Deterrence and Detection of Wrong-Way Drivers on California Highways

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California Department of Transportation

AASHTO Innovation Initiative

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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).

Wrong-Way Deterrence and Detection Pilot Projects in Caltrans Districts 3 and 11
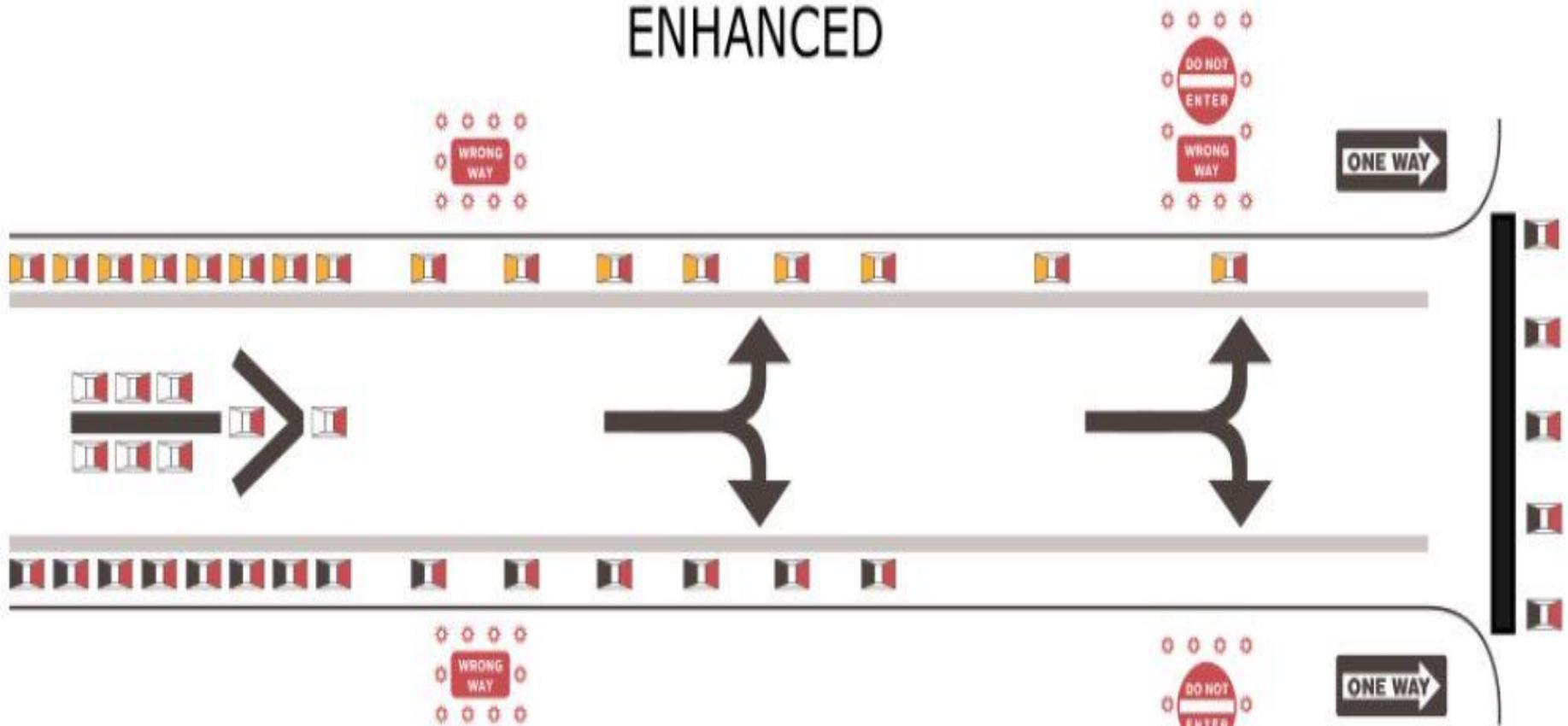
San Diego CITY LIMIT

Sacramento CITY LIMIT

60 exit ramps

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

16 exit ramps

I-80, & US-50

ENHANCED

Red-Clear Retroreflective   Red-Yellow Retroreflective   Red-Blank Retroreflective

LED Flashing Lights Bordering Signs (Active Monitoring System Locations Only)

Two-Way Retro-Reflective Pavement Markers
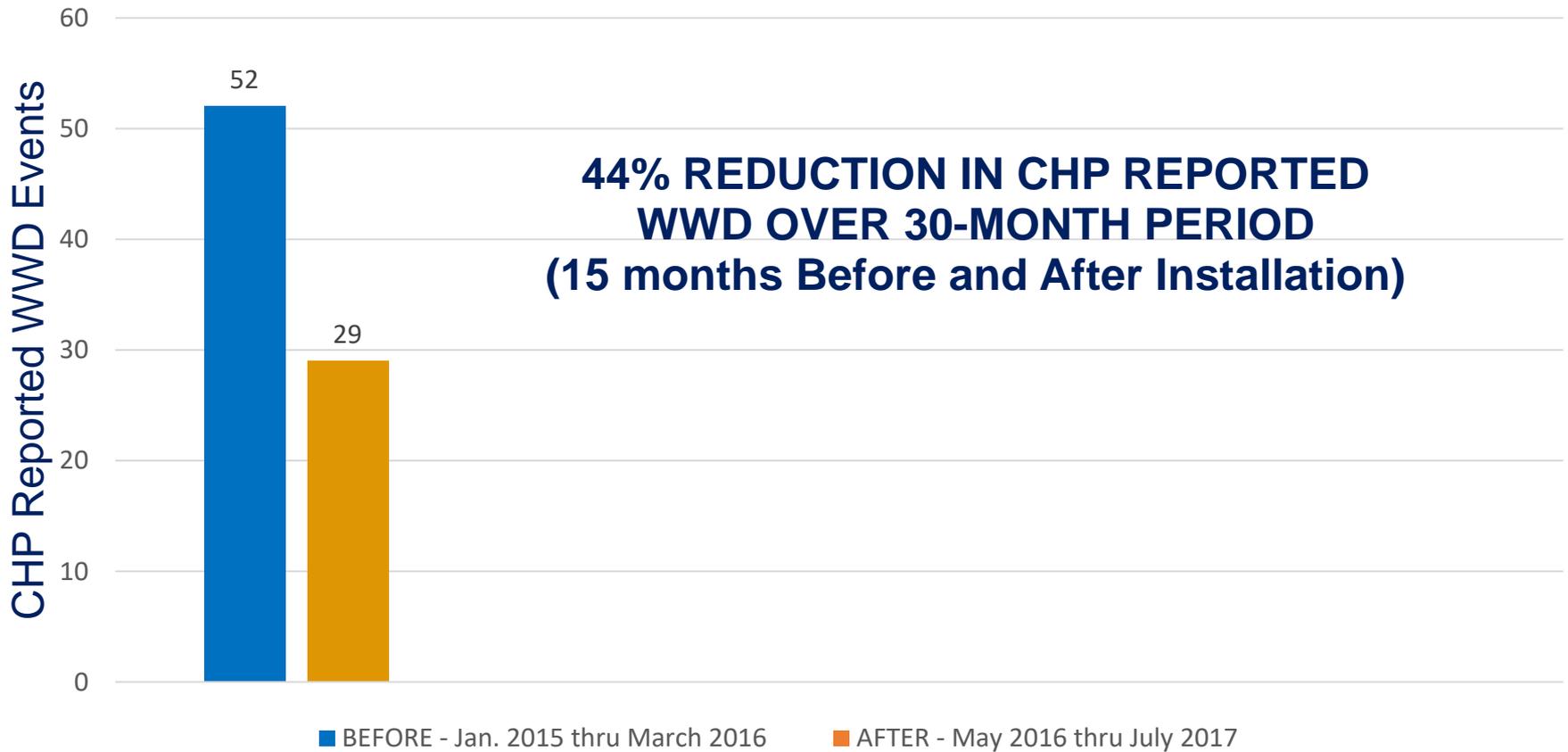
Right-Way Driver View

