Deterrence and Detection of Wrong-Way Drivers on California Highways

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California Department of Transportation

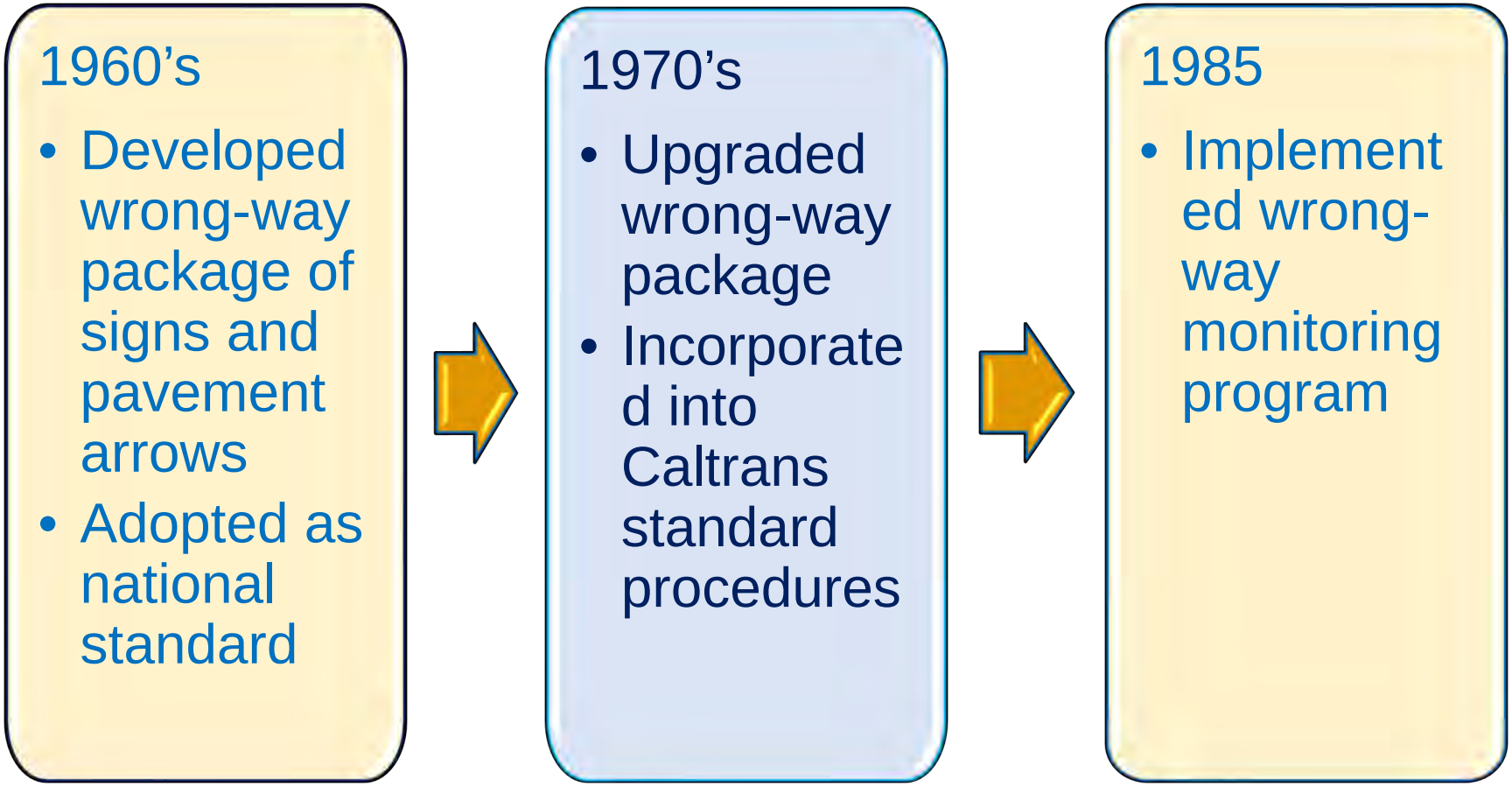
Western States Rural Transportation Technology Implementers Forum

October 5th, 2021

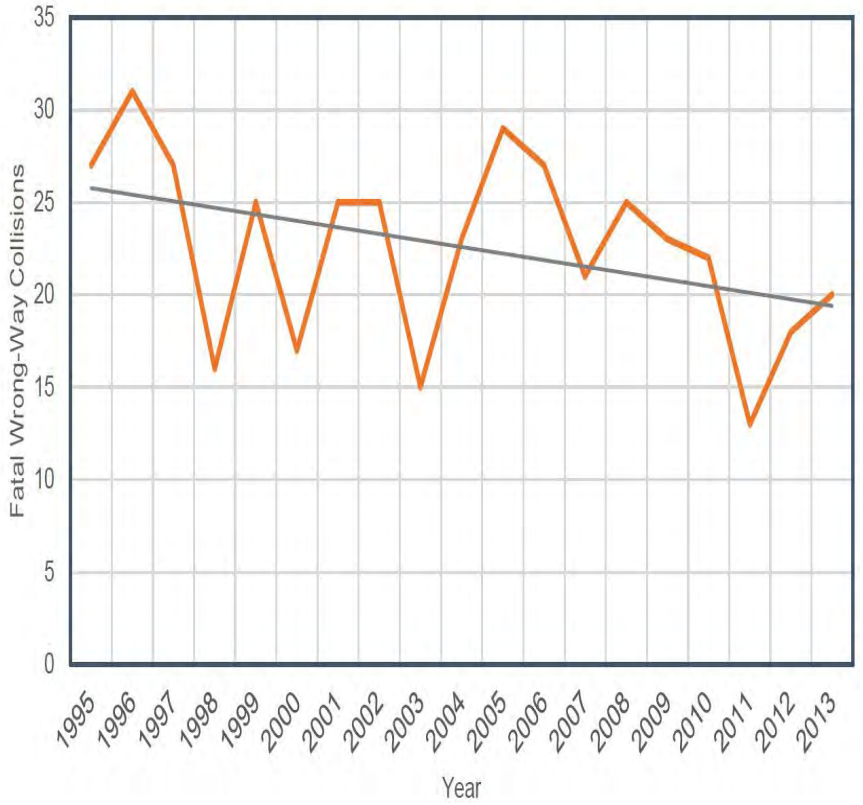
Wrong-Way Collisions

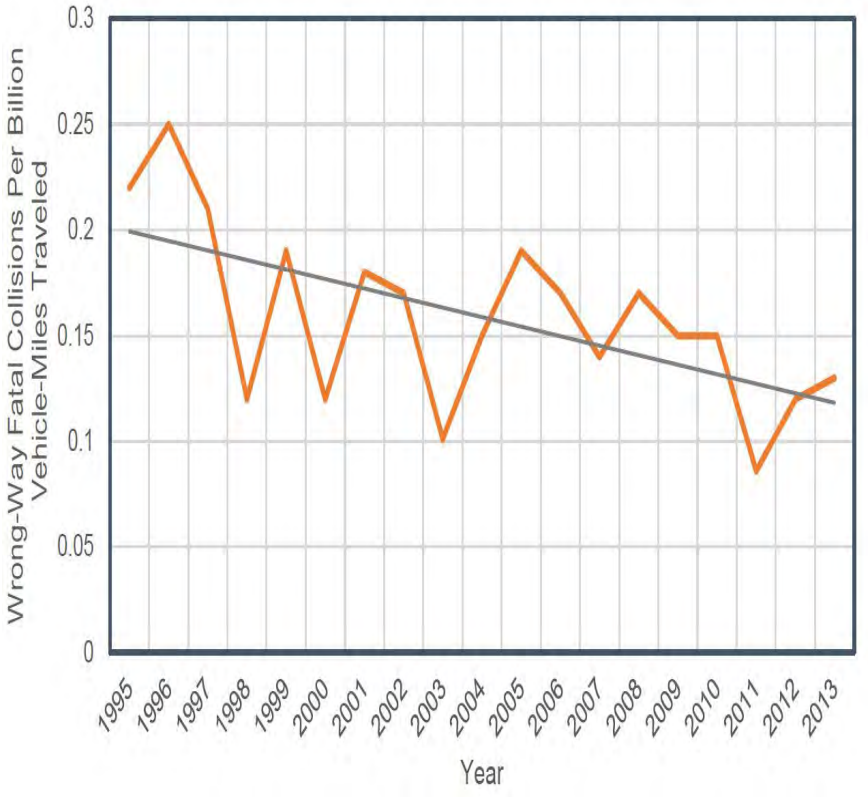
- Wrong-way collisions are rare
- Less than .002% of total highway collisions
- 2.8% of fatal collisions on California highways

Historic Efforts to Combat Wrong-Way Collisions



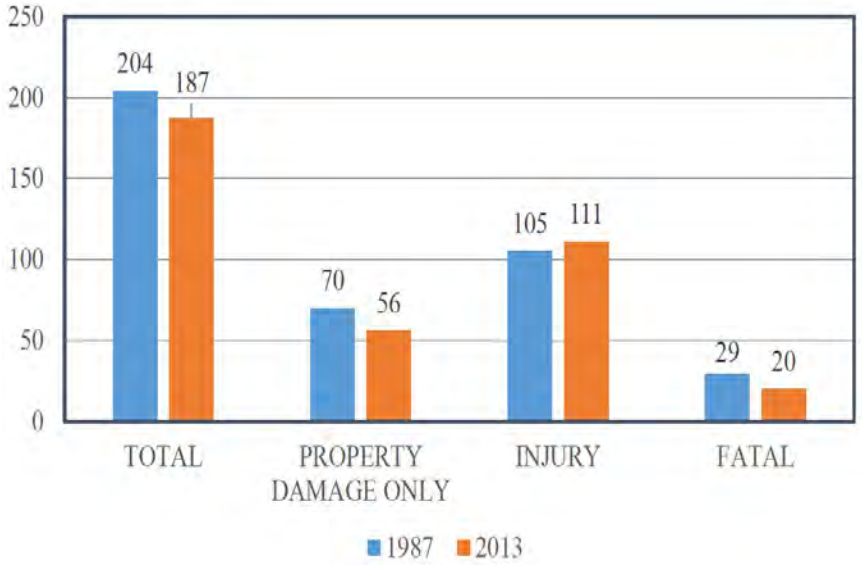
Comparison between Total Number and Rate of Fatal Wrong-Way Collisions on California Freeways and Expressways



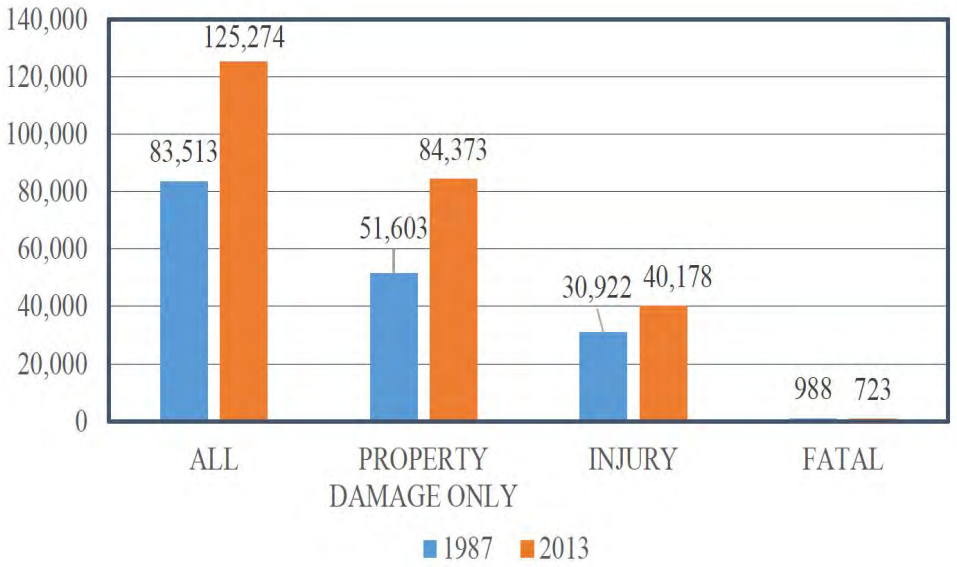


Comparison between Wrong-Way Collisions and all Types of Collisions on California Freeways and Expressways

Wrong-Way Collisions



All Types of Collisions



In the first six months of 2015, 24 people were killed in 10 wrong-way collisions in Sacramento and San Diego.

In May 2015, Caltrans set up a working group to establish pilot projects in both District 3 (Sacramento County) and District 11 (San Diego County).

The pilot projects installed additional two-way, red/clear retroreflective raised pavement markers, enlarged DO NOT ENTER / WRONG WAY signage, and active Detection and Alerting systems with dual radars to detect wrong-way drivers, activate red flashing lights bordering local signage, and transmit real-time notifications to Caltrans and the CHP at their joint Traffic Management Centers (TMC).

2016 Caltrans Wrong-Way Driving Report

- Updated the Caltrans 1989 report
- Reviewed methodological and technological advancements studied by academia and implemented by state departments of transportation
- Described staff meetings with TxDOT and FDOT to see firsthand and discuss the techniques and systems being used and piloted in these states.
- Described plans for the deterrence and detection pilot projects in the Sacramento and San Diego areas

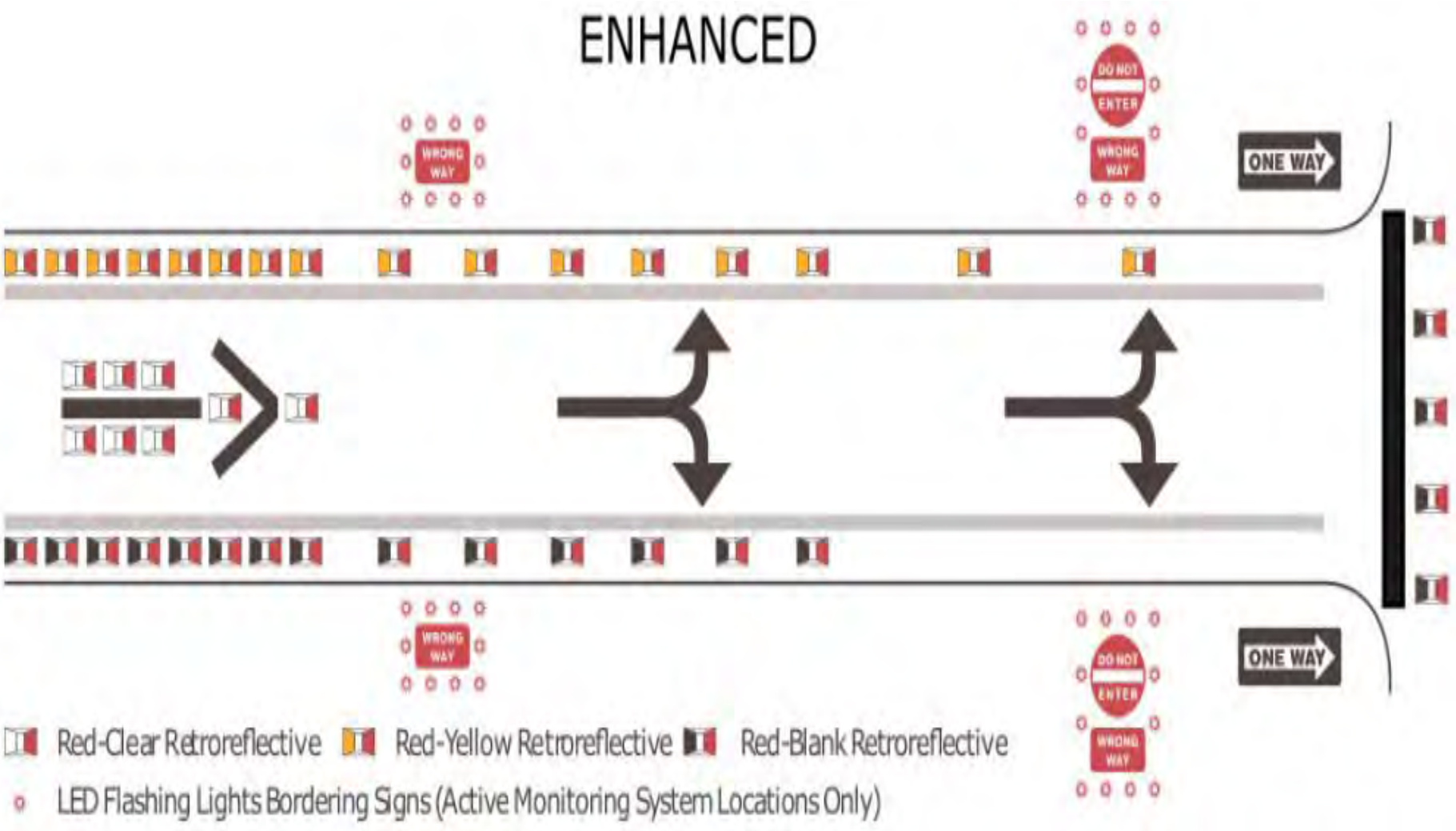
Wrong-Way Deterrence and Detection Pilot Projects in Caltrans Districts 3 and 11

60 exit ramps

SR-15 & I-15 between I-805 & SR-78

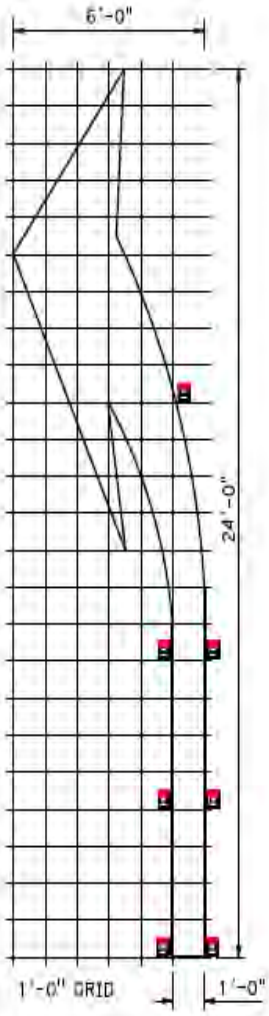
16 exit ramps

I-80, & US-50


ENHANCED
WRONG WAY
DO NOT ENTER
WRONG WAY
ONE WAY
WRONG WAY
DO NOT ENTER
WRONG WAY
ONE WAY
Red-Clear Retroreflective
Red-Yellow Retroreflective
Red-Blank Retroreflective
LED Flashing Lights Bordering Signs (Active Monitoring System Locations Only)

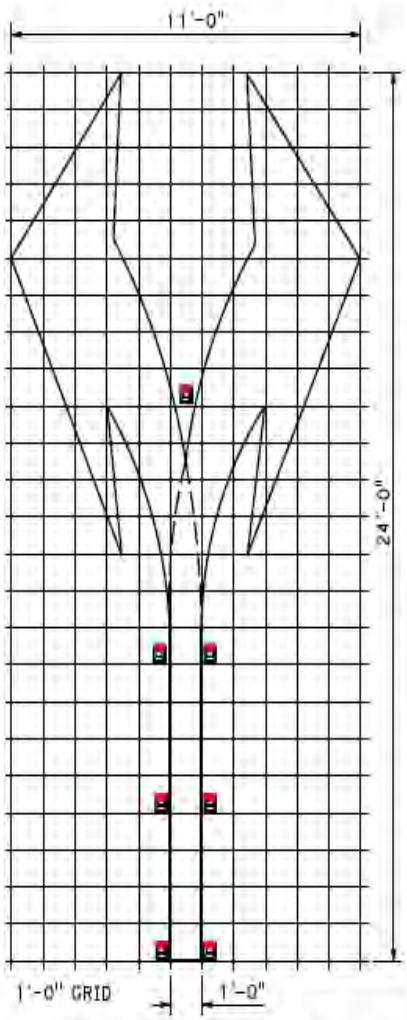
NOTE:

SEE STANDARD PLANS A20A AND A24B FOR INFORMATION NOT SHOWN.

