as well as all statewide limited access facilities.
  - can help agencies determine the optimal deployment locations for advanced WWD countermeasures which provide the most WWCR reduction for the lowest cost.

Potential Future Applications

- Professor Al-Deek's optimization approach could be used by districts, regions, counties, or cities in Florida to identify hotspots and lone wolf exits within these areas.
    - Will provide insights at a more microscopic level compared to looking at entire state.
- Approach could also be adapted to study WWD on non-limited access facilities, including signalized arterials and dense urban networks.
- Results of these applications could help agencies cost-effectively deploy WWD countermeasures and optimally reduce WWD crash risk, saving lives.

Thank you!