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

44% REDUCTION IN CHP REPORTED WWD OVER 30-MONTH PERIOD (15 months Before and After Installation)

CHP Reported WWD Events

52

29

■ BEFORE - Jan. 2015 thru March 2016   ■ AFTER - May 2016 thru July 2017

Radar-based Active Detection and Alerting Systems were installed on a subset of exit ramps.
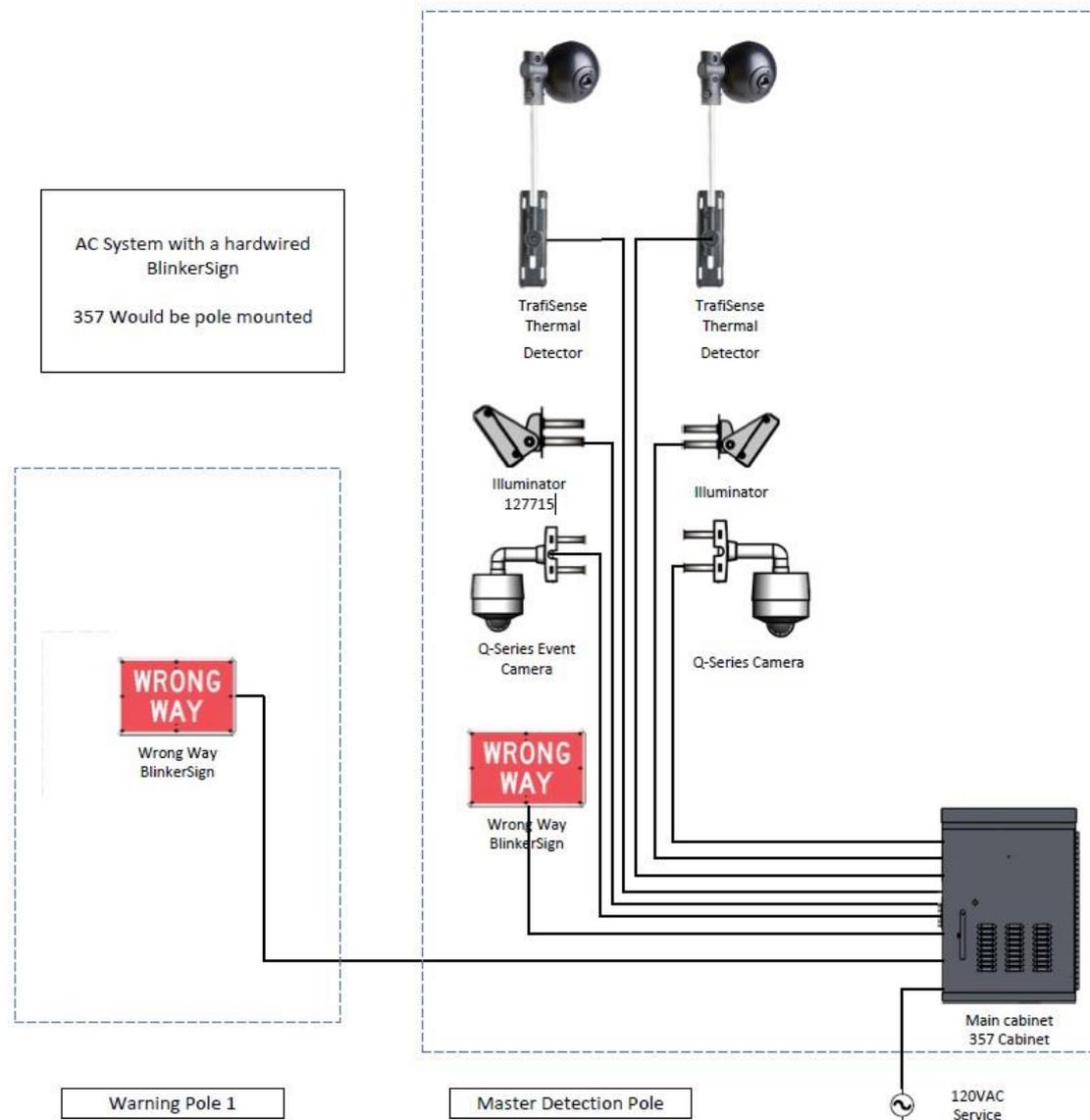
6 Ramps: Signage with TAPCO detection and alerting systems

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

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

AC System with a hardwired BlinkerSign

357 Would be pole mounted

TrafiSense Thermal Detector

TrafiSense Thermal Detector

Illuminator 127715

Illuminator

Q-Series Event Camera

Q-Series Camera

WRONG WAY

Wrong Way BlinkerSign

WRONG WAY

Wrong Way BlinkerSign

Main cabinet 357 Cabinet

Warning Pole 1

Master Detection Pole

120VAC Service

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

TAPCO System at 5th Street & EB 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™

d Alert Time: 11/17/2019 11:30:14 PM   Powered by TAPCO

BlinkLink™

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   Powere

Correct Traffic Flow: ↙

BlinkLink))

BlinkLink))

Powered by TAPCO

13

System: SR15 NB off-ramp from El Cajon Blvd   Alert Time: 11/17/2019 11:30:14 PM   Powered by TAPCO
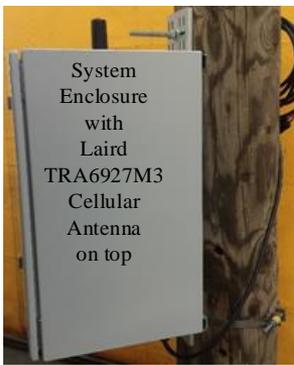
Caltrans' Division of Research, Innovation and System Information (DRISI) conducted a research project to study the effectiveness of the exit-ramp enhancements in Districts 3 and 11.