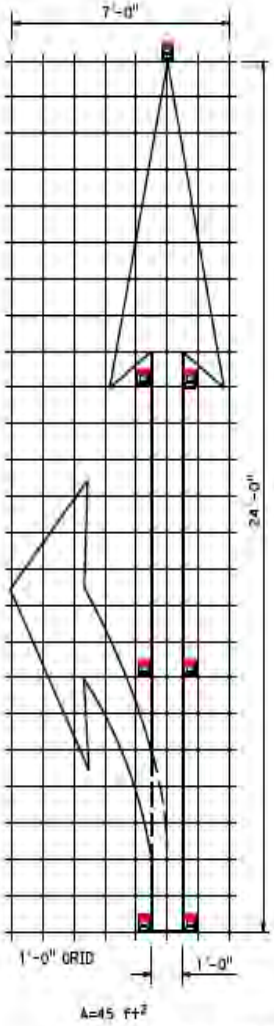


TYPE III (L) ARROW

(For Type III (R) use mirror image)

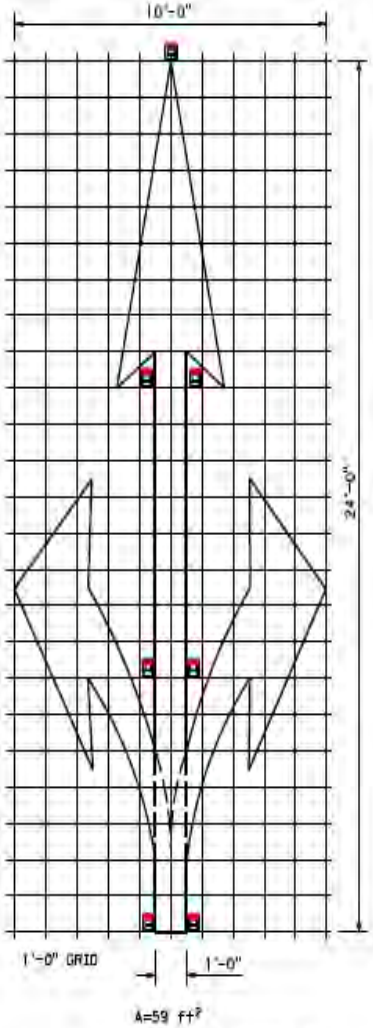


TYPE III (B) ARROW

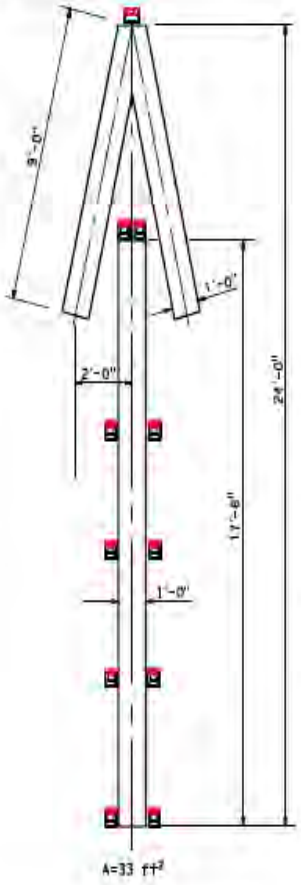


TYPE II (L) ARROW

(For Type II (R) use mirror image)



TYPE II (B) ARROW



TYPE V ARROW

NOTE:

Minor variations in dimensions may be accepted by the Engineer.

TYPE (R/C) MARKER

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

WRONG WAY
PAVEMENT MARKINGS
ARROWS AND SYMBOLS

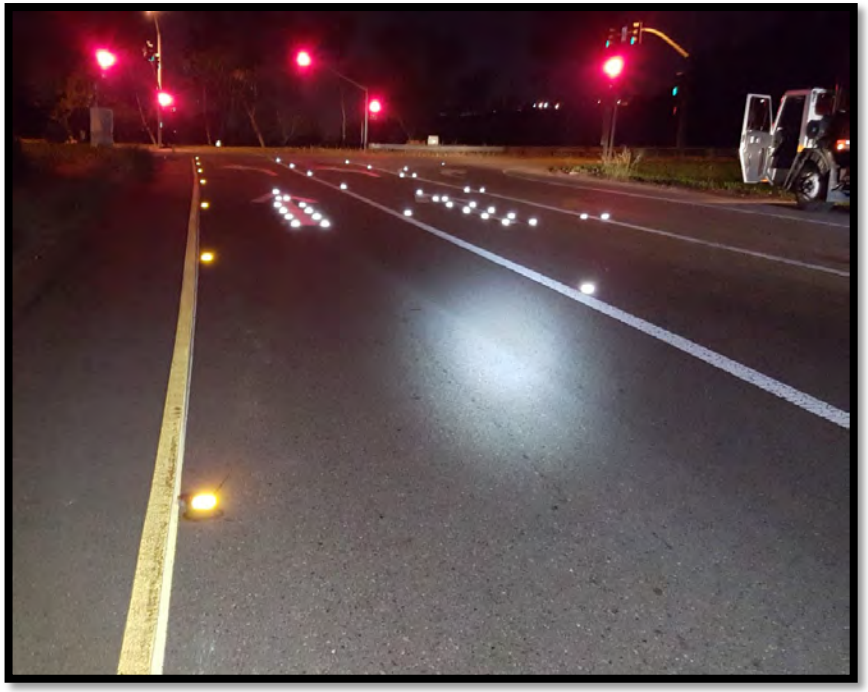
NO SCALE

A24 A/B (MOD)

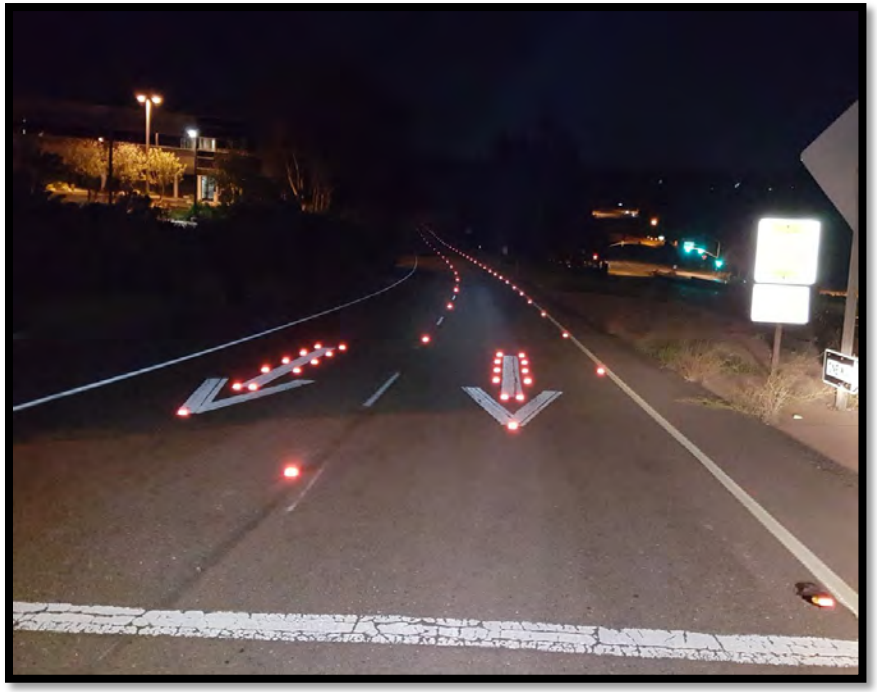
2015 STANDARD PLAN A24 A/B (MOD)

Two-Way Retro-Reflective Pavement Markers

Right-Way Driver View

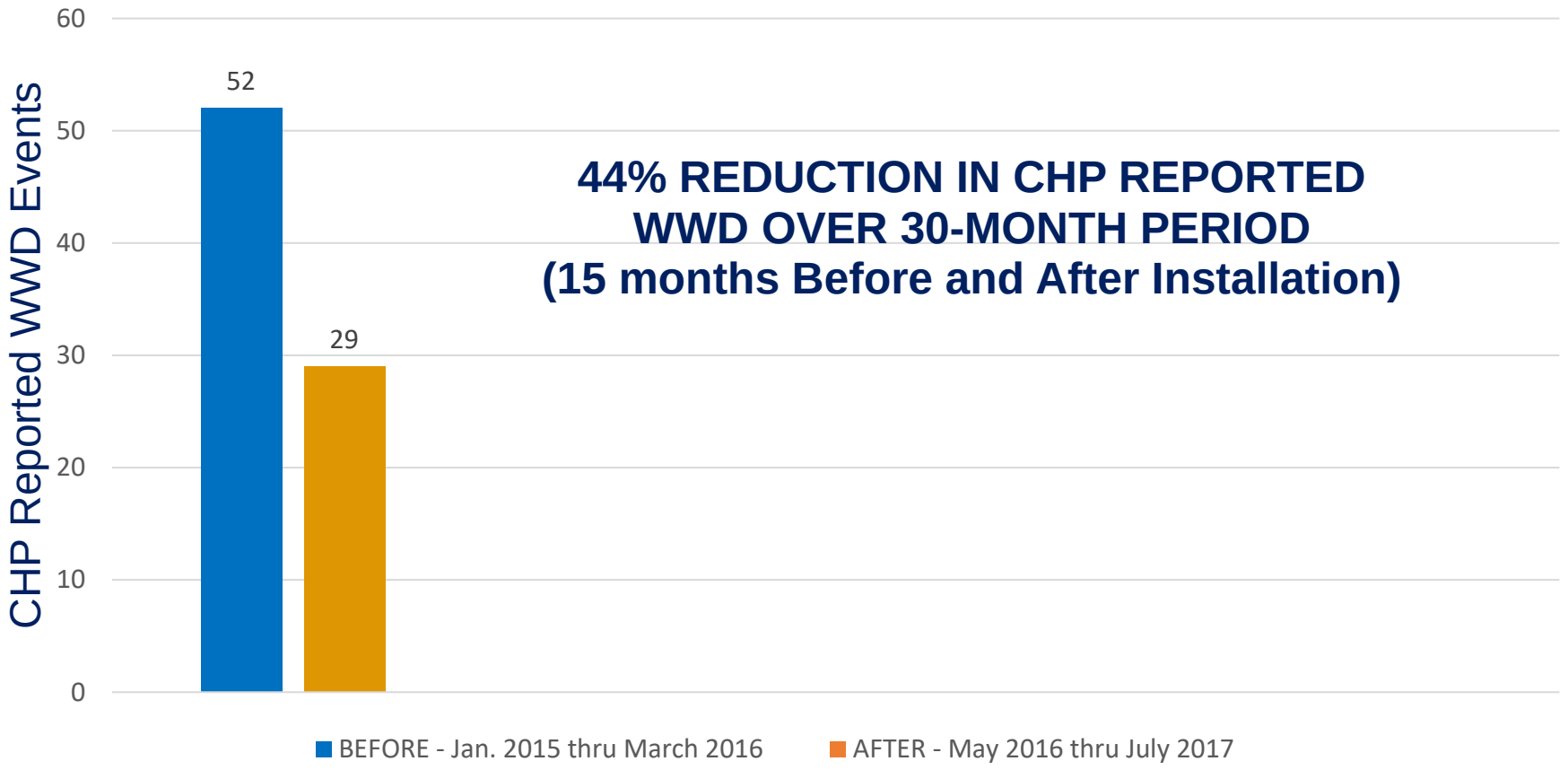


Wrong-Way Driver View



Enlarged Do Not Enter/Wrong Way Signs

Reduction in CHP Reported Wrong-Way Driver Collisions in District 11 Before and After Installation of Red-on-Backside raised reflective pavement markers



Radar-based Active Detection and Alerting Systems were installed on a subset of exit ramps.

6 Ramps: Signage with TAPCO detection and alerting systems

4 Ramps: Signage with TAPCO detection and alerting systems
2 Ramps: Signage with TraffiCalm detection and alerting systems

DIST	COUNTY	ROUTE	POST MILES TOTAL PROJECT	SHEET No.	TOTAL SHEETS
03	Sac	50	Varies		

REGISTERED CIVIL ENGINEER DATE

PLANS APPROVAL DATE

The State of California or its officers or agents shall not be responsible for the accuracy or completeness of scanned copies of this plan sheet.

TABLE A

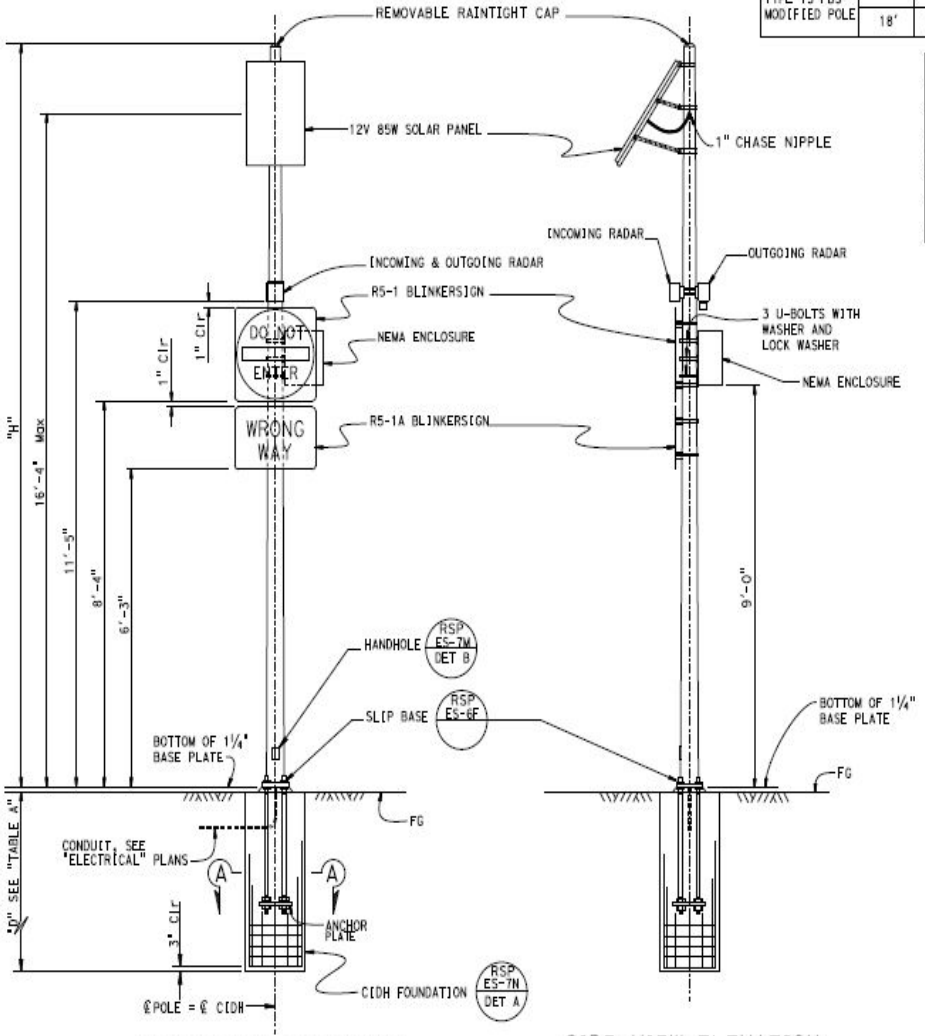
POLE TYPE	POLE DATA				BASE PLATE DATA				"D" 2'-6" ø CIDH PILE
	HEIGHT "H"	Min OD		THICKNESS	"C"	THICKNESS	HS ANCHOR BOLTS		
		BASE	TOP				SIZE	BC = BOLT CIRCLE	LEVEL GROUND
TYPE 15-FBS MODIFIED POLE	18'	8"	5¾"	0.1196"	See 2010 RSP ES-6F				8'-0"

TABLE B

ATTACHMENT	DIMENSION	MOUNTING HEIGHT	WEIGHT LIMITS (lbs)
Nema Enclosure	17"W x 22"H x 12"D	9'-0" bottom Clr	30 ± 10%
R5-1A Blinkersign	36"W x 24"H	6'-3" bottom Clr	15 ± 10%
R5-1 Blinkersign	36"W x 36"H	8'-4" bottom Clr	16 ± 10%
Incoming Radar	7¼"W x 7⅛"H x 5⅜"D	11'-5" bottom Clr	11 ± 10%
Outgoing Radar	7¼"W x 7⅛"H x 5⅜"D	11'-5" bottom Clr	11 ± 10%
Solar Pannel	26½"W x 40"H x 2"D	16'-4" Max	48 ± 10%
			TOTAL 131 ± 5%

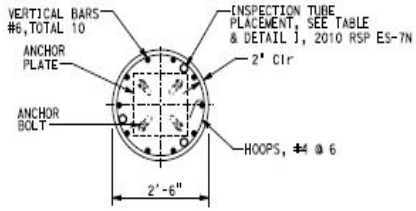
TABLE C

PHOTOVOLTAIC PANEL LIMITS	
PANEL SIZE	TILT ANGLE
7.5 ft^2 ±	45° Min



FRONT VIEW ELEVATION

SIDE VIEW ELEVATION



SECTION A-A

SEE 2010 RSP ES-7N

CHASE NIPPLE DETAIL

GENERAL NOTES:

SPECIFICATIONS

Design: AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, Sixth Edition

LOADING

Wind Loading : (3 sec gust) 100 mph

UNIT STRESSES

Structural Steel: fy = 55,000 psi tapered steel tube
fy = 50,000 psi unless otherwise noted.

