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Wrong Way Driving (WWD) Low-Cost Safety Improvements Workshop

Evaluation of Low Cost Safety Improvements Pooled Fund Study

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Abbreviations

B/C	Benefit / Cost
CMF	Crash modification factor
DNE	Do not enter
MUTCD	*Manual on Uniform Traffic Control Devices*. [1]
OW	One way
POE	Point of entry
Signed	Displaying vertical signage
TCD	Traffic control device
Unsigned	Not displaying any vertical signage
WWD	Wrong-way driving
WW	Wrong way

All images source: FHWA.[1]

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Developing CMFs and Economic Effectiveness for WWD Crashes

Study Overview

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Study Objectives

► The first objective of this study is to quantify the safety effectiveness of WWD countermeasures like CMFs.

► The second objective of this study is to assess the economic viability of WWD countermeasures.

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WWD Crash Characteristics

▶ WWD crashes represent a small portion of total freeway crashes.

▶ WWD crashes are usually head-on or fixed-object collisions.

▶ WWD crashes lead to more fatalities and injuries than other crash types.

CMFs And Economic Effectiveness for WWD Countermeasures

This study focused on freeways and found the following:

▶ WW crashes are extremely rare.

▶ WW crash occurrences are often recorded miles from the WW POE.

▶ WW crashes could be prevented by varying features or applying treatments at the POE.

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Data Collection

WWD Crashes on TX and FL Freeways

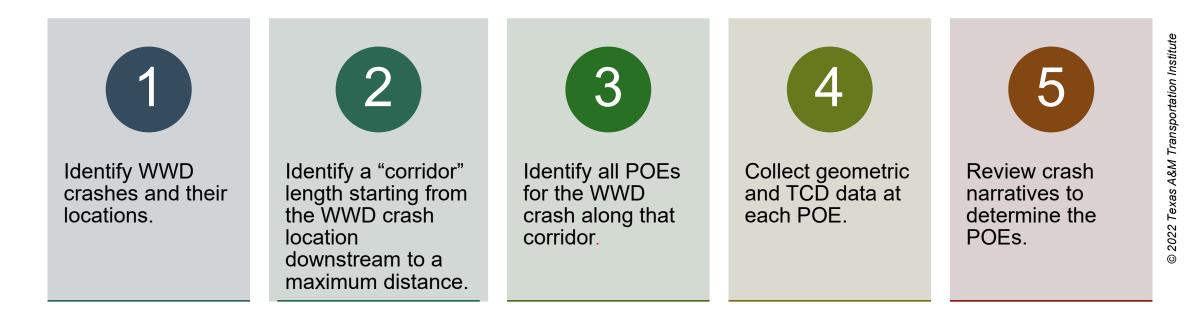| Route Class	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avg.	Total
Texas	--	148	132	173	156	173	210	192	113	187	207	169.1	169.1
Florida	43	47	27	40	37	43	48	38	--	--	--	40.4	323

► Phase I   - - - - - -

► Phase II   ———

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Data Collection Protocol

1	2	3	4	5
Identify WWD crashes and their locations.	Identify a "corridor" length starting from the WWD crash location downstream to a maximum distance.	Identify all POEs for the WWD crash along that corridor.	Collect geometric and TCD data at each POE.	Review crash narratives to determine the POEs.

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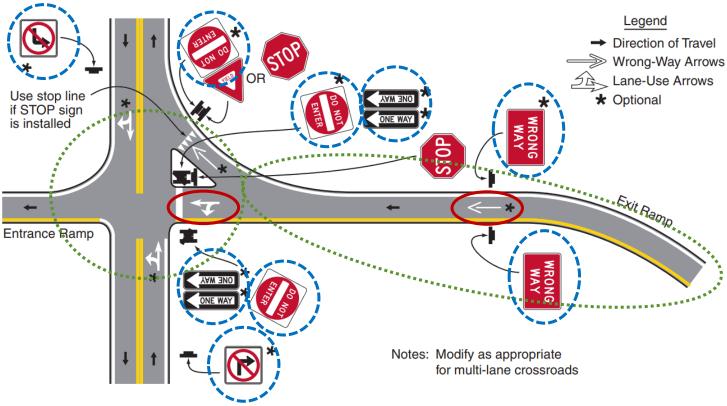
Sample of Data Collection Flow

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WWD Countermeasures At POE

Conventional TCDs:
- ► Signs.
- ► Markings.