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
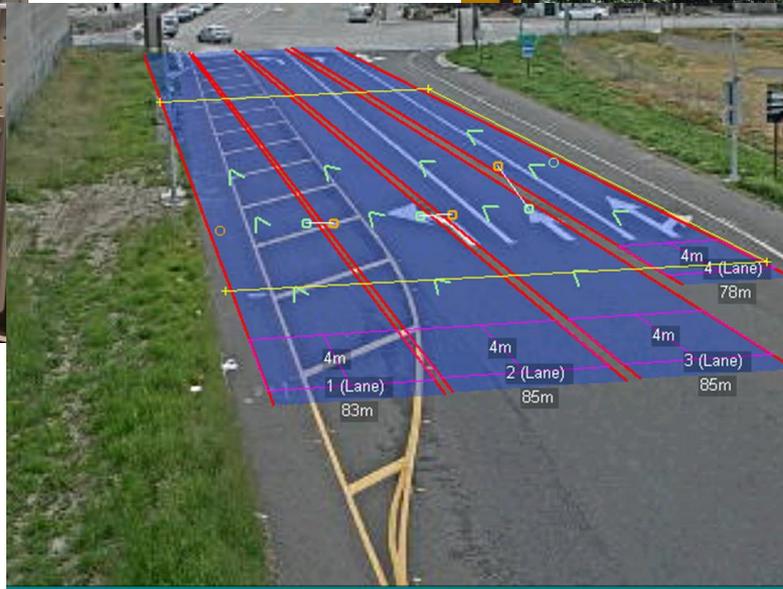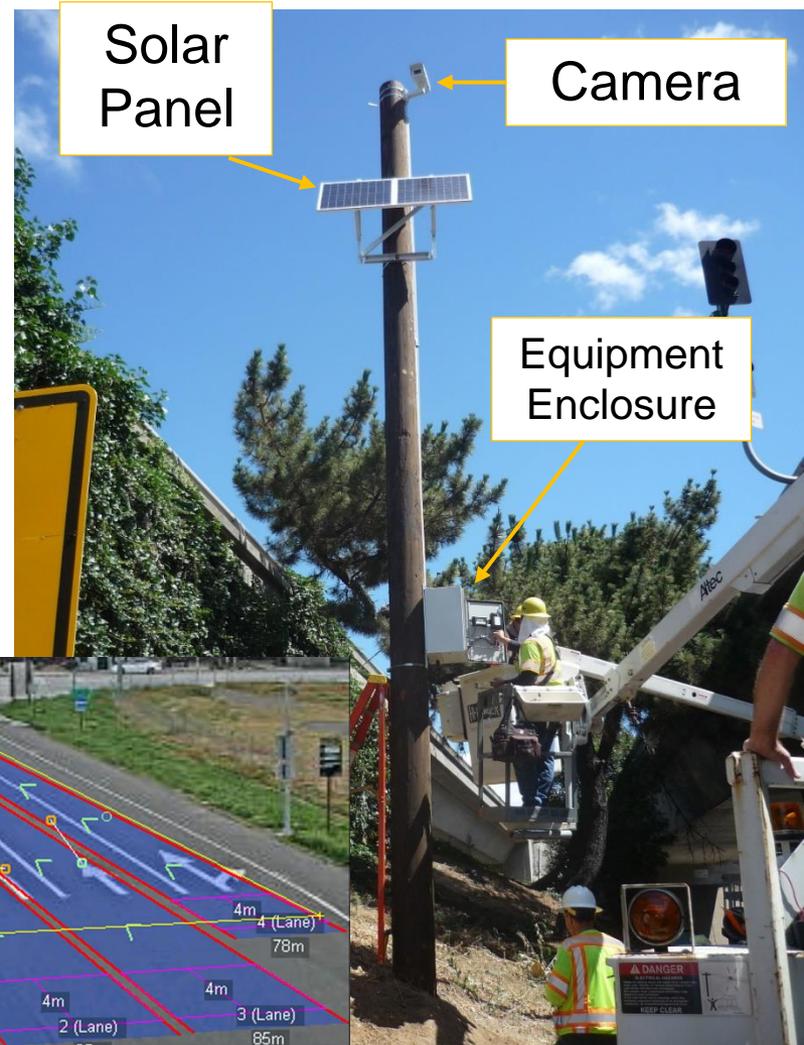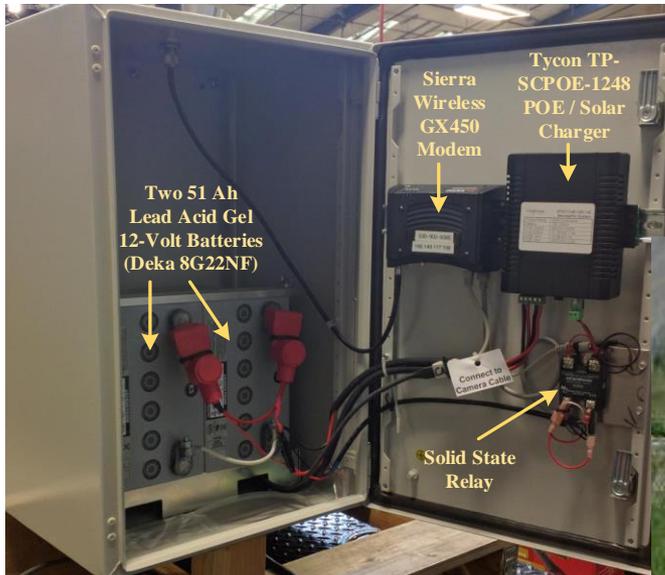- Accuracy of the TAPCO and TraffiCalm active detection and alerting systems

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

System Enclosure with Laird TRA6927M3 Cellular Antenna on top

Axis Q1615-E Camera with Pole Mount

Two 70 W Solarland SLP070-12U Solar Panel

Sierra Wireless GX450 Modem

Tycon TP-SCPOE-1248 POE / Solar Charger

Two 51 Ah Lead Acid Gel 12-Volt Batteries (Deka 8G22NF)
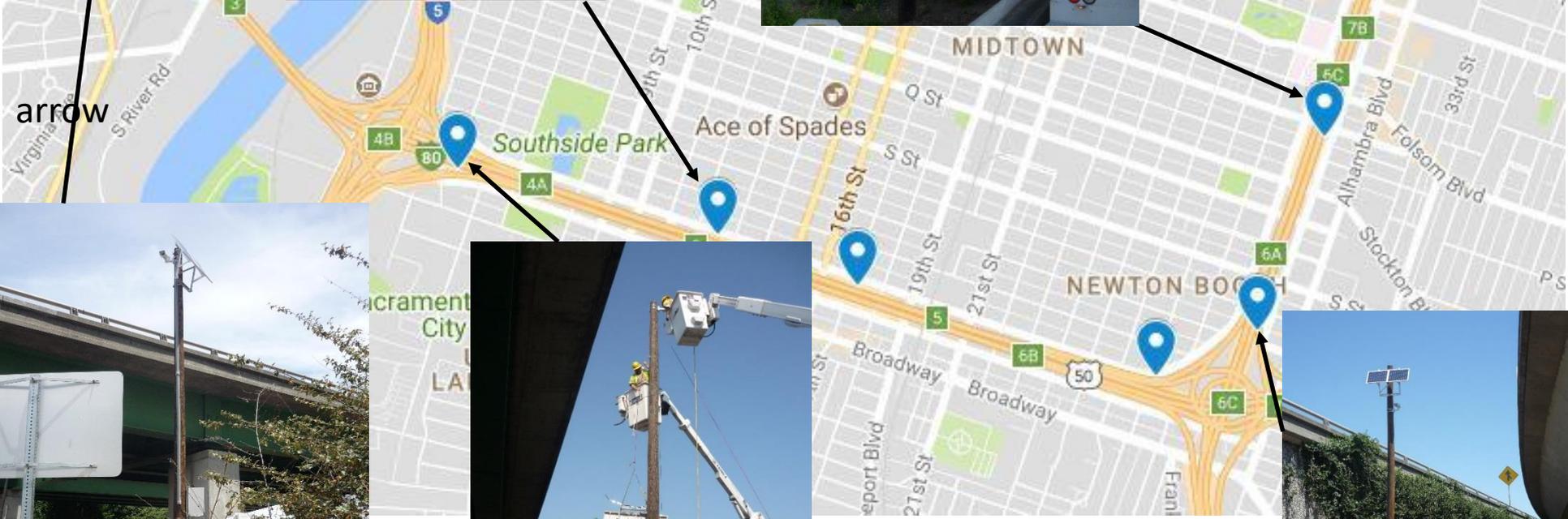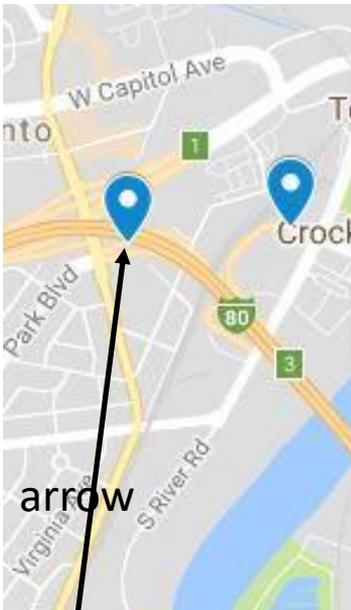
Connect to Camera Cable