Anchor bolts: fy = 105,000 psi unless otherwise noted.

Reinforced Concrete: f'c = 3,600 psi
fy = 60,000 psi

NOTES:

1. For pole location, see"Roadway Plans".
2. All steel must be galvanized after fabrication.
3. During pole erection the post shall be raked as necessary with the use of leveling nuts to provide a plumb pole axis.
4. The foundation shall be treated as level ground condition if the slope inclination is flatter than 4H:1V.
5. Foundation design is based on AASHTO LTS-6 article 13.6 Broms' approximate procedure assuming a cohesionless material. The angle of internal friction used is 30 degrees and unit weight of soil used is 120 lbs/ft .
6. All attachments, unless otherwise noted, must be mounted to pole with stainless steel straps or other method without drilling holes in pole.
7. For Type 15-FBS Pole details not shown, see "2010 REVISED STANDARD PLANS ES-7J".
8. For details not shown, see "2010 STANDARD PLANS" and "2010 REVISED STANDARD PLANS".

THE CONTRACTOR MUST VERIFY ALL CONTROLLING FIELD DIMENSIONS BEFORE ORDERING OR FABRICATING ANY MATERIAL.

NO SCALE

STANDARD PLAN SHEET No.

DETAIL SHEET No.

BRANCH CHIEF JEFFREY B WOODY

	BY	CHECKED
DESIGN	ELISEO LOPEZ	STANLEY P. JOHNSON
DETAILS	T. NGUYEN	STANLEY P. JOHNSON
QUANTITIES		

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION

DIVISION OF ENGINEERING SERVICES
DESIGN AND TECHNICAL SERVICES
SPECIAL DESIGNS BRANCH A

BRIDGE NO.	WRONG WAY DETECTION SYSTEM	SES-1
N/A		
POST MILE	TYPE 15-FBS MODIFIED POLE DETAILS	
VARIES		

(ENGLISH) SPECIAL DESIGNS BRANCH BORDER SHEET (REV. 7-1-09)

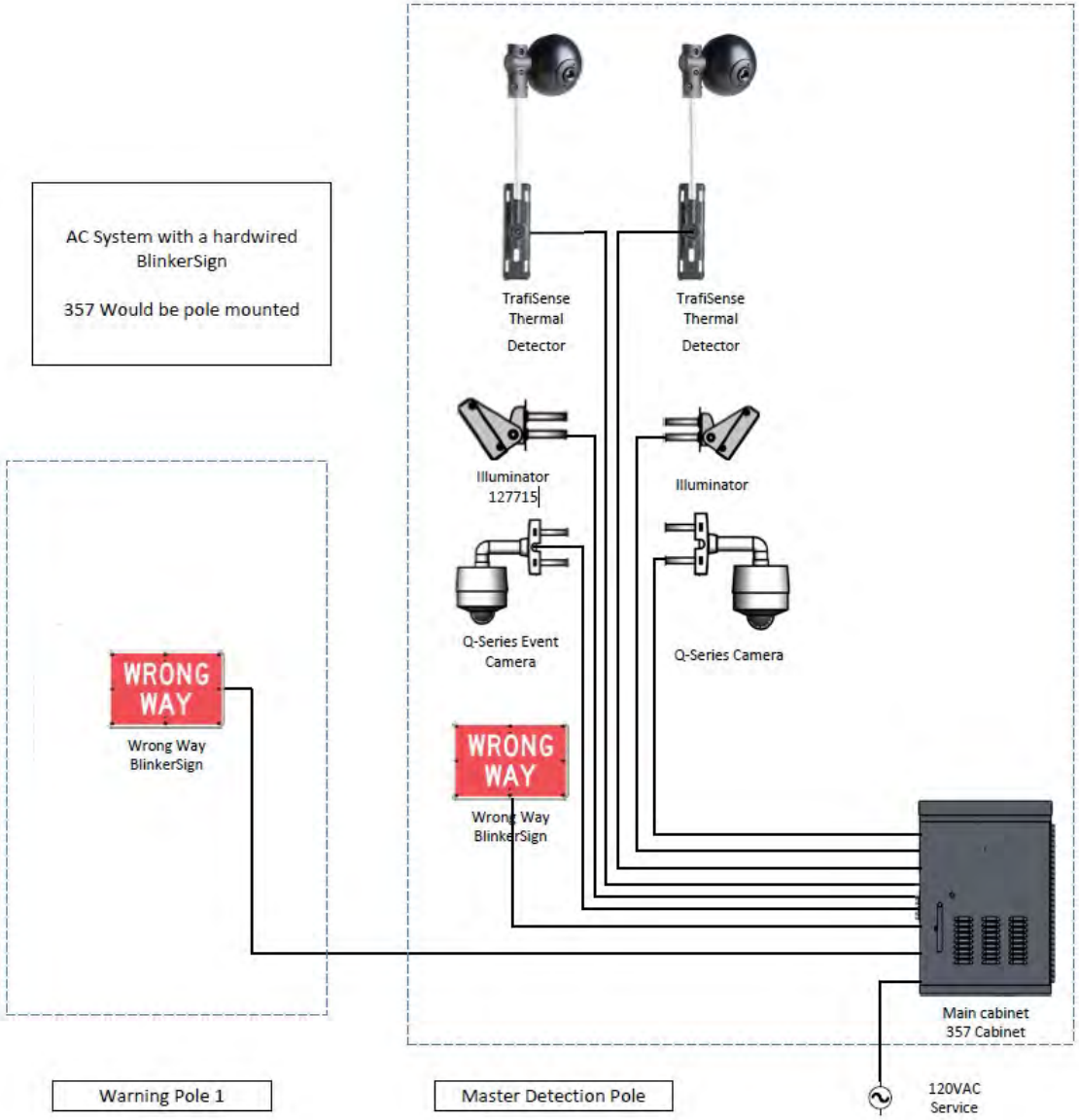
ORIGINAL SCALE IN INCHES FOR REDUCED PLANS 0 1 2 3

UNIT: 3619
PROJECT NUMBER & PHASE: 0316000054-1
CONTRACT NO.: 03-1H0701

DESIGNERS PRINTS BEARING EARLIER REVISION DATES

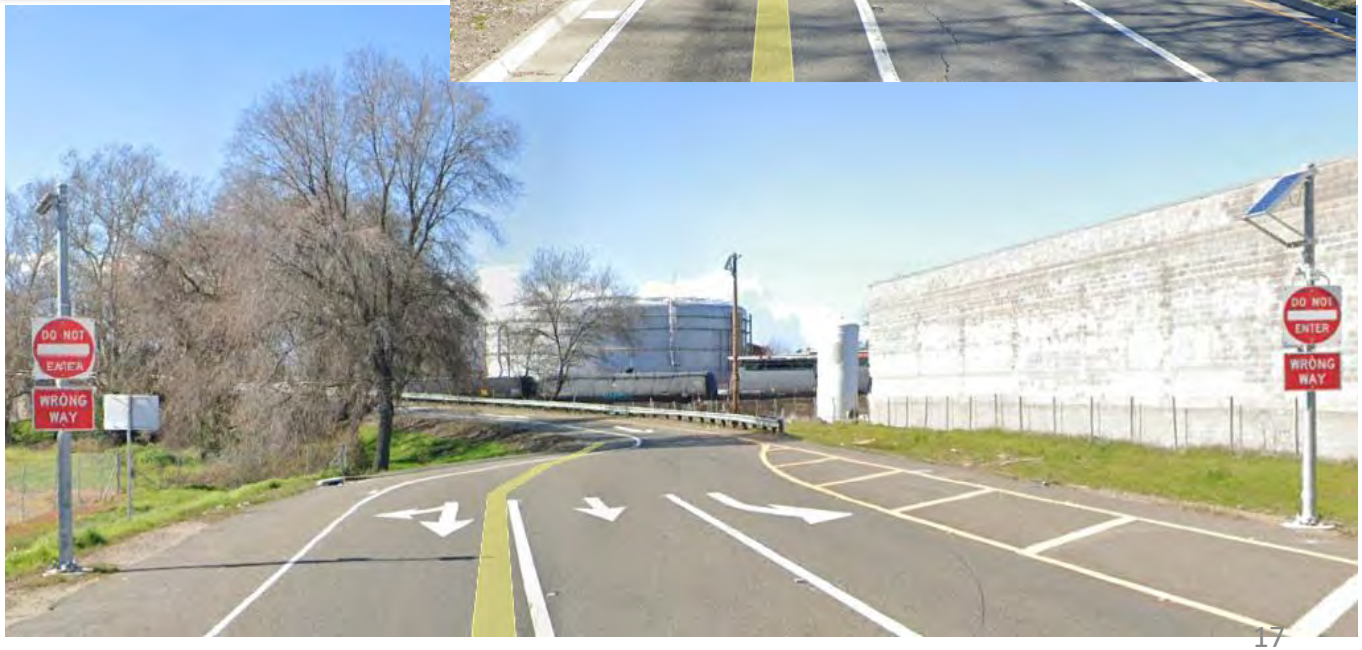
REVISION DATES				SHEET	OF
DATE	DATE	DATE	DATE		

The latest TAPCO wrong way detection systems use thermal imaging sensors and infrared illuminators instead of radar detectors

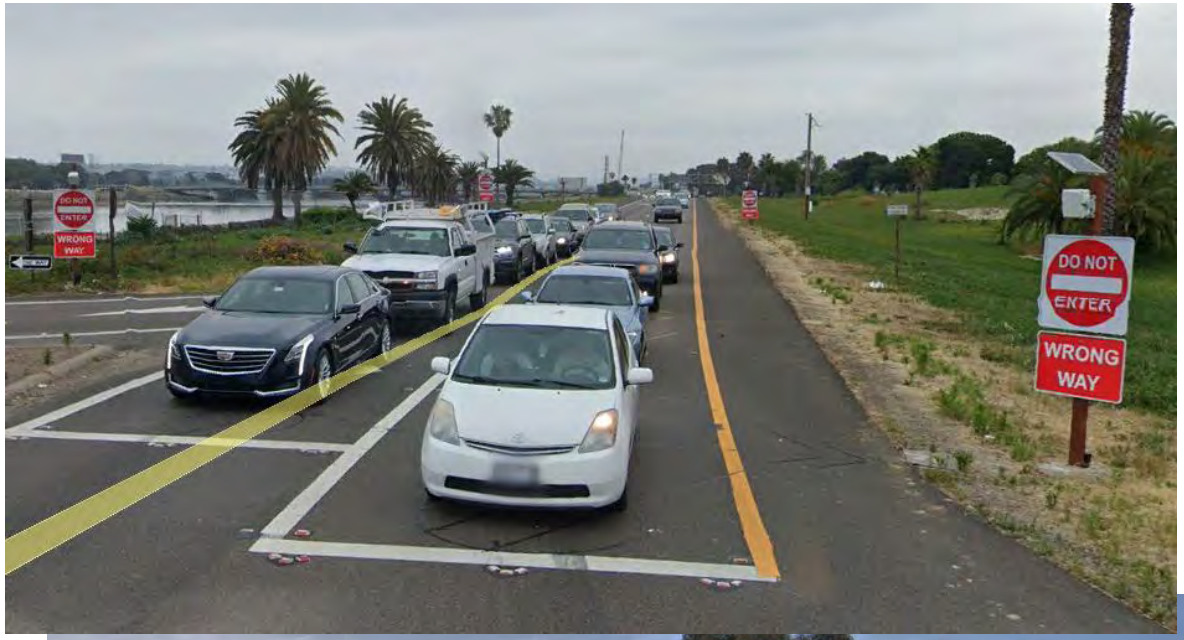


TAPCO System at 5th Street & EB US 50 in District 3

TAPCO System at Jefferson Blvd & WB US 50 in District 3

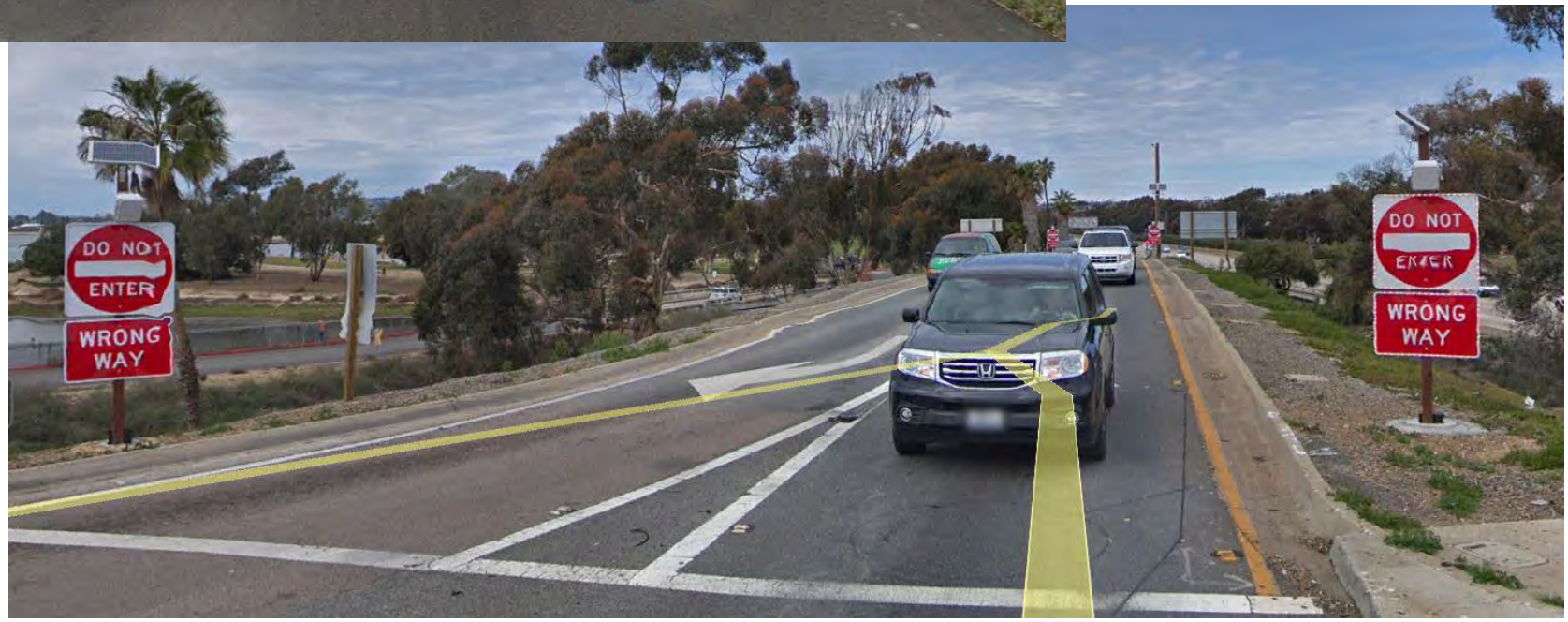


TAPCO System at South River Road & WB US 50 in District 3 >



TraffiCalm System at Sunset Cliffs Blvd & WB I-8 in District 11

TraffiCalm System at Sea World Drive & SB I-5 in District 11




BlinkLink
vd Alert Time: 11/17/2019 11:30:14 PM Powered by TAPCO
BlinkLink
v:
B off-ramp from El Cajon Blvd Alert Time: 11/17/2019 11:30:14 PM Powered by TAPCO
: 11/17/2019 11:30:08 PM Power


Correct Traffic Flow:
BlinkLink
System: SR15 NB off-ramp from El Cajon Blvd Alert Time: 11/17/2019 11:30:14 PM Powered by TAPCO


BlinkLink
Powered by TAPCO

Caltrans' Division of Research, Innovation and System Information (DRISI) conducted a research project to study the effectiveness of the exit-ramp enhancements in Districts 3 and 11.