Geometric features:
- ► Ramp and cross-road features.
- ► Frontage road access.

Mandatory and optional signs and markings at the exit terminal (Source MUTCD)

Source: FHWA.[1]

[1]Federal Highway Administration (FHWA). 2009. *Manual on Uniform Traffic Control Devices for Streets and Highways.* Washington, DC: FHWA.
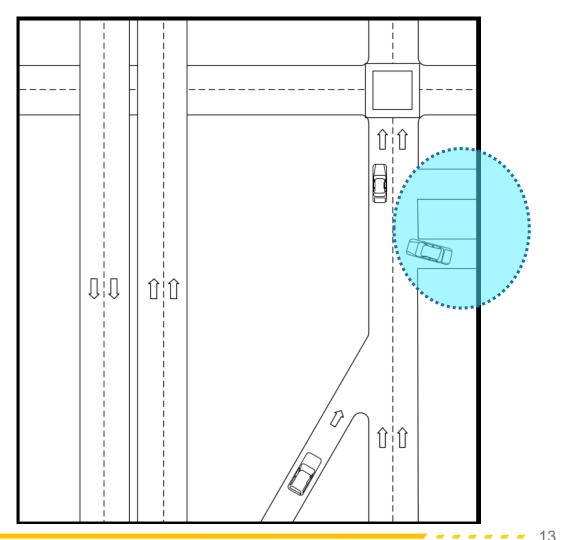
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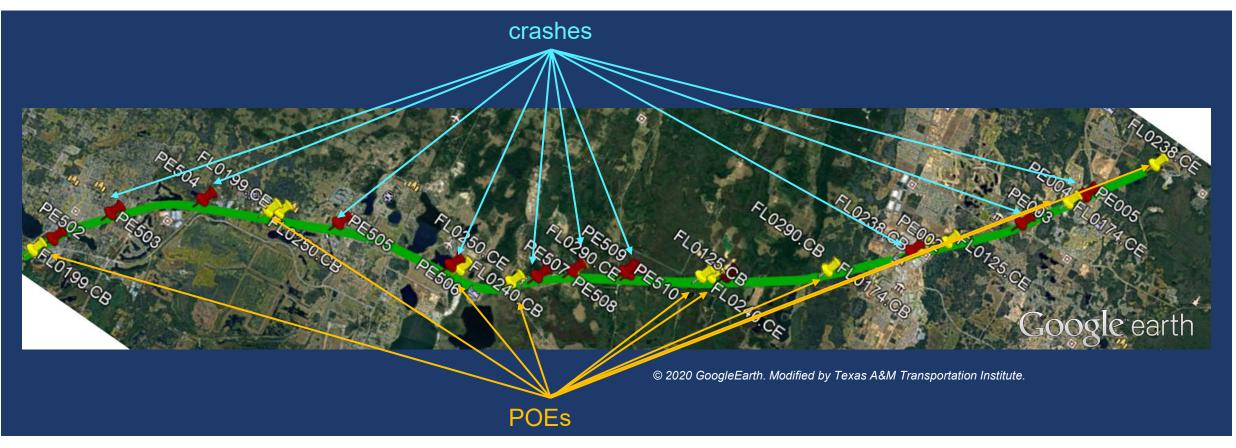
WWD Countermeasures At POE

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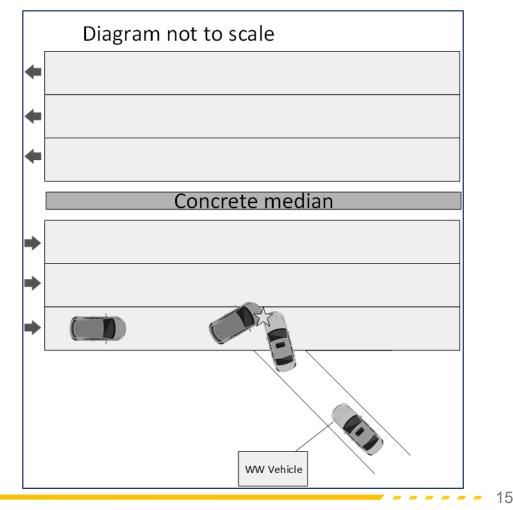
Identifying WWD Crashes and Entry Points

© 2020 GoogleEarth. Modified by Texas A&M Transportation Institute.

From which POE did each crash come?