Solid State Relay

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.
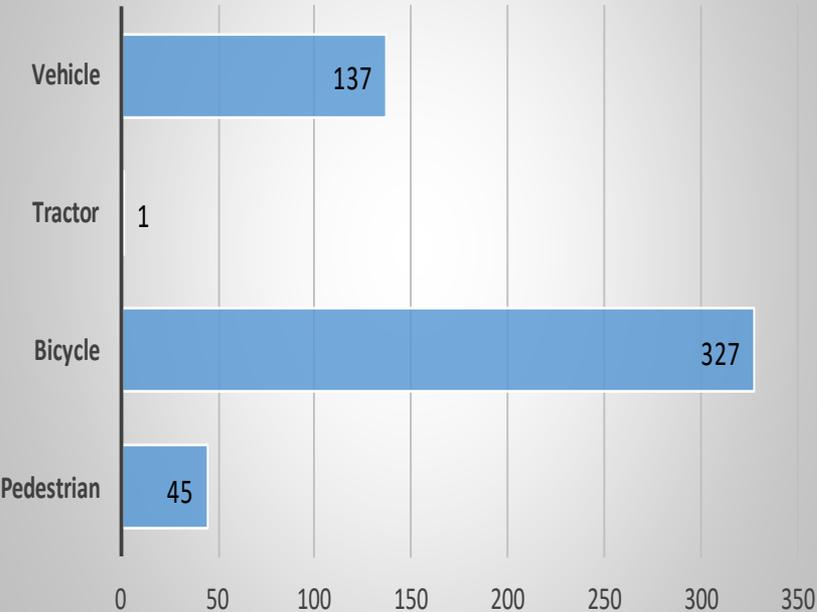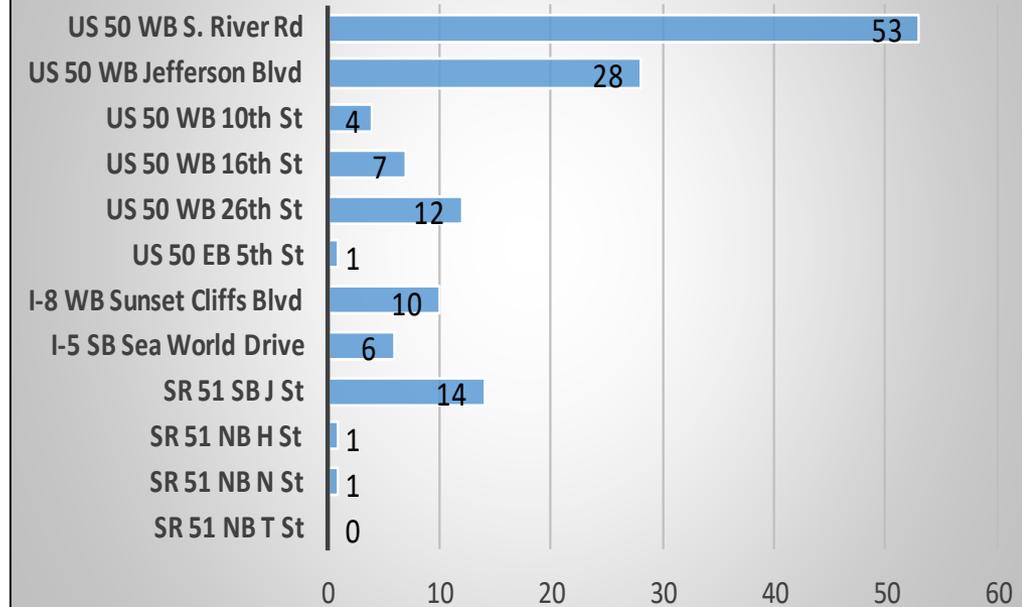

Solar Panel

Camera

Equipment Enclosure

4m 4 (Lane) 78m
4m
4m 4m
1 (Lane) 83m 2 (Lane) 85m 3 (Lane) 85m

15

arrow

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

All Captured Events by Entity

Entity	Value
Vehicle	137
Tractor	1
Bicycle	327
Pedestrian	45

All Vehicle Events by Exit Ramp

Exit Ramp	Value
US 50 WB S. River Rd	53
US 50 WB Jefferson Blvd	28
US 50 WB 10th St	4
US 50 WB 16th St	7
US 50 WB 26th St	12
US 50 EB 5th St	1
I-8 WB Sunset Cliffs Blvd	10
I-5 SB Sea World Drive	6
SR 51 SB J St	14
SR 51 NB H St	1
SR 51 NB N St	1
SR 51 NB T St	0