The main objective of the research is to determine:

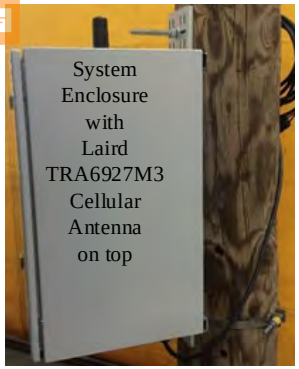
- Extent and characteristics of the WWD problem.
- Effectiveness of the off-ramp enhancements. – Before and After
- Accuracy of the TAPCO and TraffiCalm active detection and alerting systems

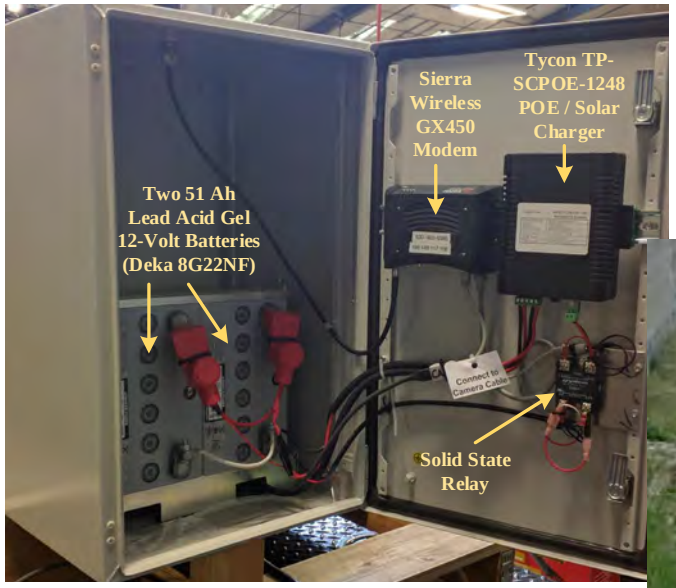
DRISI partnered with its research contractor, the Advanced Highway Maintenance and Construction Technology Research Center (AHMCT), at the University of California at Davis, to independently monitor the 6 TAPCO-equipped Exit-ramps in District 3 and the 2 TraffiCalm-equipped Exit-ramps in Distrct11.

Caltrans DRISI
Caltrans Division of Research, Innovation and System Information

UCDAVIS

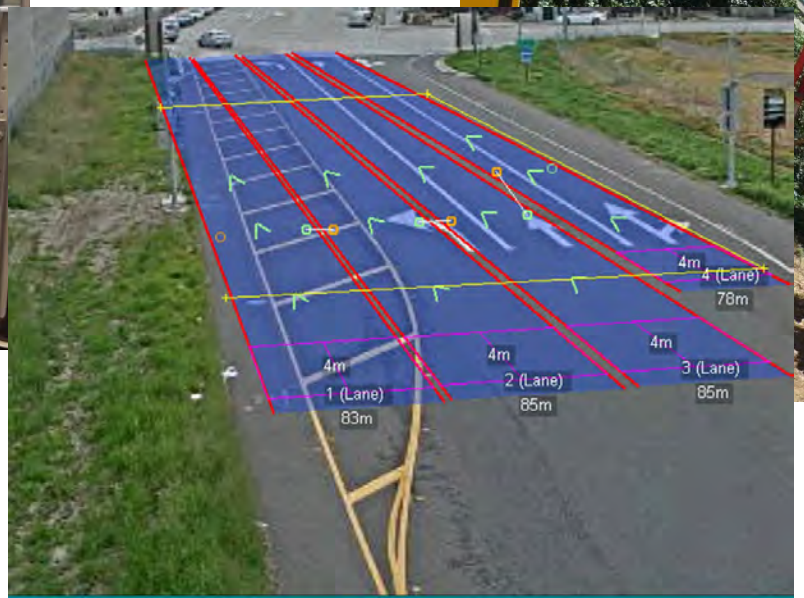
AHMCT
ADVANCED HIGHWAY MAINTENANCE & CONSTRUCTION TECHNOLOGY RESEARCH CENTER

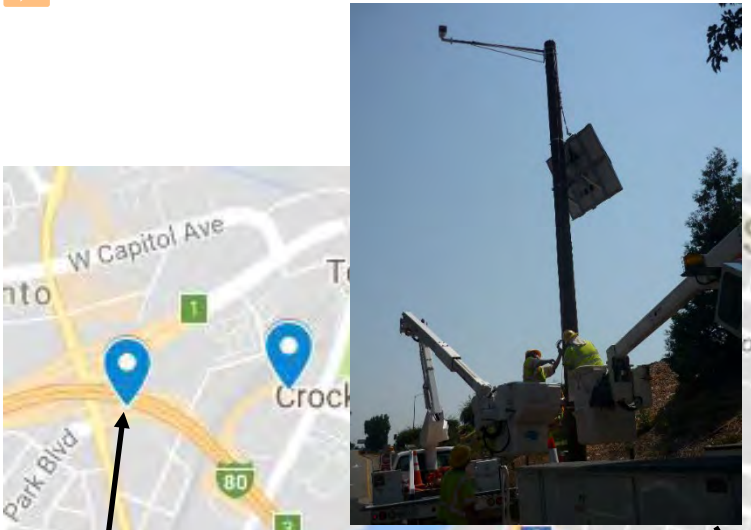




The AHMCT researchers developed and installed zone-triggered video-based site monitoring (VBSM) systems at 8 off-ramps on which active detection and alerting systems were later installed.

4 more of VBSMs were installed at control off-ramps not receiving enhancements.





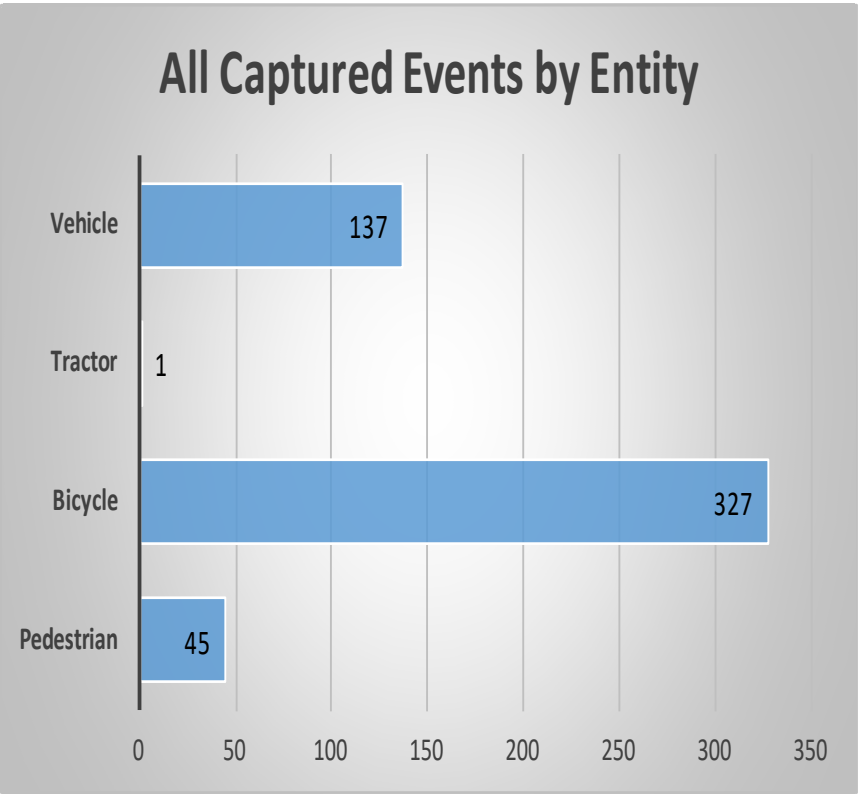
arrow
W Capitol Ave
Park Blvd
S River Rd
I St
9th St
10th St
California
Capitol Mus
MIDTOWN
Q St
S St
16th St
19th St
21st St
Ace of Spades
Southside Park
Alhambra Blvd
33rd St
Folsom Blvd
Stockton Bl
D St
Kinley Park
NEWTON BOO
Broadway
Broadway
21st St
80
50
5
3
1
4A
4B
5C
6A
6B
6C
7B

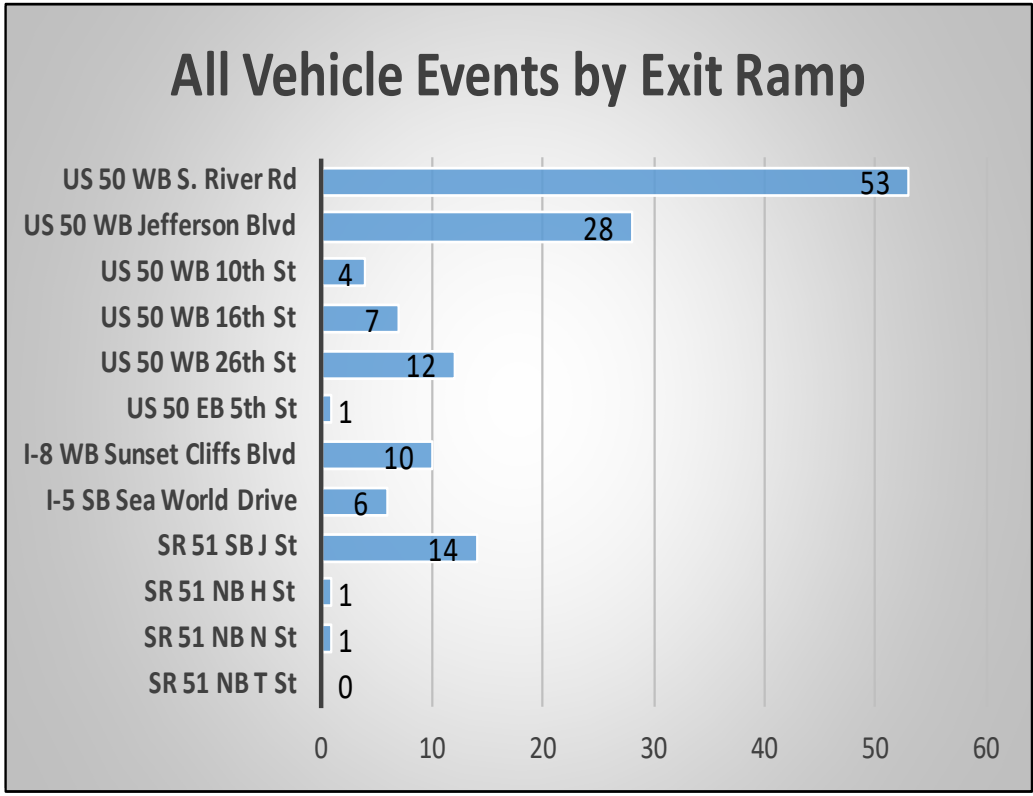

DO NOT
ENTER
WRONG
WAY


Tecolote Rd
Morena Blvd
Univ of San Diego

Giant Dipper
Roller Coaster
Belmont Park
Mission Beach Park
Mission Bay Channel
Mariner's Point Park
Perez Cove
Fiesta Island Rd
Tecolote Creek
Tecolote Canyon Natural Park and Nature...
Hyatt Regency Mission Bay Spa and Marina
SeaWorld San Diego
Hospitality Point
Marina Village Conference Center
South Shores Park
Mission Valley
Point Medanos
Ocean Beach Athletic Area Robb Field
Mariner's Cove Apartments
Dusty Rhodes Park
TEMECULA HEIGHTS
Old Town San Diego State Historic Park
Whaley House Museu
W Mission Bay Dr
Quivira Rd
Quivira Way
Sea World Dr
S Shores Rd
Friars Rd
Pacific Hwy
Mission Blvd
Bayside Ln
Strandway
Mariners Basin
Ingraham St
Sunset Cliffs Blvd
Nimitz Blvd
Camino Del Rio W
Morena Blvd
Tecolote Rd
W Morena Blvd
East Mission Bay Dr

The UC Davis VBSMs captured 510 total events, of which only 137 were caused by vehicles





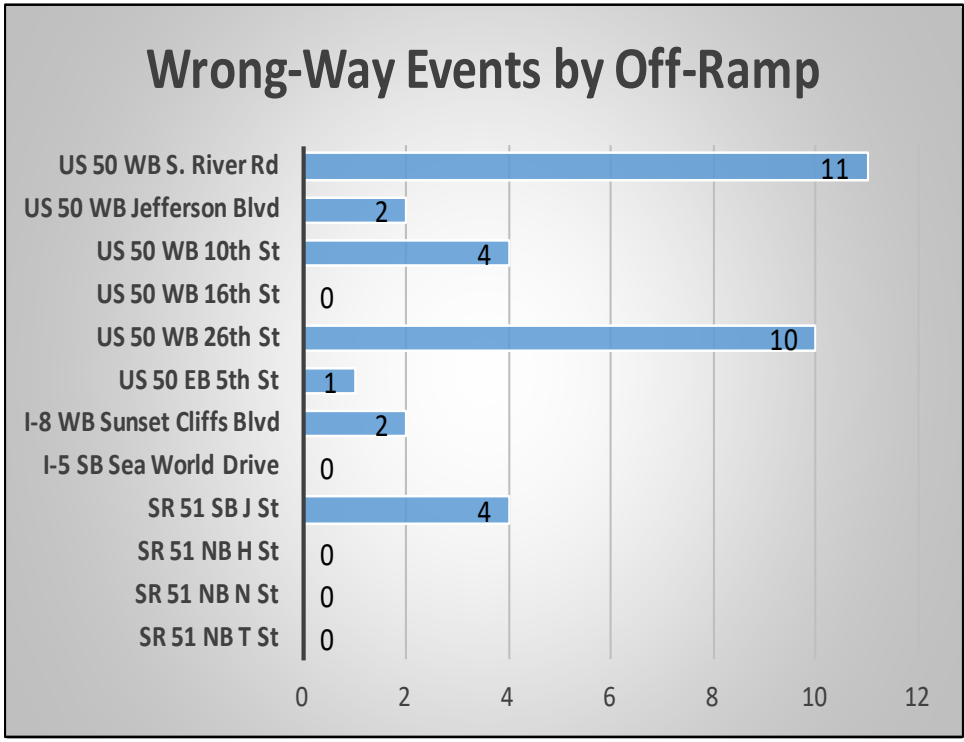
Of those 137 vehicle events, only 34 were considered wrong way driving behavior.

County	Route	PM	Off Ramp	Direction	Purpose	Installation date	Verified WWD events
Yolo	50	2.811	5th Street / South River Road	WB	active	June 13th, 2016	11
Yolo	50	2.812	Jefferson Blvd.	WB	active	June 13th, 2016	2
Sacramento	50	L0.398	5th & X Streets	EB	active	August 23rd, 2016	1
Sacramento	50	L1.437	10th & W Streets	WB	active	August 23rd, 2016	4
Sacramento	50	L1.600	16th & W Streets	WB	active	August 23rd, 2016	0
Sacramento	50	L2.396	26th & W Streets	WB	active	August 23rd, 2016	10
Sacramento	51	0.086	30th & T Streets	NB	control	June 6th, 2016	0
Sacramento	51	0.579	30th & N Streets	NB	control	June 6th, 2016	0
Sacramento	51	1.066	30th & H Streets	NB	control	June 16th, 2016	0
Sacramento	51	1.255	29th & J Streets	SB	control	June 6th, 2016	4
San Diego	5	R20.96	Sea World Drive	SB	active	December 13th, 2017	0
San Diego	8	T0.10	Sunset Cliffs Boulevard	WB	active	December 13th, 2017	2

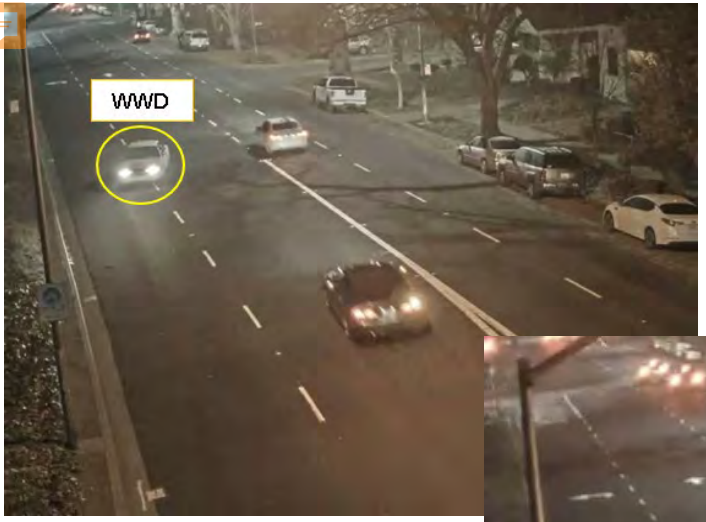
All VBSM-captured WWD events classified by off-ramp and group

Off-ramp	Quantity	Percent	Events/year
US 50 WB S. River Rd	11	32.4%	3.4
US 50 WB Jefferson Blvd	2	5.9%	0.6
US 50 WB 10th St	4	11.8%	1.3
US 50 WB 16th St	0	0.0%	0.0
US 50 WB 26th St	10	29.4%	3.3
US 50 EB 5th St	1	2.9%	0.3
I-8 WB Sunset Cliffs Blvd	2	5.9%	1.2
I-5 SB Sea World Drive	0	0.0%	0.0
SR 51 SB J St	4	11.8%	1.2
SR 51 NB H St	0	0.0%	0.0
SR 51 NB N St	0	0.0%	0.0
SR 51 NB T St	0	0.0%	0.0
Total	**34**	**100.0%**	

By off-ramp group	Quantity	Percent	Events/year/ramp
Sacramento ramps with mitigation	28	82.4%	1.5
San Diego ramps with mitigation	2	5.9%	0.6
Sacramento ramps without mitigatior	4	11.8%	0.3



A Particularly Dangerous WWD Trajectory was Captured on 10th Street & WB US 50 Off-Ramp.