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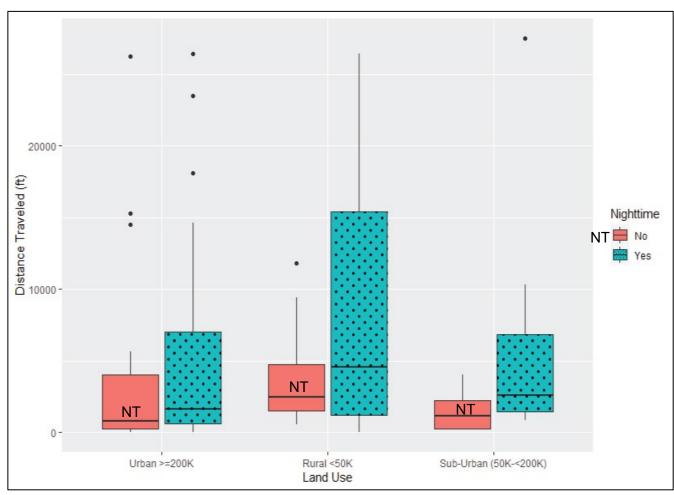Highway Research Center

Review of Crash Narratives in TX

The intent of this review of text and narrative diagrams was to quantify relationships between POE and crash location.

In-Depth Review of TX Crash Narratives

▶ The researchers searched to identify POEs in narratives from 2011 through 2020 (1,300+ TX crash narratives).

▶ The POE could be identified for a total of 192 crashes in that period.

▶ The period from 2016-2019 was supplemented with non-crash corridors and used for analysis.

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Characteristics of WWD Distances Travel prior to Crash

	Observation	Average (mi)	Minimum (mi)	Maximum (mi)	Std dev (mi)
Overall	192	0.71	0.0	5.21	0.97

WWD Crash Databases

Two databases:

▶ Phase I database: 68 WWD crashes and 406 POEs.

▶ Phase II database: 891 WWD crashes and 2,843 POEs.

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Methodology and Analysis

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Analyses at a Glimpse

Databases used for the two-stage analysis:

1. Phase 1: A smaller database of locations with POEs known for every crash.

2. Phase 2: A larger database of crashes linked to a set of potential originating POEs.

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Phase 1 Analysis: POE Known for Crash

The phase 1 analysis included:

► A binomial regression of WWD crash risk (i.e., probability of WWD crash).

► Non-WWD crash locations (randomly selected).

The explanatory variables included:

► Distance traveled from POE to WWD crash location.

► POE geometric features.

► Time of day.

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Phase 1 Results

► Longer WWD travel distances are more likely at night.

► Higher WWD risk with increasing number of driveways and unsigned T-intersections (frontage roads).

► Lower WWD risk with increasing number of signed T-intersections (frontage roads).

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Phase 2

The phase 2 analysis included:

► A binomial regression of WWD crash risk.

► The phase 1 locations (i.e., crash risk = 1.0 for actual POE ; the crash risk = 0.0 for all other potential POEs nearby).

► The non-WWD crash locations (WWD risk for all potential POEs = 0.0).

► The total combined risk of WWD crash nearby POEs defined as 0.85 (i.e., farthest linked POE can be as far as the 85th percentile of known WWD travel distances).

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Phase 2 Data Subsets

▶ Data were subdivided by State (FL and TX).

▶ State data were subdivided into four categories by POE type:
  ▷ Freeway exits at frontage roads intersecting divided roadways.
  ▷ Freeway exits at frontage roads intersecting undivided roadways.
  ▷ Freeway exits at intersections on divided roadways.
  ▷ Freeway exits at intersections on undivided roadways.

Phase 2 Data Subsets

▶ Analyses yielded various statistically significant results in TX.

▶ Analyses yielded only one statistically significant result in FL dataset.

▶ FL dataset was about one-third the size of the TX database.

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Phase 2 Results Overview for Frontage Roads

► Number of driveways directly proportional to WWD crash risk.

► Number of signed T-intersections inversely proportional to WWD crash risk.

► Types of TCDs with statistically significant reductions of WWD crash risk:

  ▷ WW sign.
  ▷ OW sign.
  ▷ Stop bar at point of intersection.
  ▷ Lane path (turning lanes).

Phase 2 Results Overview for Off-Ramps at Intersections

▶ WWD crash risk increases with an increasing number of lanes at an intersection located on an undivided street.

▶ TCDs associated with reduced WWD crash risk:

▷ DNE Signs.

▷ Pavement markings:

- Stop bar.
- Lane use arrow.
- WW arrow.