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 mitigation	4	11.8%	0.3

Wrong-Way Events by Off-Ramp

Off-Ramp	Events
US 50 WB S. River Rd	11
US 50 WB Jefferson Blvd	2
US 50 WB 10th St	4
US 50 WB 16th St	0
US 50 WB 26th St	10
US 50 EB 5th St	1
I-8 WB Sunset Cliffs Blvd	2
I-5 SB Sea World Drive	0
SR 51 SB J St	4
SR 51 NB H St	0
SR 51 NB N St	0
SR 51 NB T St	0
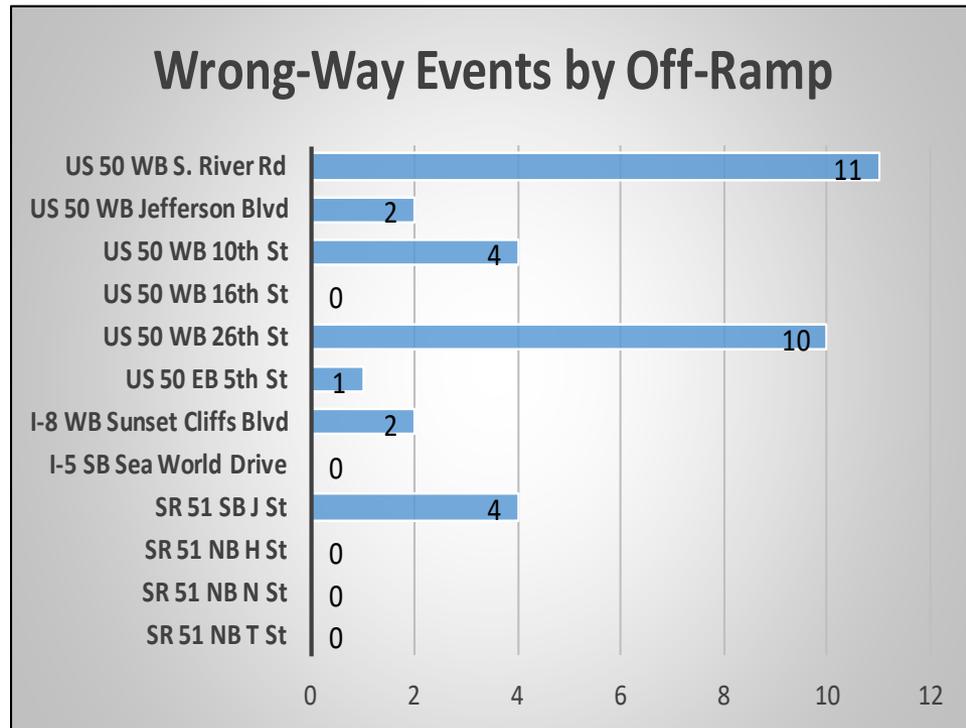
A Particularly Dangerous WWD Trajectory was Captured on 10th Street & WB US 50 Off-Ramp.

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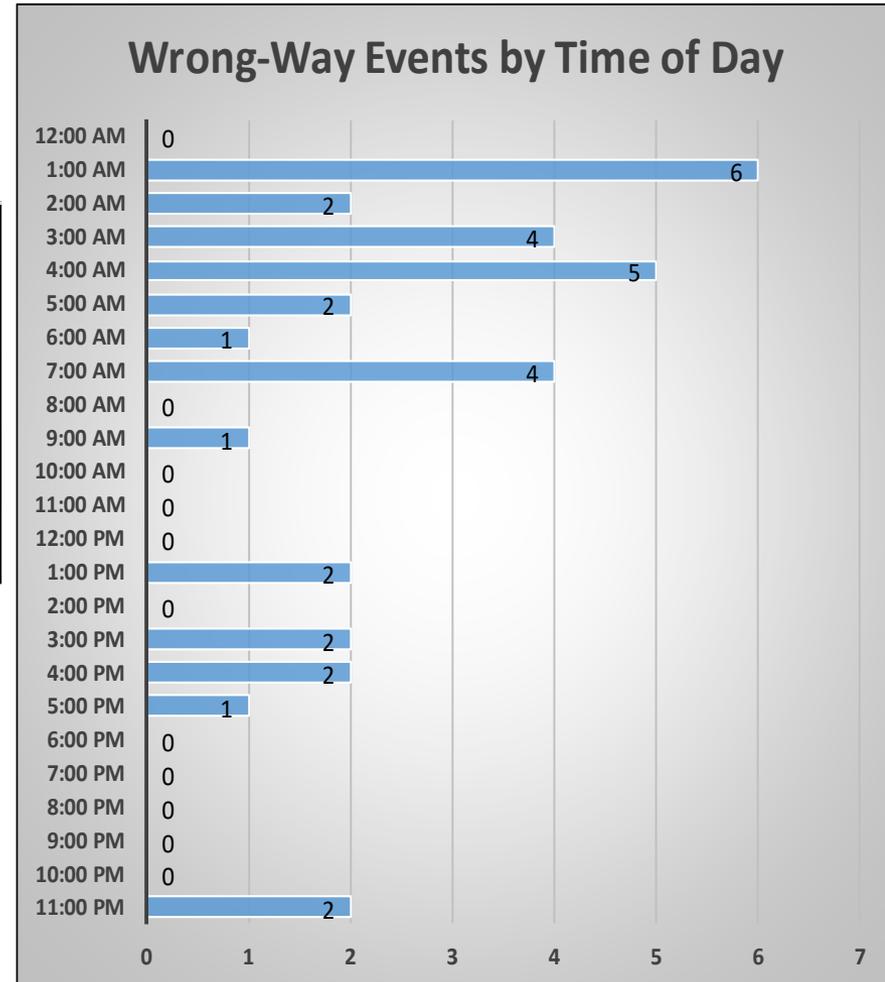
Entry manner	Quantity	Percent
Right Turn	13	38.2%
Left Turn	9	26.5%
One-Way	12	35.3%
Total	34	100.0%

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.

Wrong-Way Events by Time of Day

Time	Events
12:00 AM	0
1:00 AM	6
2:00 AM	2
3:00 AM	4
4:00 AM	5
5:00 AM	2
6:00 AM	1
7:00 AM	4
8:00 AM	0
9:00 AM	1
10:00 AM	0
11:00 AM	0
12:00 PM	0
1:00 PM	2
2:00 PM	0
3:00 PM	2
4:00 PM	2
5:00 PM	1
6:00 PM	0
7:00 PM	0
8:00 PM	0
9:00 PM	0
10:00 PM	0
11:00 PM	2

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 AM	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
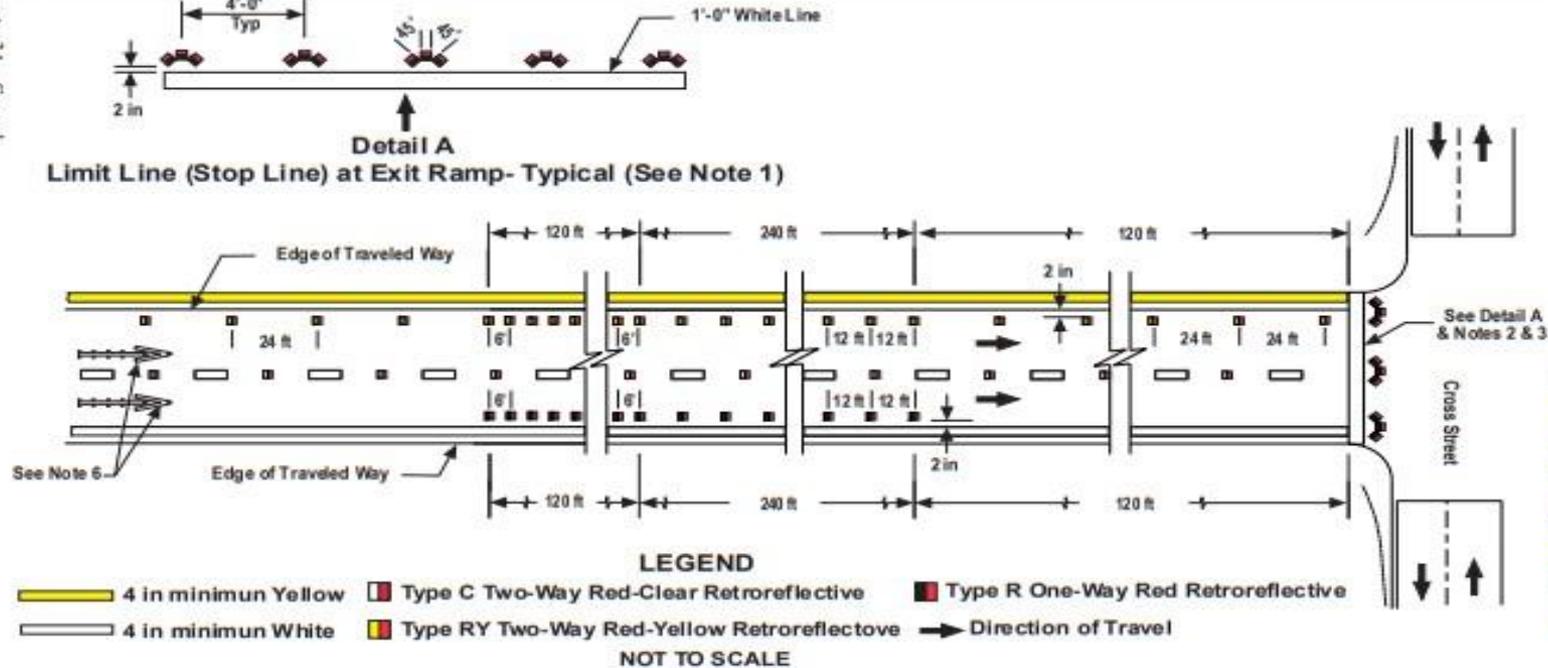
Detail A
Limit Line (Stop Line) at Exit Ramp- Typical (See Note 1)