35.3% of WWD events were drivers entering an exit-ramp while travelling the wrong way on a municipal one-way street.

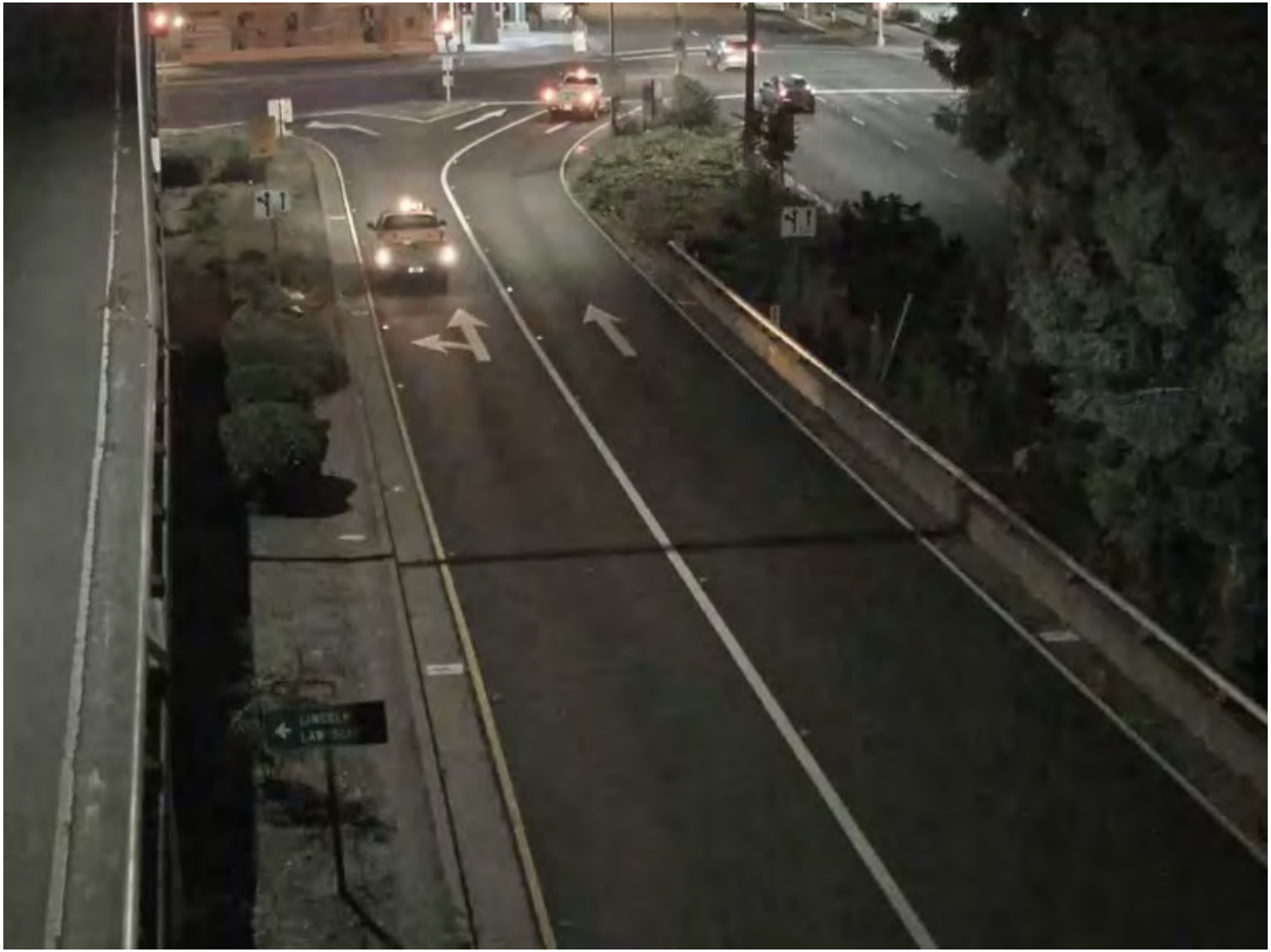
Not all detected wrong way movements were caused by motor vehicles.

Not all detected wrong way movements were unintentional.

Not all detected wrong way movements were unintentional 2.

Not all detected wrong way movements were unintentional 3.

Not all detected wrong way movements were unintentional 4.



Not all detected wrong way movements were unintentional 5.

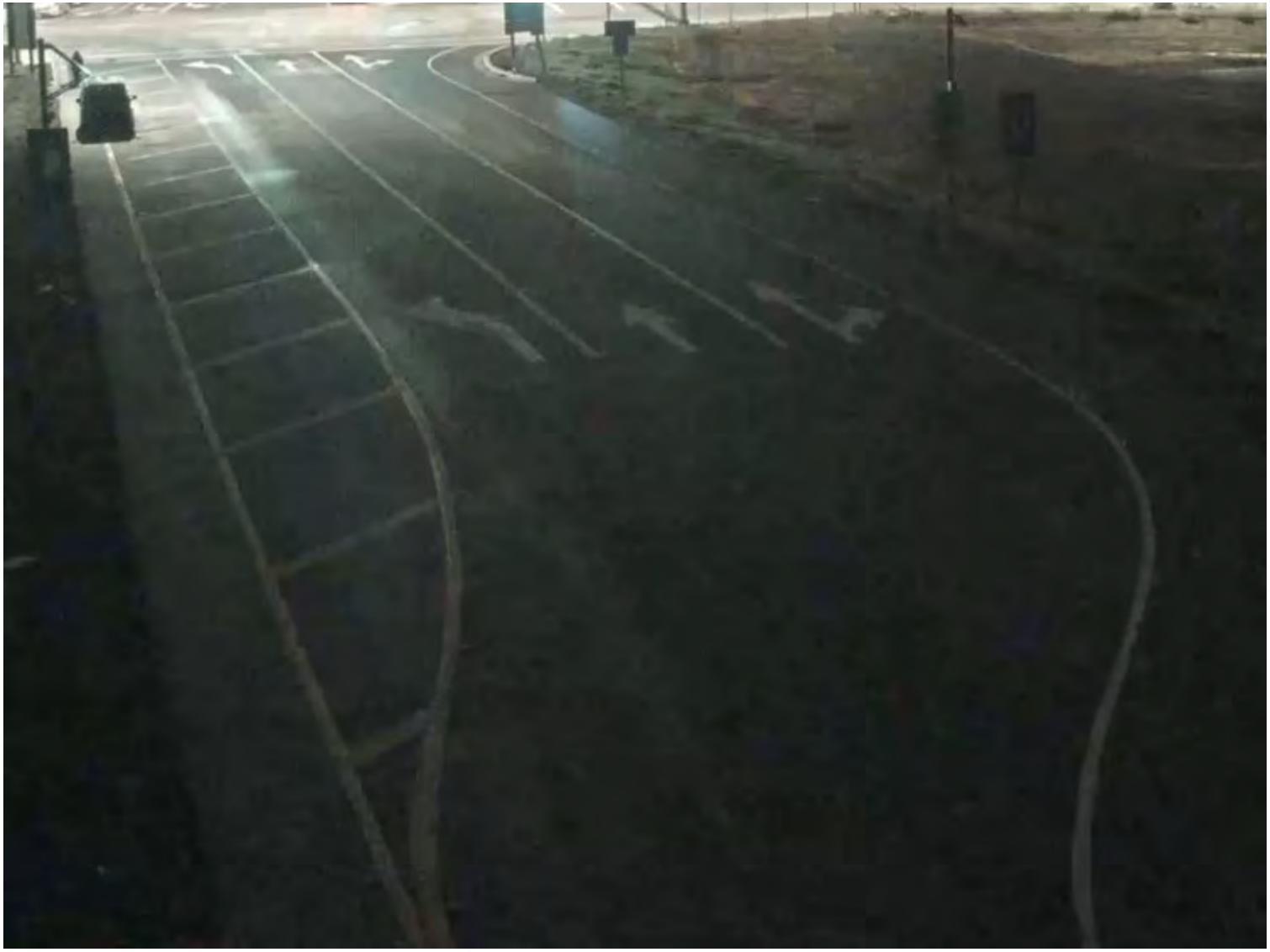
Other wrong way movements caused by mistakes by drivers

Other wrong way movements caused by mistakes by drivers 2

Other wrong way movements caused by mistakes by drivers 3

Other wrong way movements caused by mistakes by drivers 4

Other wrong way movements caused by mistakes by drivers 5



Results

Extent and characteristics of the WWD problem.

Even for the 3 ramps most prone to wrong way driving, the percentage of wrong way vehicles was very low.

Ramp	Average Yearly Traffic	Average Yearly Wrong Way Traffic	Percentage of Traffic in the Wrong Direction
WB US 50 at South River Road	2,901,600	3.4	0.000117%
WB US 50 at 26th Street	3,762,470	3.3	0.000088%
WB US 50 at 10th Street	3,178,940	1.3	0.000041%

Extent and characteristics of the WWD problem.

For the 34 total VBSM-detected wrong-way events, the driver self-corrected 85.3% of the time

Driver-corrected	Quantity	Percent
Yes	29	85.3%
No	5	14.7%
Total	**34**	**100.0%**

For the 34 total VBSM-detected wrong-way events, the drivers entered the exit ramps in three ways:

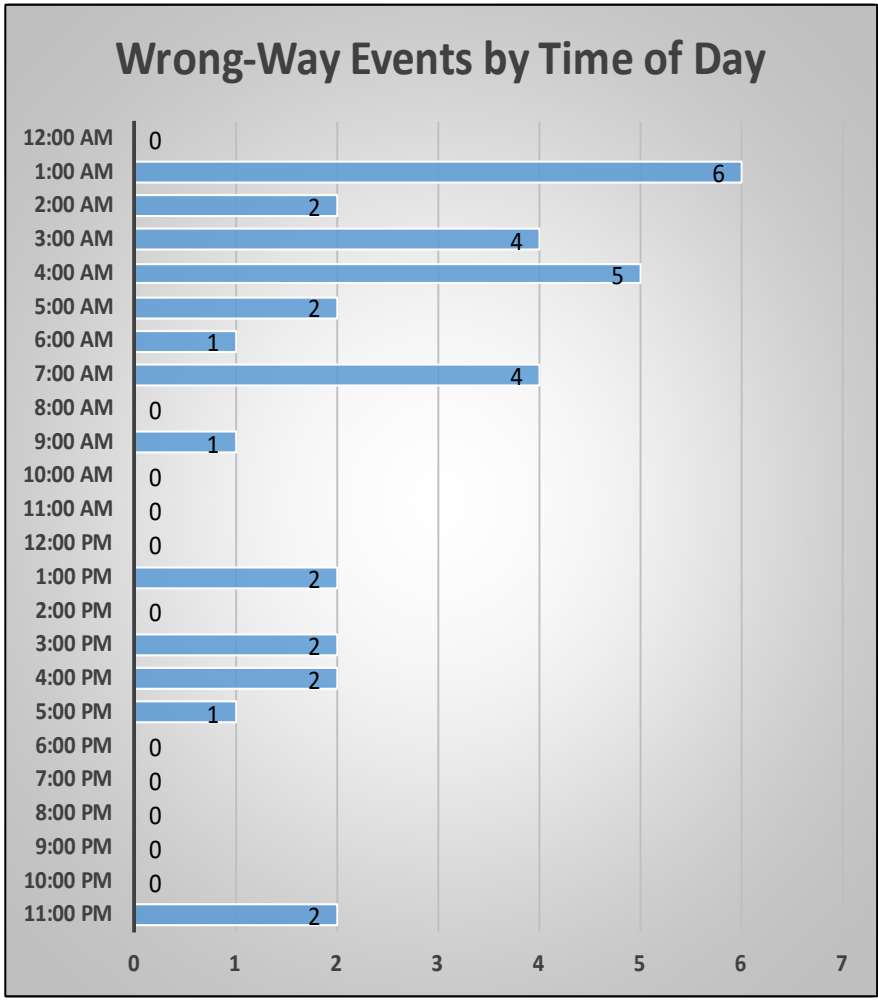
Entry manner	Quantity	Percent
Right Turn	13	38.2%
Left Turn	9	26.5%
One-Way	12	35.3%
Total	**34**	**100.0%**

Extent and characteristics of the WWD problem 2.

Most of the 34 total VBSM-detected wrong-way events happened in the early morning hours,

	Quantity	Percent	Driver-corrected	% Driver-corrected
Daytime	12	35.3%	11	91.7%
Nighttime	22	64.7%	18	81.8%
Total	**34**	**100.0%**	**29**	**85.3%**

But a significant percent (35.3%) occurred in the Daytime.



Effectiveness of the off-ramp enhancements. – Before and After

For the Sacramento exit ramps, there was a 53% reduction in VBSM-detected wrong-way driving events per ramp per year

Period	Events	Start	End	Years	Events/Year/Ramp
Before mitigation	4	8/21/2016	11/9/2016	0.22	3.0
After mitigation	24	11/10/2016	8/31/2019	2.81	1.4
Total	**28**				

Accuracy of the TAPCO and TraffiCalm active detection and alerting systems

6 Sacramento area exit ramps had both the VBSM (UC Davis) and TAPCO systems. These systems detected a total of 42 WWD events. Of this total, 27 were detected only by the VBSMs (blue entries), 14 were detected only by the TAPCO systems (orange entries), and only 1 event was detected by both (purple entry).

Date	Time	Ramp	VBSM	TAPCO	Note / Resolution
8/11/2016	4:10 AM	US 50 WB Jefferson Blvd	X		left to exit ramp, through camera, recovered
10/21/2016	1:52 PM	US 50 WB S. River Rd	X		right to exit ramp, quick recovery
11/2/2016	1:04 AM	US 50 WB 26th St	X		up one-way (W), just onto ramp, recovered
11/6/2016	4:46 PM	US 50 WB S. River Rd	X		right to exit ramp, quick recovery
12/22/2016	5:41 AM	US 50 WB 10th St	X		Likely impaired, all the way onto exit ramp
3/25/2017	2:44 AM	US 50 WB 26th St		X	construction WW driver
3/29/2017	9:51 AM	US 50 WB S. River Rd	X		Left from 5th, onto shoulder, then quick u-turn recover
4/17/2017	7:22 PM	US 50 WB S. River Rd		X	wrong way vehicle
5/4/2017	3:47 AM	US 50 WB 10th St	X		Wrong way up W St, quick U-turn recover
5/16/2017	11:43 PM	US 50 WB 10th St	X		Right onto W, seems to go around block, out at 1:20 on 12th St
5/26/2017	4:12 AM	US 50 WB 26th St	X		Right onto W, mostly in lane 2, seems to be turning around, never seen again, but not up exit ramp. Probably turned onto 27th.
7/19/2017	3:13 AM	US 50 WB 26th St		X	wrong way vehicle
7/25/2017	6:48 PM	US 50 WB S. River Rd		X	wrong way vehicle
7/30/2017	6:12 AM	US 50 WB S. River Rd	X		truck right on ramp, recovers before camera
7/31/2017	11:16 PM	US 50 WB S. River Rd		X	wrong way vehicle
8/1/2017	11:30 PM	US 50 WB Jefferson Blvd		X	wrong way vehicle
8/23/2017	12:49 AM	US 50 WB Jefferson Blvd	X		Through camera, eventually recovers
9/13/2017	5:39 AM	US 50 WB 16th St		X	WW Veh chase by law Enforcement
10/10/2017	3:12 PM	US 50 WB 26th St	X		Left from 26th onto W, u-turn just into ramp
11/23/2017	7:48 AM	US 50 WB 26th St	X		red SUV wrong way up W, see next clip, 2 unrelated
11/23/2017	7:48 AM	US 50 WB 26th St	X		silver car wrong way up W, see previous clip, 2 unrelated
4/17/2018	1:04 PM	US 50 WB S. River Rd	X		right onto ramp, tries to go lane 1, blocked, swerves to zero
5/18/2018	5:14 PM	US 50 WB S. River Rd	X		enters on shoulder, quick recovery
5/26/2018	7:31 AM	US 50 WB S. River Rd	X		enters on shoulder, most of way to camera, then u-turn recover
6/5/2018	8:58 PM	US 50 WB S. River Rd		X	wrong way vehicle
8/7/2018	1:14 PM	US 50 WB S. River Rd		X	wrong way vehicle
8/18/2018	7:21 AM	US 50 EB 5th St	X		full-on wrong-way, no recovery, broad daylight
11/4/2018	11:30 PM	US 50 WB S. River Rd	X		vehicle, realizes quickly due to oncoming vehicle
11/19/2018	9:07 AM	US 50 WB S. River Rd		X	wrong way vehicle
12/2/2018	3:32 AM	US 50 WB 26th St	X		vehicle, wrong way, stops, takes a wee
1/14/2019	5:26 AM	US 50 WB 26th St	X		vehicle, wrong way, doesn't enter ramp, continues wrong way on W
1/30/2019	4:13 AM	US 50 WB 26th St	X		vehicle, wrong way, doesn't enter ramp, continues wrong way on W
2/2/2019	1:47 AM	US 50 WB 10th St		X	WW law enforcement
2/4/2019	1:36 AM	US 50 WB 10th St	X	X	Wrong-way, never returns
2/28/2019	1:28 AM	US 50 WB S. River Rd	X		see event 1:22, returns to vehicle, drives onto freeway
4/21/2019	5:41 PM	US 50 WB S. River Rd		X	pedestrian
5/3/2019	4:21 PM	US 50 WB S. River Rd	X		vehicle, realizes quickly due to oncoming vehicles
5/18/2019	3:33 PM	US 50 WB S. River Rd	X		vehicle, realizes quickly due to oncoming vehicles
6/16/2019	12:18 AM	US 50 WB S. River Rd		X	scooter wrong way
6/22/2019	3:06 AM	US 50 WB 26th St	X		vehicle, wrong way, doesn't enter ramp, continues wrong way on W
6/22/2019	4:58 AM	US 50 WB 26th St	X		vehicle, wrong way, up ramp, no recovery
7/21/2019	10:02 PM	US 50 WB S. River Rd		X	wrong way vehicle

The newly installed directional sign to the Golden 1 Center blocked the rear-facing radar detector of the TAPCO system at US 50 and 16th Street. (The UC Davis detection system can be seen on the wood pole in the background.)