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CMF Results

Countermeasures at Frontage Roads

Countermeasure	Crash Type	CMF	Lower Limit 95 Percent Confidence	Upper Limit 95 Percent Confidence	Signif.
Remove driveway from frontage[a]	Day WWD	0.870	0.823	0.919	***
Remove driveway from frontage[a]	Night WWD	0.912	0.849	0.980	*
Add signs at a frontage T- intersection[a]	Day WWD	0.622	0.912	0.450	*
Additional WW sign at cross-street intersection[a]	Day WWD	0.490	0.296	0.810	**
Lane path through cross-street intersection[a]	Night WWD crashes	0.387	0.186	0.803	*

*   Significant at the 95.0 percent confidence level.
**   Significant at the 99.0 percent confidence level.
*** Significant at the 99.9 percent confidence level.
a. Base condition: frontage road intersecting divided cross street.

Countermeasures at Intersections with Off-Ramps

Countermeasure	Crash Type	CMF	Lower Limit 95 Percent Confidence	Upper Limit 95 Percent Confidence	Signif.
Ramp lane removal from intersection[a]	Day WWD crashes	0.435	0.232	0.814	*
Ramp lane removal from intersection[a]	Night WWD crashes	0.561	0.326	0.965	~
Lengthening 100 ft of off-ramp[a]	Day WWD crashes	0.928	0.852	1.010	~
Adding STOP_Bar, WW Arrow, or LANEUSE Arrow[a]	Day WWD crashes	0.189	0.028	1.299	~
Adding STOP_Bar, WW Arrow, or LANEUSE Arrow[a]	Night WWD crashes	0.227	0.055	0.944	*
Adding DNE sign[b]	Day WWD crashes	0.358	0.177	0.723	**
Adding DNE sign[b]	Night WWD crashes	0.307	0.149	0.630	**

~ Significant at the 90.0 percent confidence level.
* Significant at the 95.0 percent confidence level.
** Significant at the 99.0 percent confidence level.
a. Base condition: frontage road intersecting divided cross street.
b. Base condition: off-ramp at undivided cross street intersection.

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Economic effectiveness

Estimation of B/C Ratios for Redundant WW Sign

► WWD daytime crashes averaged 0.491 in 3 yr (per combined TX and FL dataset).

► WWD daytime crash reduction of an estimated 51 percent for each additional WW sign in a corridor.

► Sign and post replacement assumed to occur every 2 yr and yielded the following B/C ratios:

▷ B/C ratio = 30.27 for adding 1 redundant WW sign at each POE.

▷ B/C ratio = 22.52 for adding 2 redundant WW signs at each POE.

▷ B/C ratio = 14.00 for adding 4 redundant WW signs at each POE.

Estimation of B/C Ratios for Redundant DNE Sign

▶ WWD nighttime crashes averaged 0.714 in 3 yr (per combined TX and FL dataset).

▶ WWD nighttime crash reduction of 69 percent for each additional DNE sign in a corridor.

▶ Sign and post replacement assumed to occur every 2 yr yielded the following B/C ratios:

  ▷ B/C ratio = 56.22 for adding 1 redundant DNE sign at each POE.

  ▷ B/C ratio = 38.00 for adding 2 redundant DNE signs at each POE.

  ▷ B/C ratio = 21.4 for adding 4 redundant DNE signs at each POE.

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Conclusions

Recommendations for Frontage Roads

► Recommendations for access management along frontage road segments:

▷ Fewer driveways and unsigned T-intersections between off-ramp and cross-road intersections.

▷ Appropriate signs at frontage T-intersections.

► Recommendations for at frontage-road/crossroad intersections:

▷ Consider the use of optional OW and WW signs.

▷ Apply and enhance pavement markings:

• Stop bars.
• Lane paths for turning lanes.

Concluding Remarks and Recommendations for Off-Ramps at Intersections

▶ **Off-ramp geometric design considerations include the following facts:**
- ▷ Fewer ramps at intersections are linked to a lower risk of WWD crashes.
- ▷ Shorter ramps are linked to an increased risk of WWD crashes.

▶ **TCDs to consider include the following:**
- ▷ Vertical signage:
  - DNE signs.
  - Possibly others (not supported by statistical analyses).
- ▷ Pavement markings and delineation:
  - Stop bars.
  - WW arrows.
  - Lane use arrows.

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Questions?

Discussion?

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Thank You!

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