4'-0" Typ
1'-0" White Line
2 in

120 ft   240 ft   120 ft
Edge of Traveled Way
2 in
See Detail A & Notes 2 & 3
24 ft   6   6   12 ft 12 ft   24 ft   24 ft
Cross Street
See Note 6
Edge of Traveled Way
6   6   12 ft 12 ft
2 in
120 ft   240 ft   120 ft

LEGEND

4 in minimun Yellow	Type C Two-Way Red-Clear Retroreflective
4 in minimun White	Type RY Two-Way Red-Yellow Retroreflectove
	Type R One-Way Red Retroreflective
	Direction of Travel

NOT TO SCALE

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

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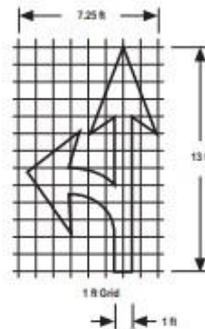
Figure 3B-24 (CA). Examples of Standard Arrows for Pavement Markings (Sheet 2 of 8)
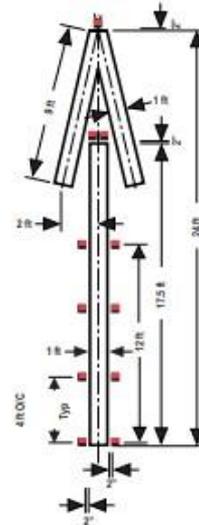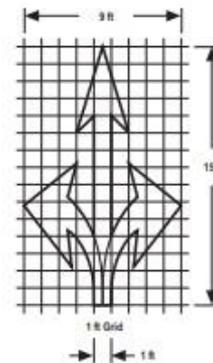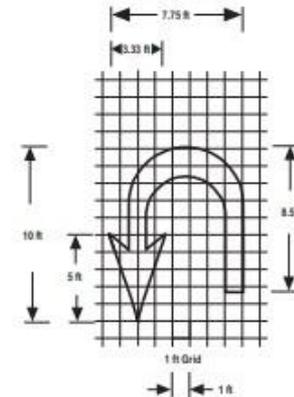

TYPE V ARROW WITH
PAVEMENT MARKERS
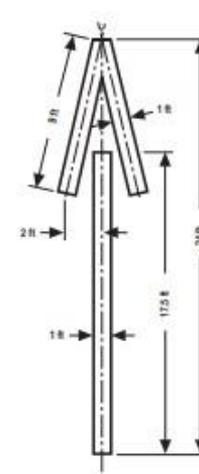
TYPE V ARROW
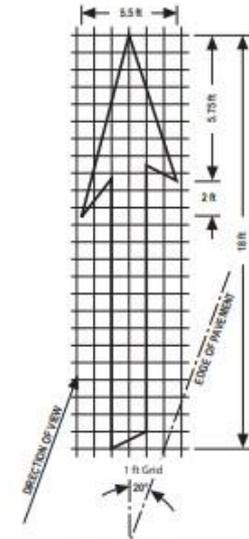
TYPE VI ARROW
RIGHT LANE DROP ARROW
(FOR LEFT LANE,
USE MIRROR IMAGE)

TYPE VII (L) ARROW
(FOR TYPE (R) ARROW, USE MIRROR IMAGE)

TYPE VIII ARROW

TYPE XI ARROW

LEGEND

■ One- Way Blank-Red
Retroreflective Pavement Markers

NOT TO SCALE

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

Chapter 3B – Pavement and Curb Markings
Part 3 – Markings

Revised March 30, 2021

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

Added left/right turn sign

Added straight/right turn sign

Added straight/right turn sign

Added straight/right turn sign

Replaced left turn sign

Added straight sign

Added no right turn sign

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.

Correct Approach

Incorrect Approach

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
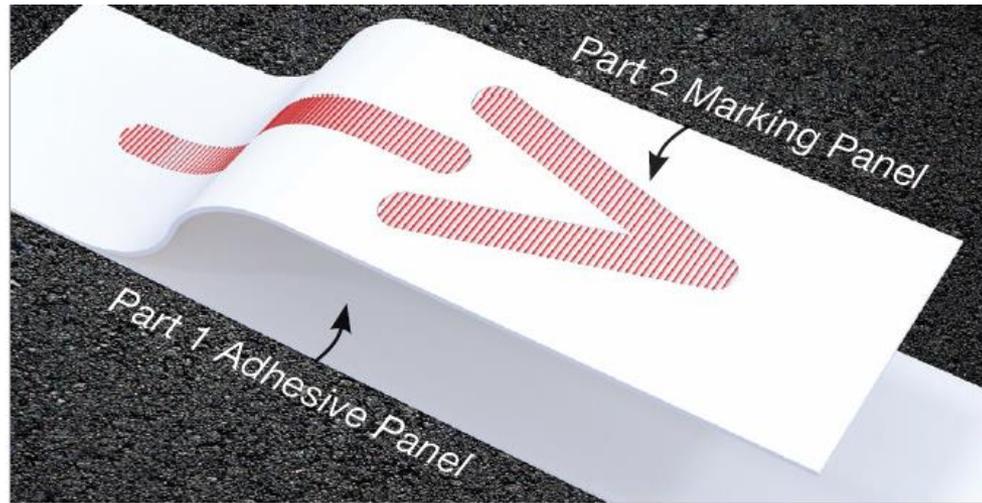
2

Pigmented coating provides high contrast visibility for messaging
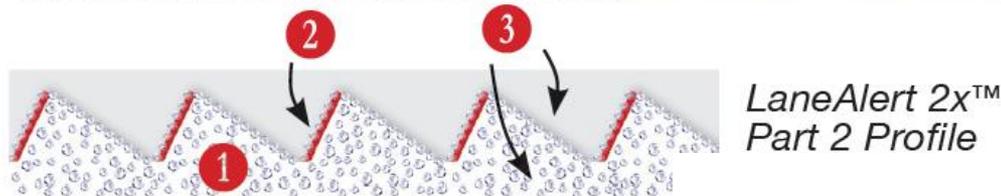
3