The TAPCO systems activated its flashing sign, thus warning wrong-way drivers locally, for 64.3% of the VBSM-detected WWD events

	Quantity	Percent
Relevant wrong-way events for activation	14	100.0%
Tapco did activate sign	9	64.3%
Tapco did not activate sign	5	35.7%

However, the TAPCO systems only sent alerts to the Traffic Management Center (TMC) for 30% of the VBSM-detected WWD events

	Quantity	Percent
Relevant wrong-way events for alert	10	100%
Tapco did alert	3	30%
Tapco did not alert	7	70%

The TraffiCalm systems activated its flashing sign, thus warning wrong-way drivers locally, for 50% of the VBSM-detected WWD events

	Quantity	Percent
Relevant wrong-way events for activation	2	100.0%
TraffiCalm did activate sign	2	100.0%
TraffiCalm did not activate sign	0	0.0%

However, the TraffiCalm systems sent alerts to the Traffic Management Center (TMC) for 100% of the VBSM-detected WWD events

	Quantity	Percent
Relevant wrong-way events for alert	2	100.0%
TraffiCalm did alert	1	50.0%
TraffiCalm did not alert	1	50.0%

Outcomes

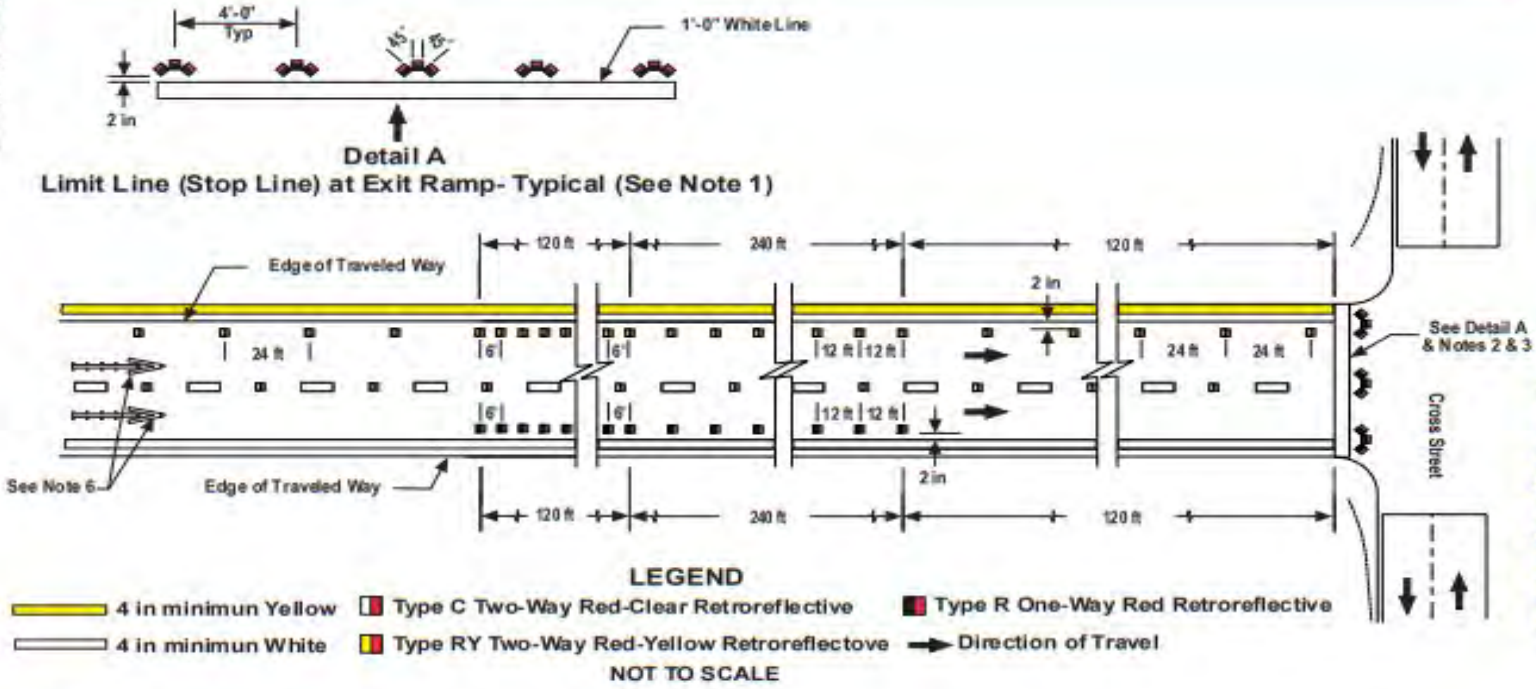
Detail Drawings for red retroreflective raised pavement markings on ramp lane lines, freeway and expressway lane lines and Type V arrows on ramps have been added to the California Manual for Uniform Traffic devices (MUTCD) and are approved for all new highway construction and maintenance projects. Caltrans has already installed the reflective markers on hundreds of miles of highways.

LED Illuminated DO-NOT-ENTER signs require no further approvals and can be installed as needed or warranted.

Active Detection and Alerting Systems require no additional approval for use, however business policies should be developed for their use in projects, because they are significantly more expensive than other countermeasures tested. Also, while the TAPCO and TraffiCalm systems often functioned as intended, they are not yet a foolproof method of detecting wrong way driving events. Therefore, these systems should not be installed on ramps that have not evaluated other lower cost countermeasures first.

Caltrans District 3 added straight/right signs, straight/left + no right signs, and left or right turn only signs to the intersection of US 50 WB exit ramp and South River Road, which was shown by the research project to be the most prone to wrong way driving movements.

Page 667 of the current California MUTCD, added in 2021, showing the layout of the new standard for two-way reflective pavement markers on exit ramps



NOTES:

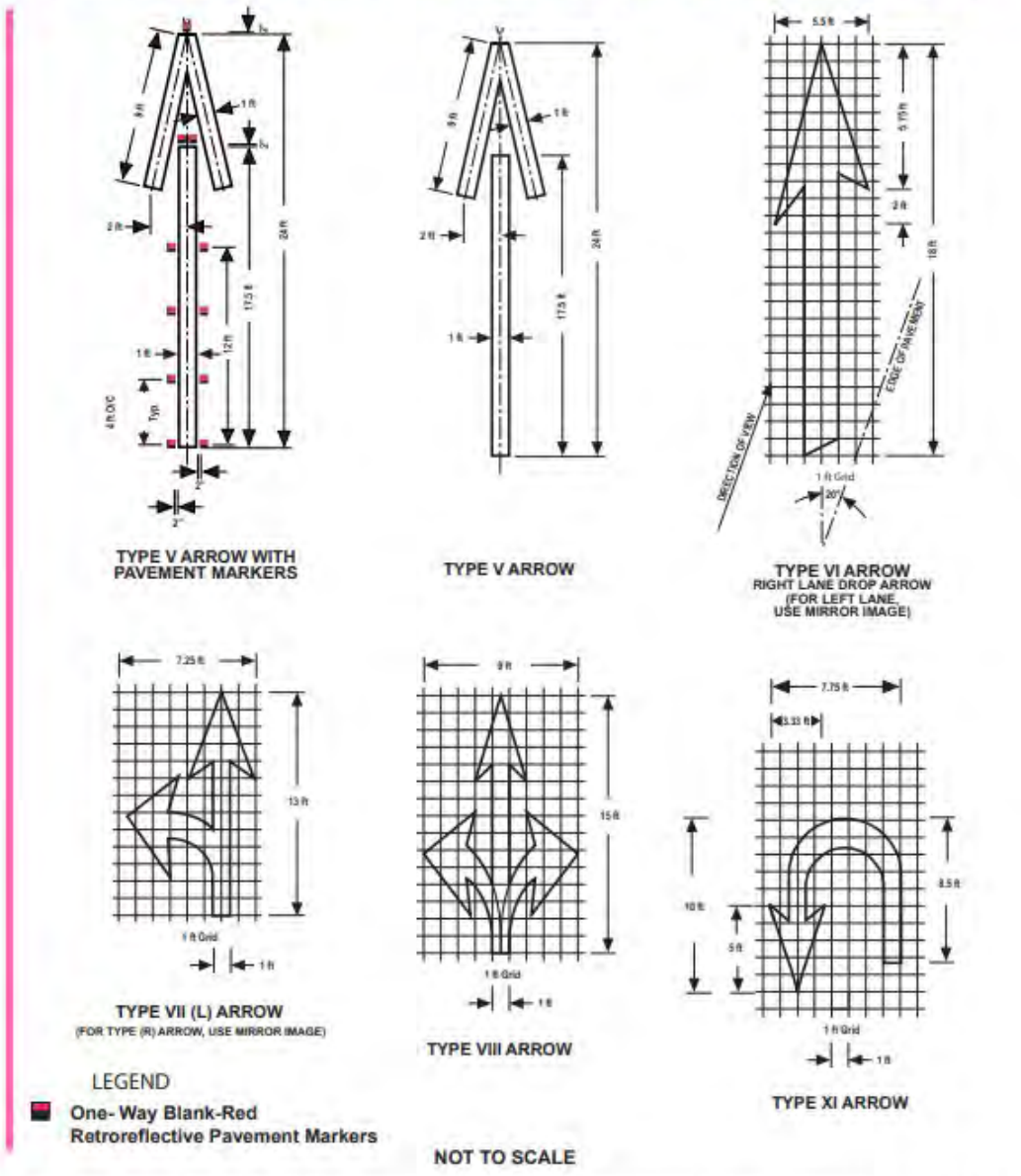
1. May be a limit line or crosswalk.
2. Place Type R one-way red retroreflective markers on outermost limit line or crosswalk line with red facing the intersection.
3. If there is crosswalk at the end of the exit ramp, place Type R markers in front of the first line for wrong way vehicle that travels up the ramp with the red reflective side facing the intersection.
4. The distances and marker spacings may be adjusted based on site specific conditions or exit ramp geometry.
5. The layout shown is a typical detail of an exit ramp, see Figure 3B-24 of the CA MUTCD for exit ramp configuration and arrow placement and spacing.
6. See Figure 3B-24 for Type V arrow detail with Type R one-way red retroreflective markers

Figure 3A-114 (CA). Exit Ramp with Enhanced Pavement Markers for Wrong Way Details

California MUTCD 2014 Edition
(FHWA's MUTCD 2009 Edition, including Revisions 1 & 2, as amended for use in California)

Page 748 of the current California MUTCD, added in 2021, showing a detail of the new standard for two-way reflective pavement markers overlaid on a Type V arrow

Figure 3B-24 (CA). Examples of Standard Arrows for Pavement Markings (Sheet 2 of 8)



NOTE: The design details for various arrows are also shown in Department of Transportation's Standard Plans.

Signs were added to the intersection of US 50 WB exit ramp and South River Road to deter wrong way driving movements onto the exit ramp

Other countermeasures currently being evaluated and studied

Bidirectional pavement markings use raised, angled surfaces to display a warning to wrong way drivers without distracting other drivers.

They were not part of the original pilot projects but were recently installed for pilot testing in San Diego County (Caltrans District 11).

Bidirectional pavement markings – design and application

1

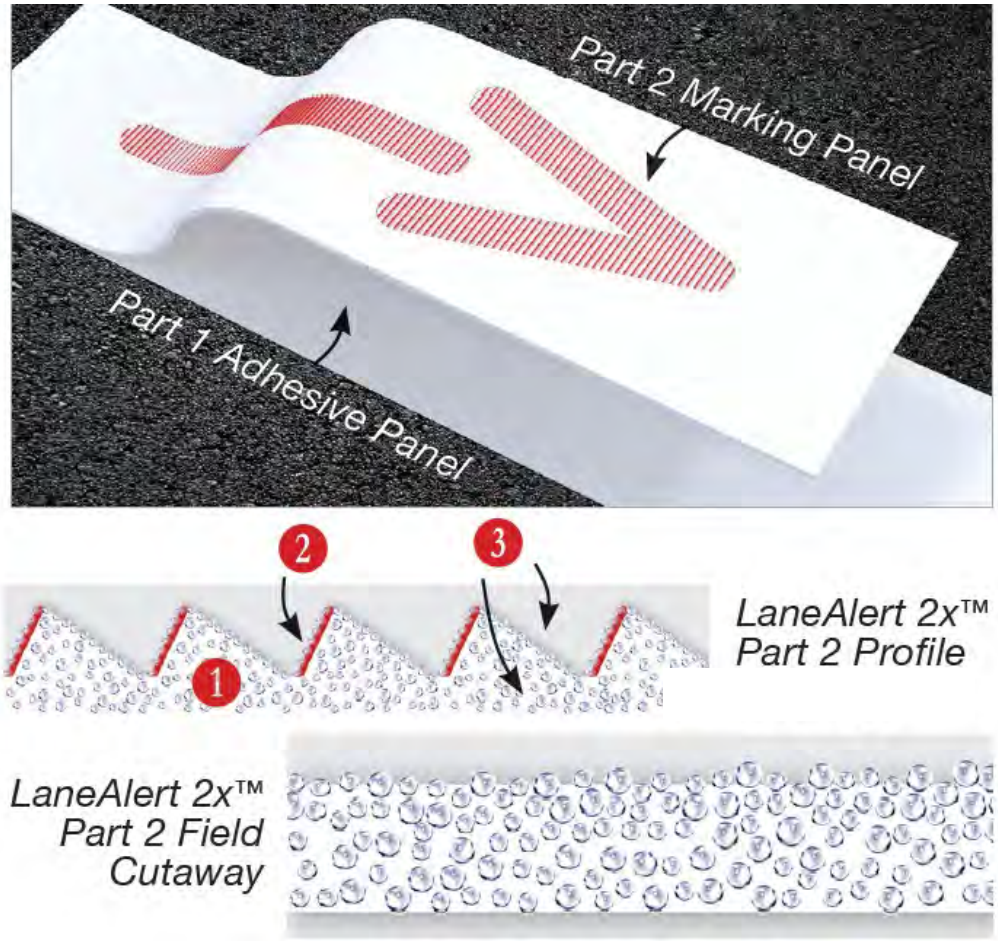
Bi-angular profile produces bi-directional visibility with unidirectional messaging

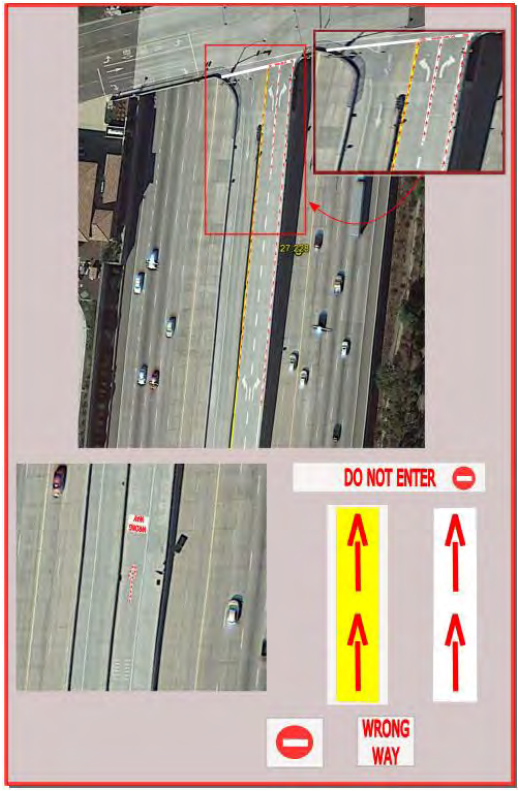
2

Pigmented coating provides high contrast visibility for messaging

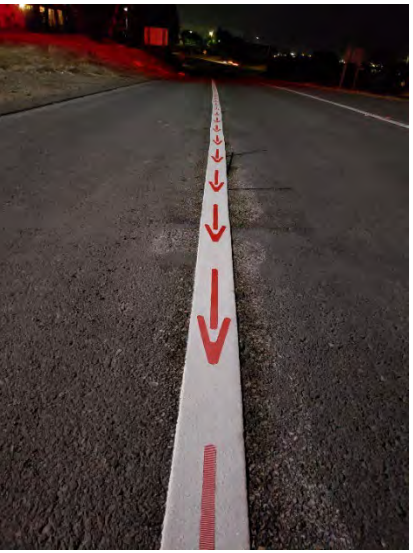
3

Base color coated with glass beads for high visibility





Bidirectional pavement markings Installed at I-5 NB exit ramp @ Palomar Street in Chula Vista, CA



Bidirectional pavement marking Installation at I-5 NB exit ramp @ Palomar Street in Chula Vista, CA

A Caltrans sponsored study at Auburn University is investigating the effectiveness of countermeasures specifically designed for intoxicated wrong way drivers.

The research will use human subjects in a driving simulator to test their responses to emerging countermeasure technologies such as bidirectional pavement markings and directional rumble strips, which generate vibrations to provide haptic feedback alerts to intoxicated drivers.

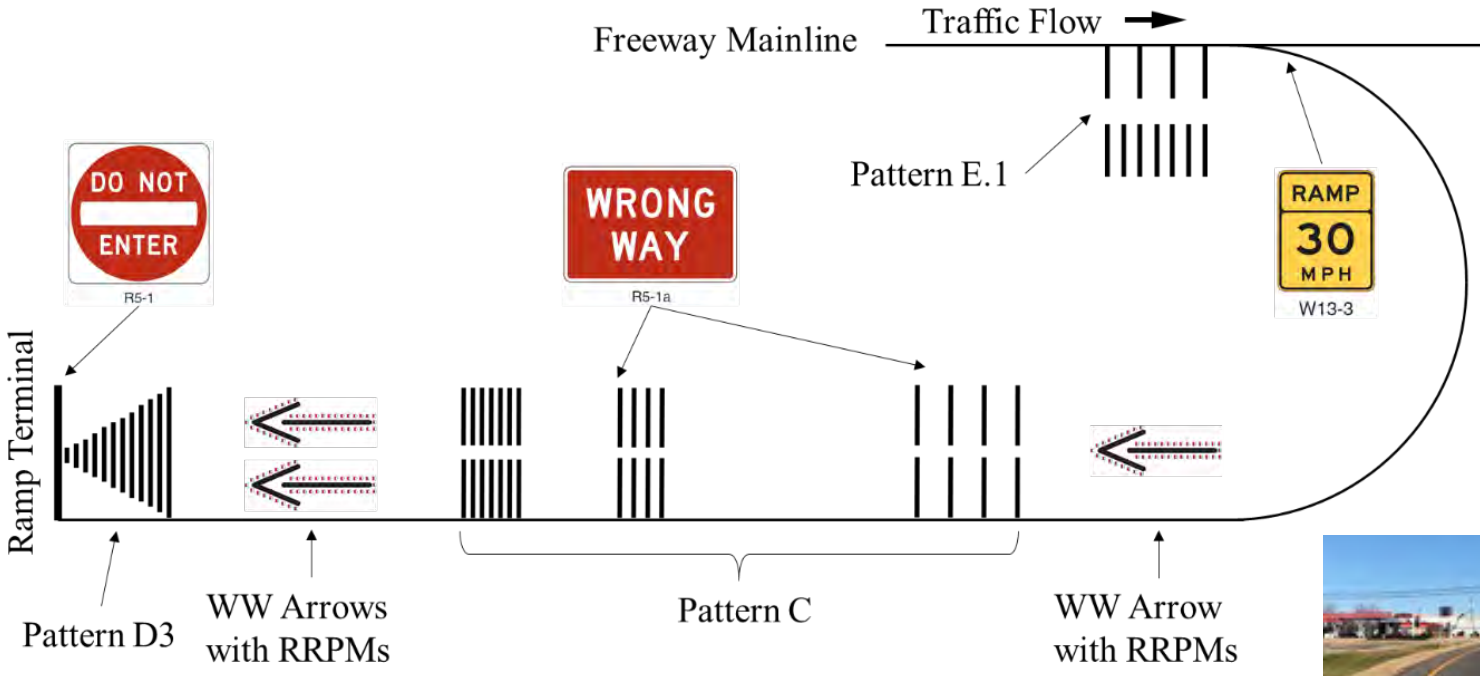
Researchers in the Psychology Department have obtained approval from Auburn University's Institutional Review Board's (IRB) to intoxicate human subjects.

30 all male participants will be recruited by offering each subject $150 for completing a driving simulator session while drunk and $50 for completing a session while sober.

The target blood-alcohol concentration (BAC) is 0.12%, which equals the highest found in academic literature for lab-based studies.

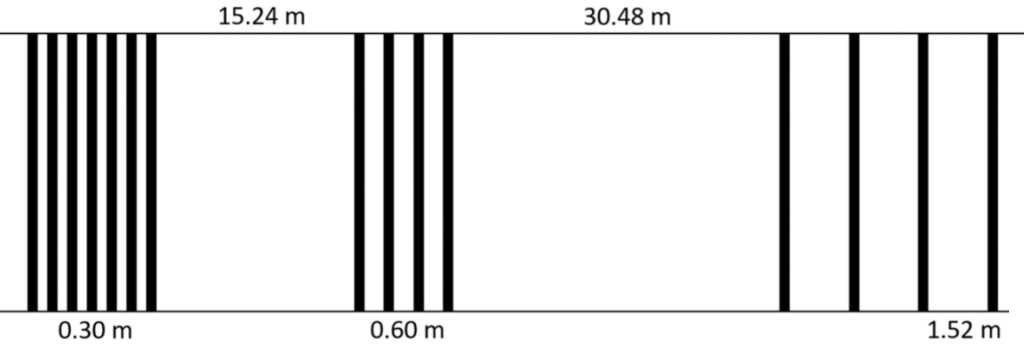
The alcohol dose will be calculated based on body weight and administered as one-part absolute alcohol (95% alc/vol) mixed with three parts carbonated lemon/lime flavored soda.

Directional rumble strips generate vibrations to provide haptic feedback alerts to intoxicated drivers

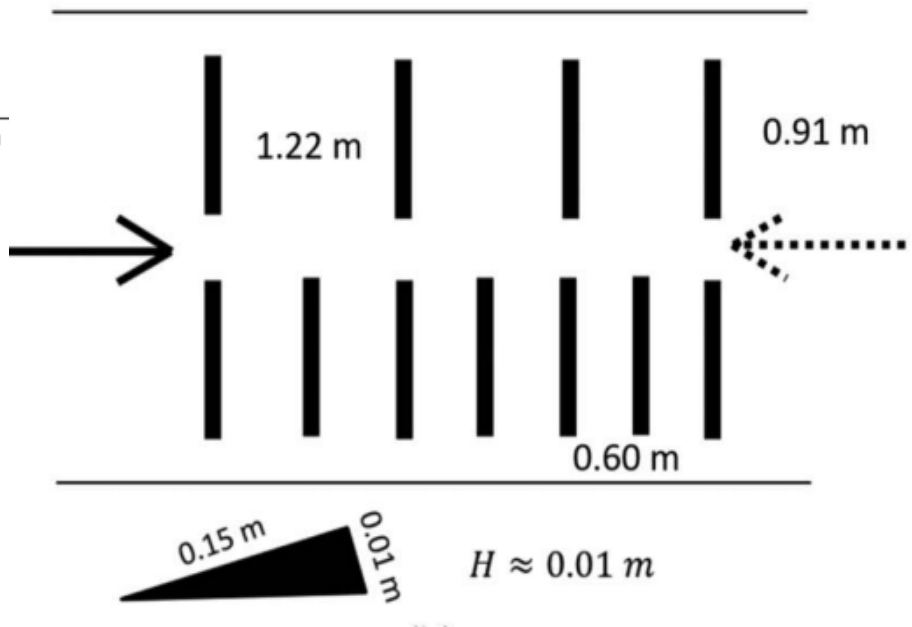


Three different patterns of directional rumble strips will be included in the driving simulator scenarios.

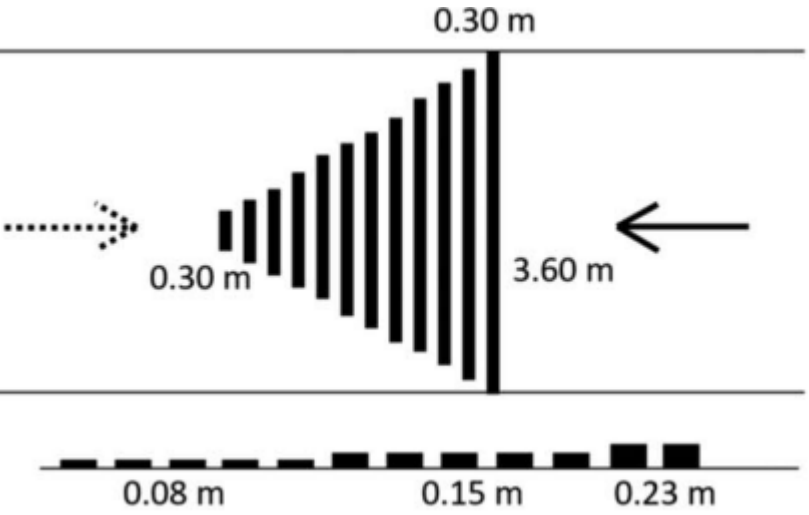
Pattern C



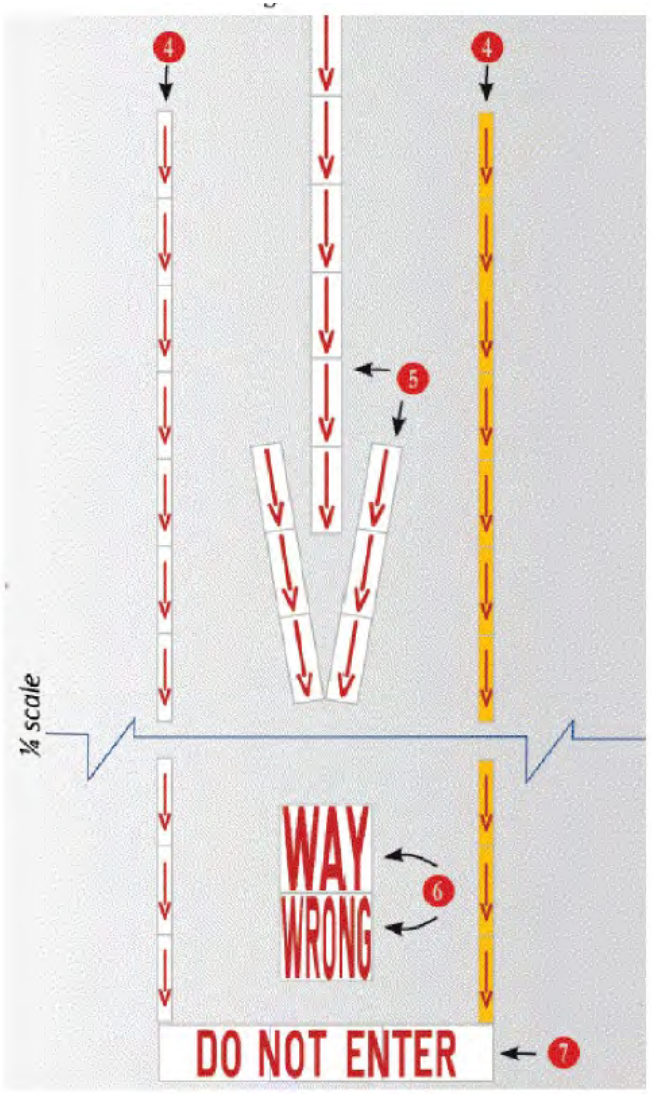
Pattern E.1



Pattern D3



Two different patterns of bidirectional pavement markings will be included in the driving simulator scenarios.

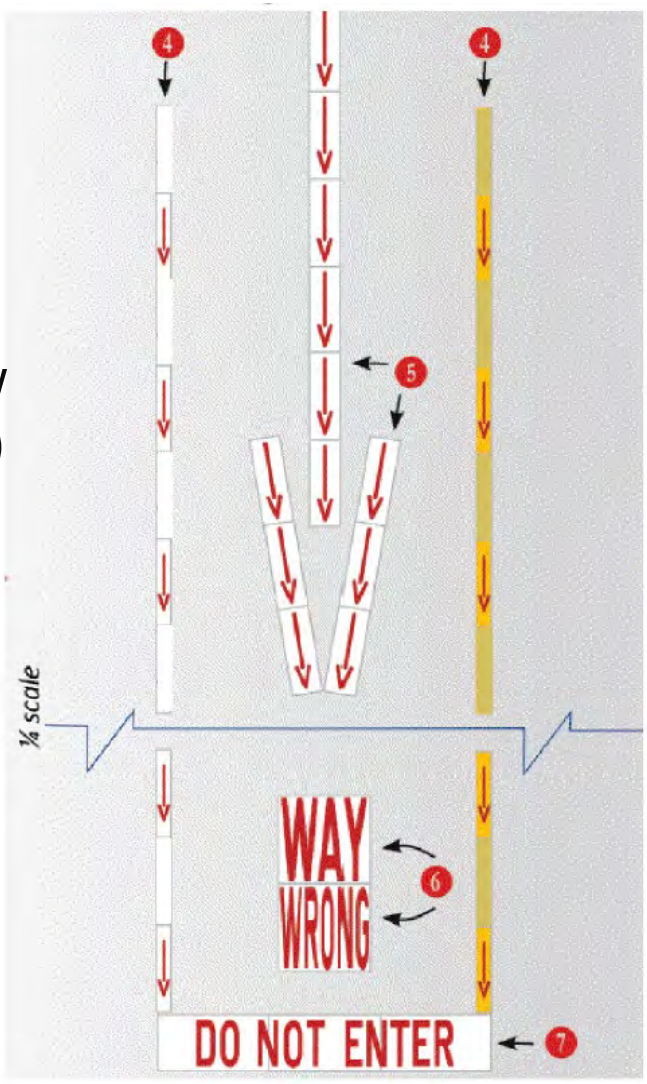


4 Longitudinal Lane Line (MUTCD 3A-05.02/03)

5 Wrong Way Arrow (MUTCD 3B-24D)

6 Wrong Way Message (MUTCD 3b-24)

7 Stop Bar (MUTCD 3B-16)



Driving simulator experiment scenarios

The objective of this driving simulator experiment is to identify effective communication methods, i.e. traffic control devices, to deter wrong-way driving for intoxicated drivers.

A nighttime environment will be simulated, because, according to the Fatality Analysis Reporting System (FARS) database, over 90% of alcohol-involved WWD fatal crashes happen during nighttime.

WWD countermeasures that will be evaluated in this study include:

- MUTCD standard Wrong Way and Do Not Enter signs
- Enlarged, low-mounted Wrong Way and Do Not Enter signs
- Wrong Way sign with flashing LED borders
- Wrong Way pavement arrow with retroreflective raised pavement markers (RRPMs)
- Bidirectional pavement markers
- Directional rumble strips

The following scenarios are being developed for this study:

- Driving simulator training to familiarize participants with the equipment (no implemented countermeasures)
- Each countermeasure presented individually
- MUTCD requirements, CAMUTCD requirements and bidirectional pavement markers
- Various combinations of all countermeasures

Each countermeasure presented individually

Low-mounted and enlarged

WW sign with LED Border

WW sign with LED Border

Directional rumble strips

DRS

Driver Stop Point

DNE(WW) Sign

DNE(WW) Sign

Bidirectional pavement markers LaneAlert 2x

LaneAlert 2x

Driver Start Point

R5-1

DO NOT ENTER and WW Standard Sign

R5-1a

WW Pavement Arrow RRPM

WW Standard Sign

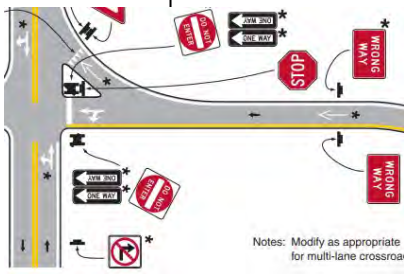
MUTCD vs CAMUTCD vs Bidirectional pavement markers