Base color coated with glass beads for high visibility

Part 2 Marking Panel

Part 1 Adhesive Panel

LaneAlert 2x™ Part 2 Profile

LaneAlert 2x™ Part 2 Field Cutaway

DO NOT ENTER

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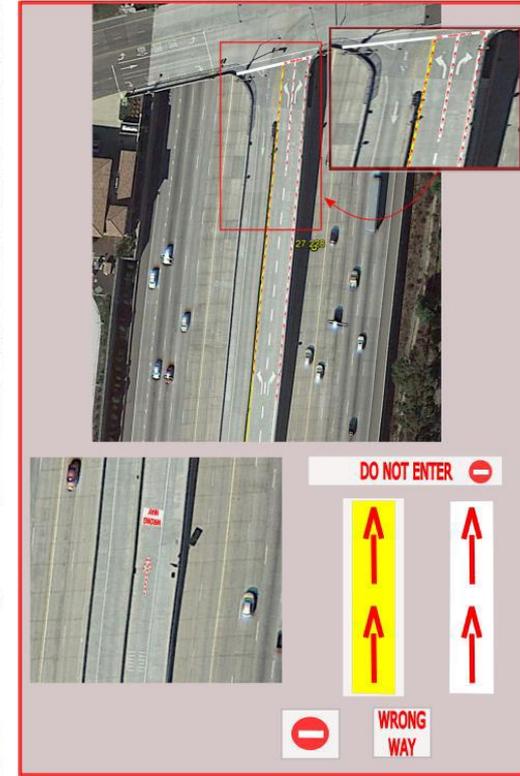
Bidirectional pavement markings Installed at I-5 NB exit ramp @ Palomar Street in Chula Vista, CA

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
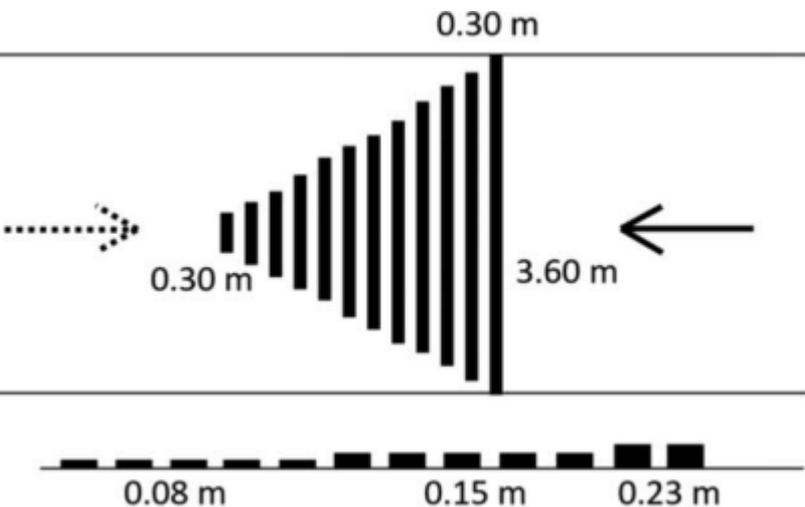

Freeway Mainline — Traffic Flow →

Pattern E.1

RAMP 30 M P H
W13-3

WRONG WAY
R5-1a

DO NOT ENTER
R5-1

Ramp Terminal

Pattern D3

WW Arrows with RRPMs

Pattern C

WW Arrow with RRPMs

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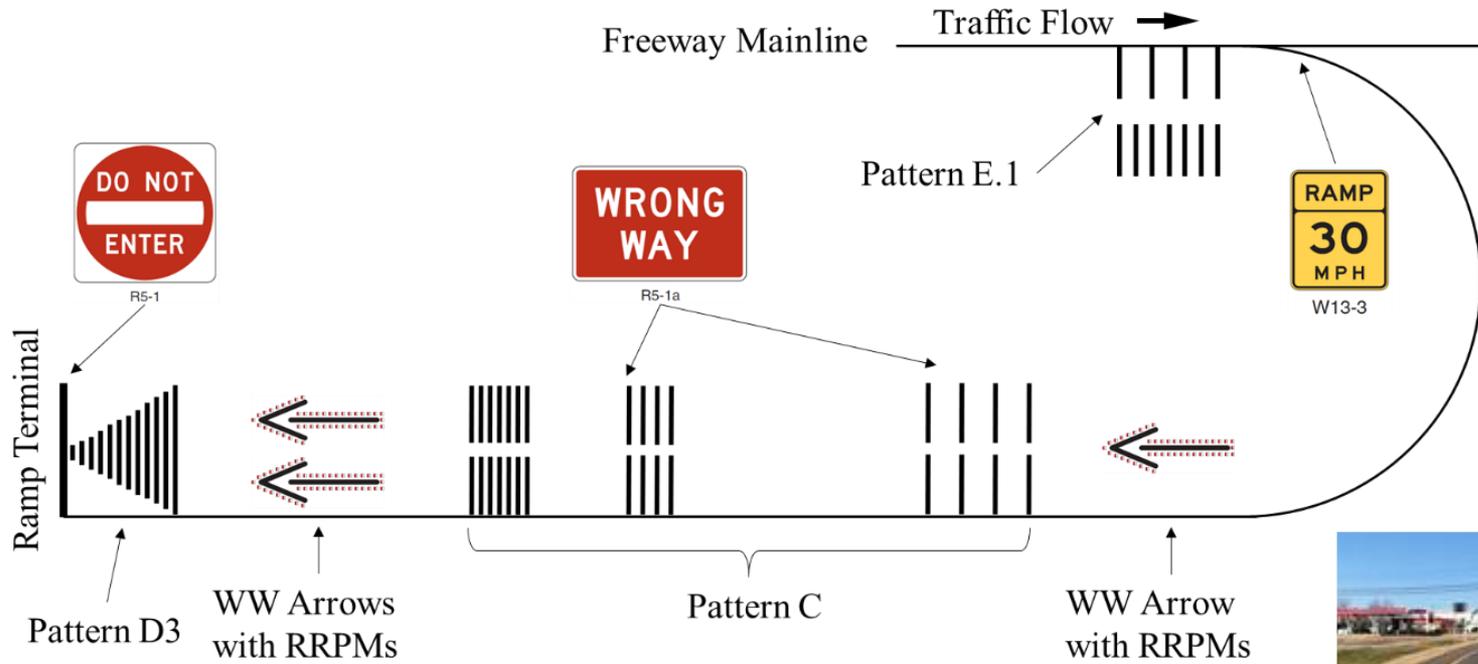
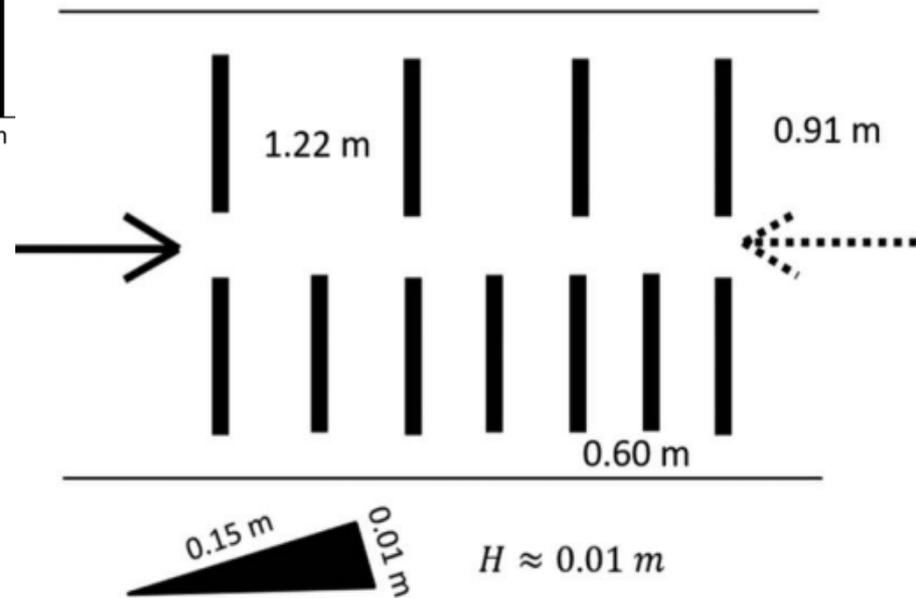# Three different patterns of directional rumble strips will be included in the driving simulator scenarios.
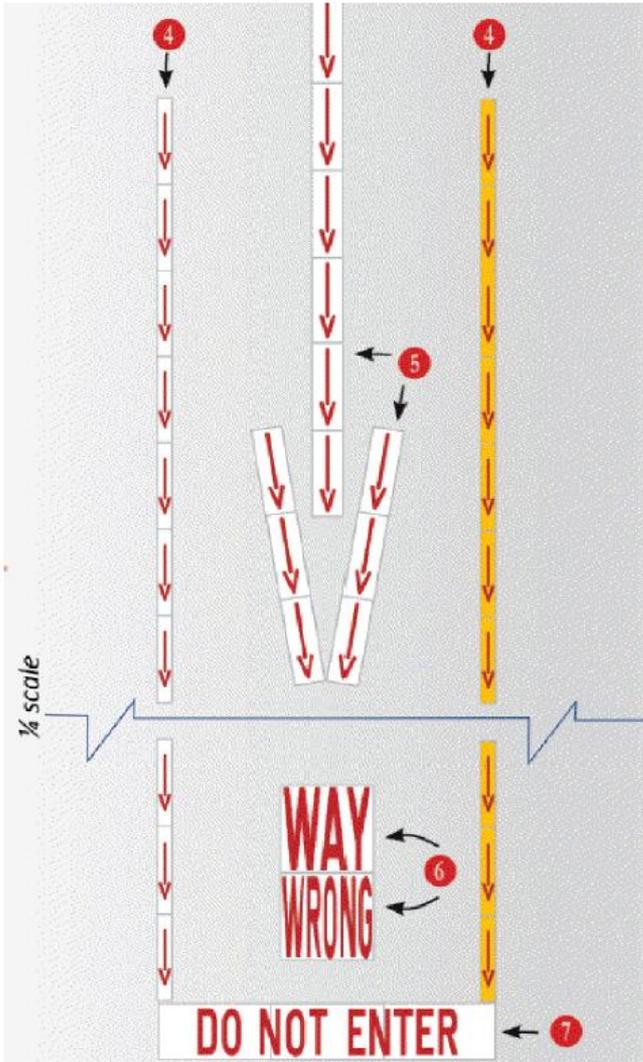
Pattern C