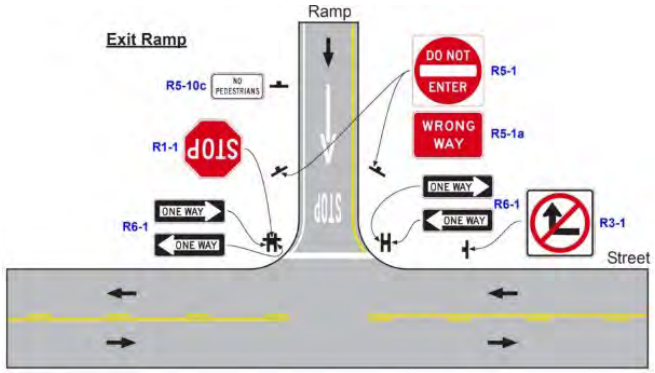
MUTCD Required

MUTCD Required

CAMUTCD Required

CAMUTCD Required

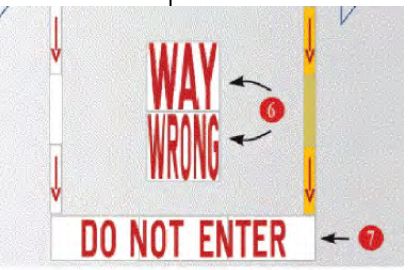




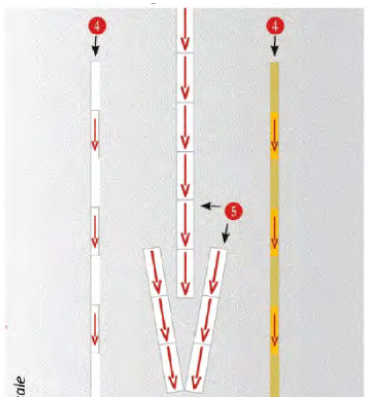
Caltrans Approved

Caltrans Approved

Bidirectional pavement markers

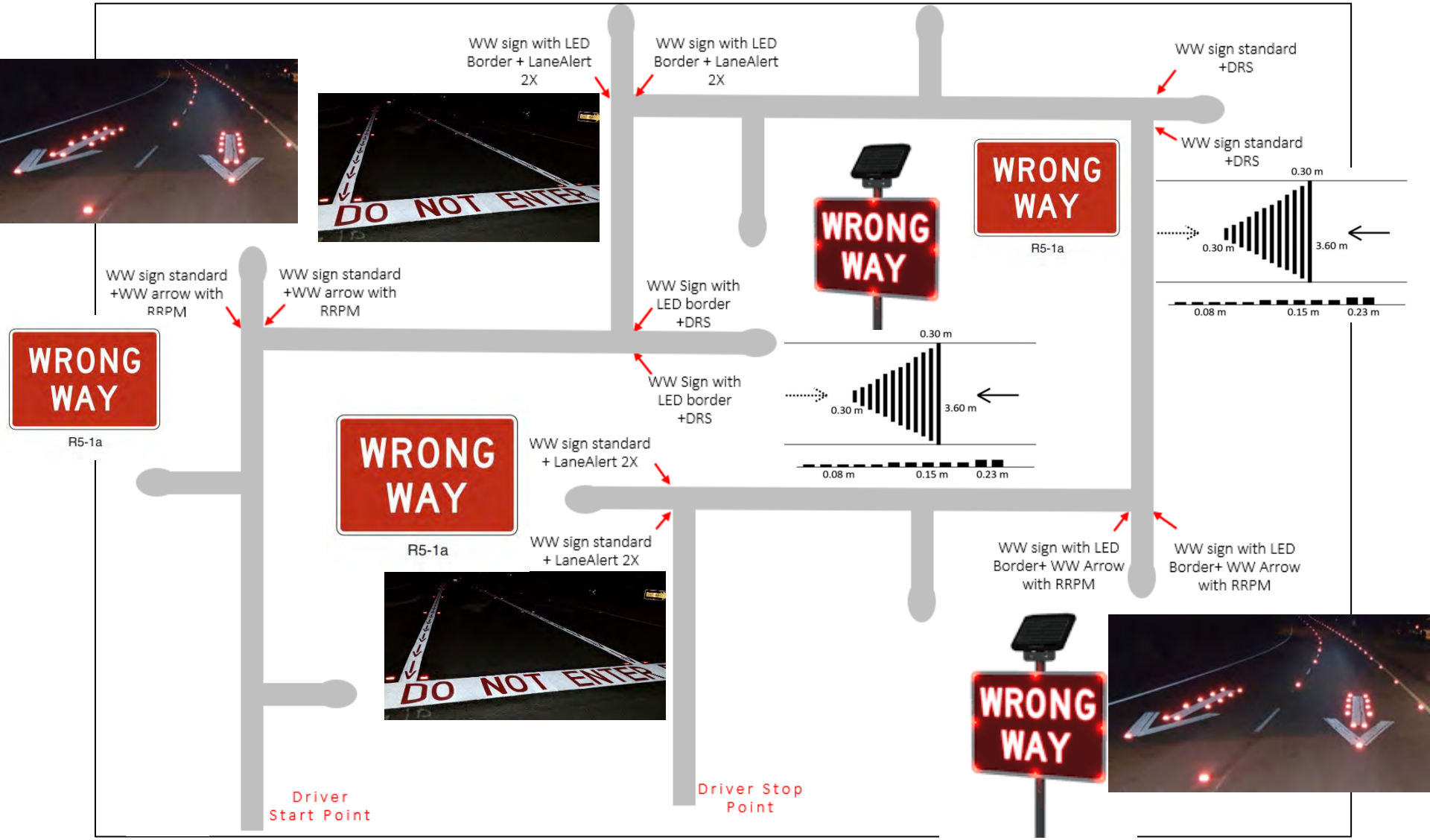


Driver Stop Point



Driver Start Point

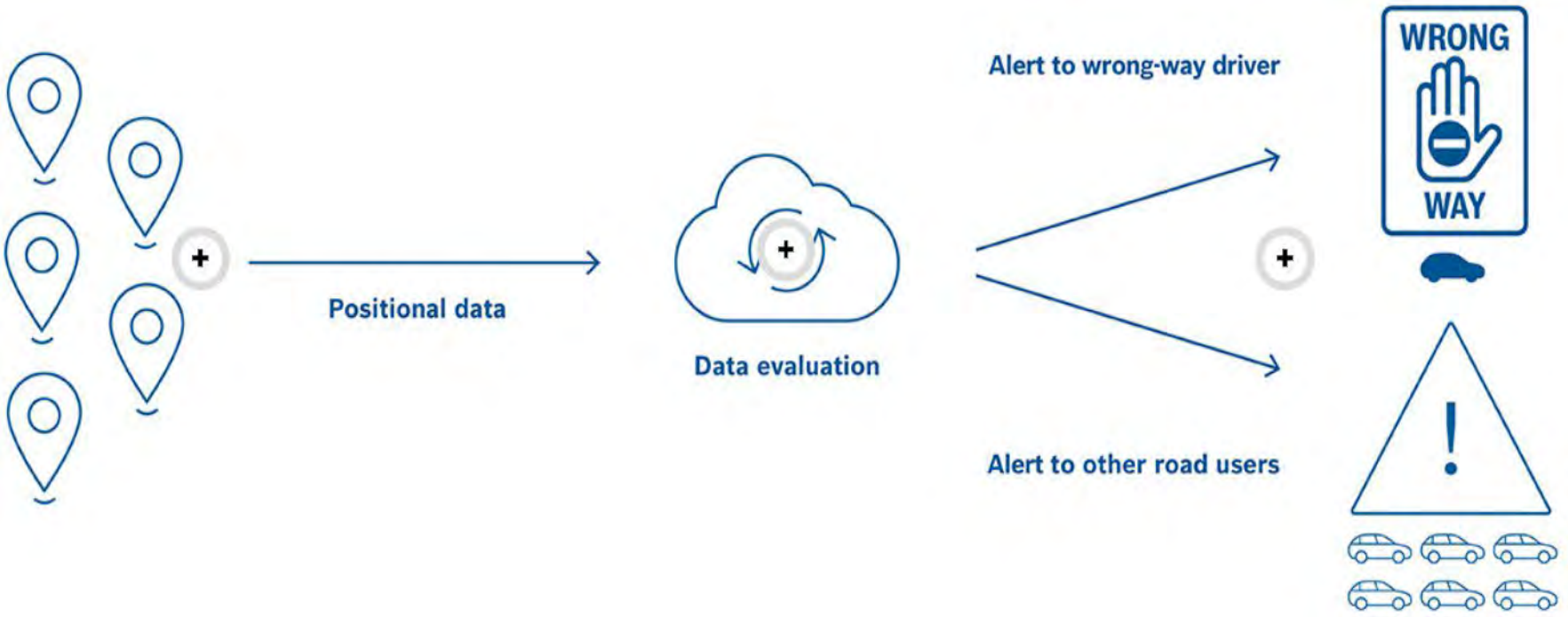
Standard WWD signs or WWD signs with LED borders combined with arrows with RRPM or bidirectional pavement markers or directional rumble strips



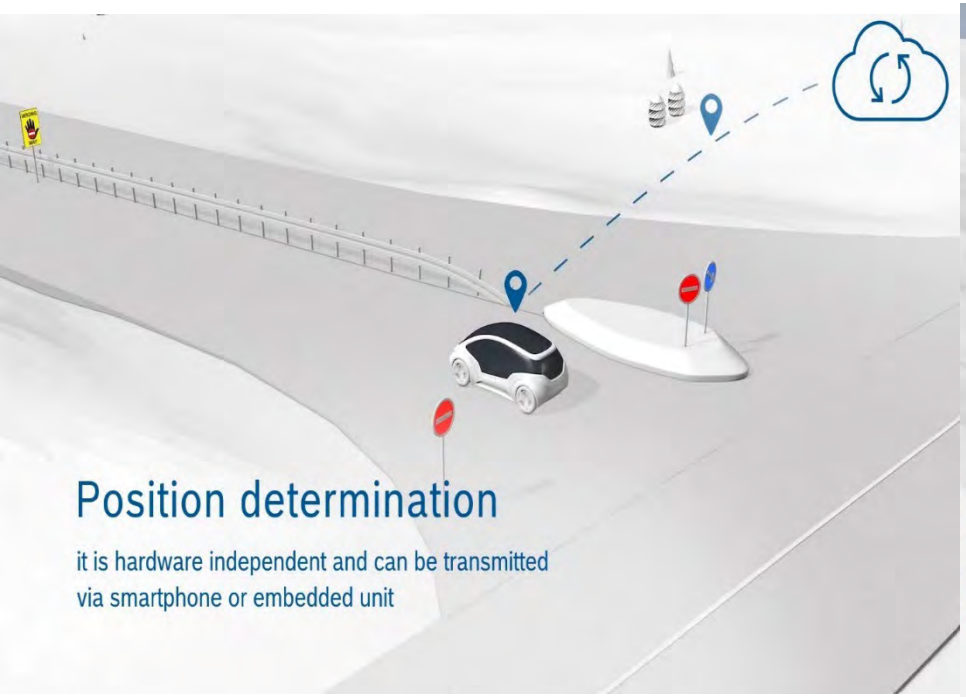
GPS mobile device to cloud Server wrong way driver detection and warning

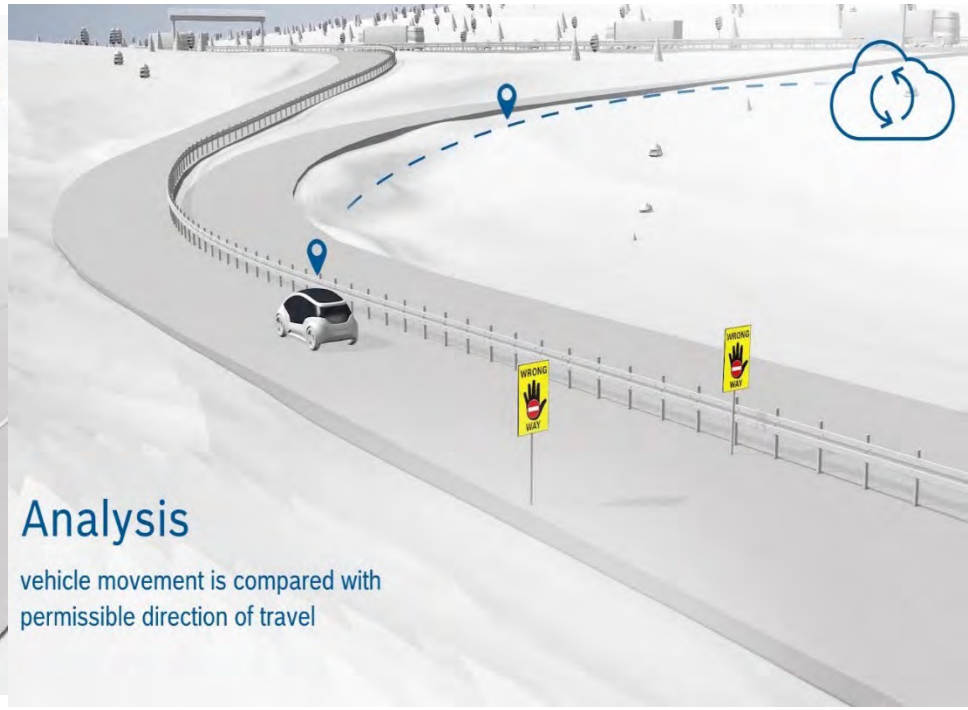
Caltrans and UC Davis are working with Bosch Mobility Solutions in Germany to test their mobile device (e.g. cellular phone) app extension on California state highways.

Bosch's software integrates into a third-party provider's existing mobile device app and uses the devices' GPS data to detect wrong way movements and send out a warning to the driver, proximate vehicles and interested government agencies.

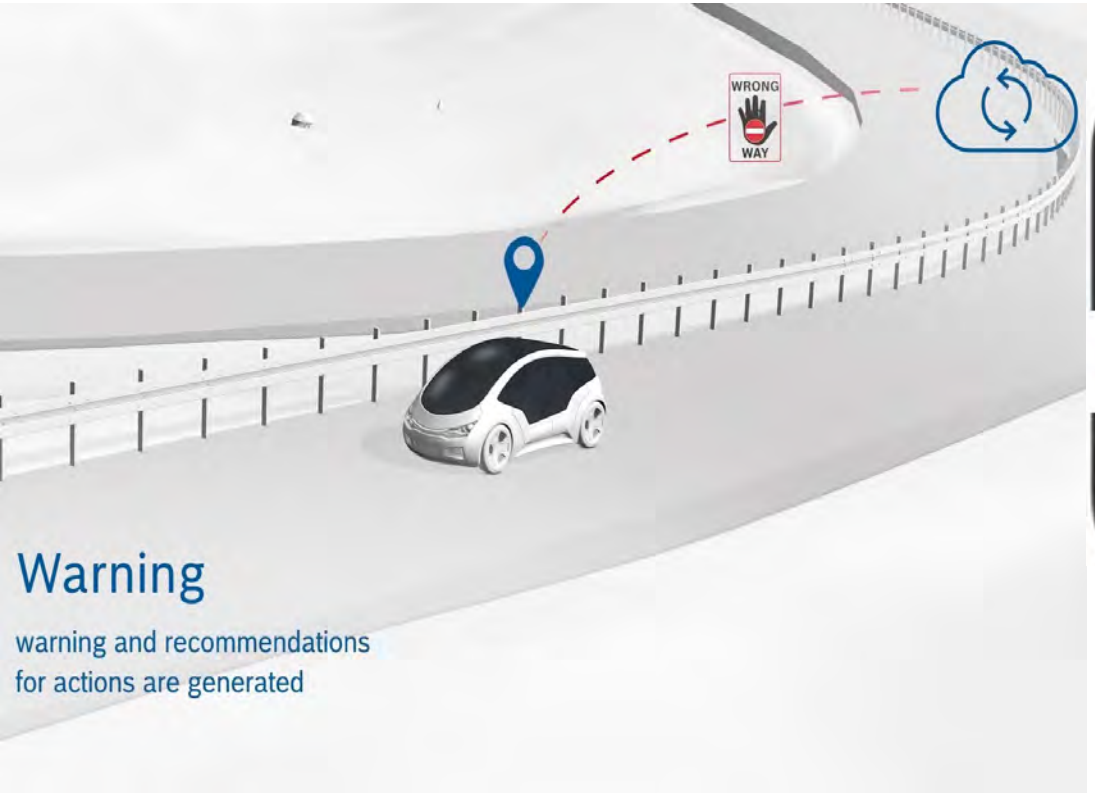


Bosch's software transmits regular, anonymized position data to a server in a central computing location. The server contains a web-based database of maps and corresponding permitted directions of travel. When the server detects a conflict in travel direction, the wrong-way driver, and all proximate networked road users, automatically receive a warning presented through the third-party app.

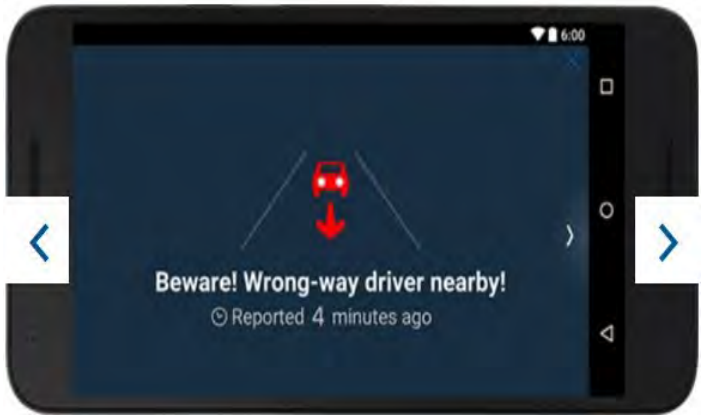




Bosch's software transmits regular, anonymized position data to a server in a central computing center. The server contains a web-based database of maps and corresponding permitted directions of travel. When the server detects a conflict in travel direction, the wrong-way driver, and all proximate networked road users, automatically receive a warning presented through the third-party app.



Bosch's software transmits regular, anonymized position data to a server in a central computing center. The server contains a web-based database of maps and corresponding permitted directions of travel. When the server detects a conflict in travel direction, the wrong-way driver, and all proximate networked road users, automatically receive a warning presented through the third-party app 2.



Caltrans would like to test the reliability, timely responsiveness and positional accuracy of the Bosch system on a small scale by working with UC Davis to develop a custom app and server program to host their software and confirm its functionality by driving test vehicles up closed exit ramps. UC Davis would coordinate with Caltrans maintenance crews to safely drive test vehicles the wrong way up exit ramps they plan to close.

Thanks for Listening

Caltrans

DRISI

Caltrans Division of Research,
Innovation and System Information

UCDAVIS

AHMCT

ADVANCED HIGHWAY MAINTENANCE
& CONSTRUCTION TECHNOLOGY
RESEARCH CENTER

AUBURN UNIVERSITY