15.24 m   30.48 m

0.30 m   0.60 m   1.52 m

Pattern E.1

1.22 m   0.91 m

0.60 m

0.15 m   0.01 m $H \approx 0.01\ m$

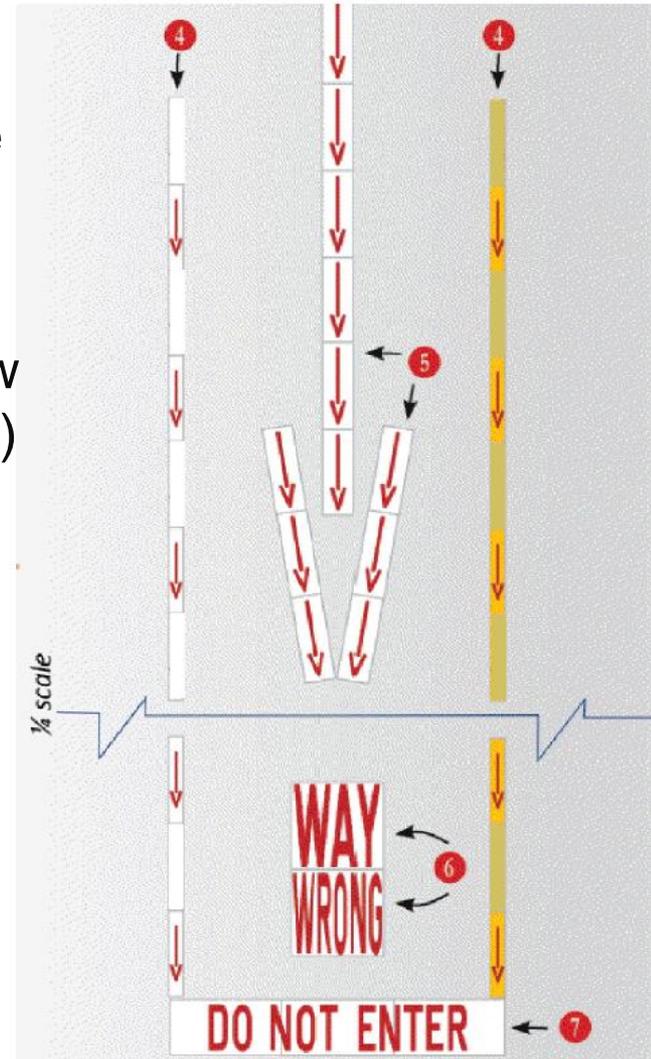## Pattern D3

0.30 m

0.30 m   3.60 m

0.08 m   0.15 m   0.23 m
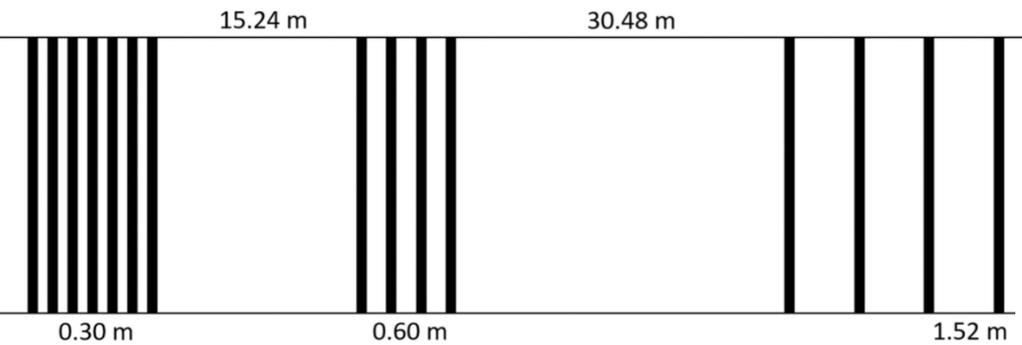
Two different patterns of bidirectional pavement markings will be included in the driving simulator scenarios.

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

❺ Wrong Way Arrow (MUTCD 3B-24D)

❻ Wrong Way Message (MUTCD 3b-24)

❼ 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
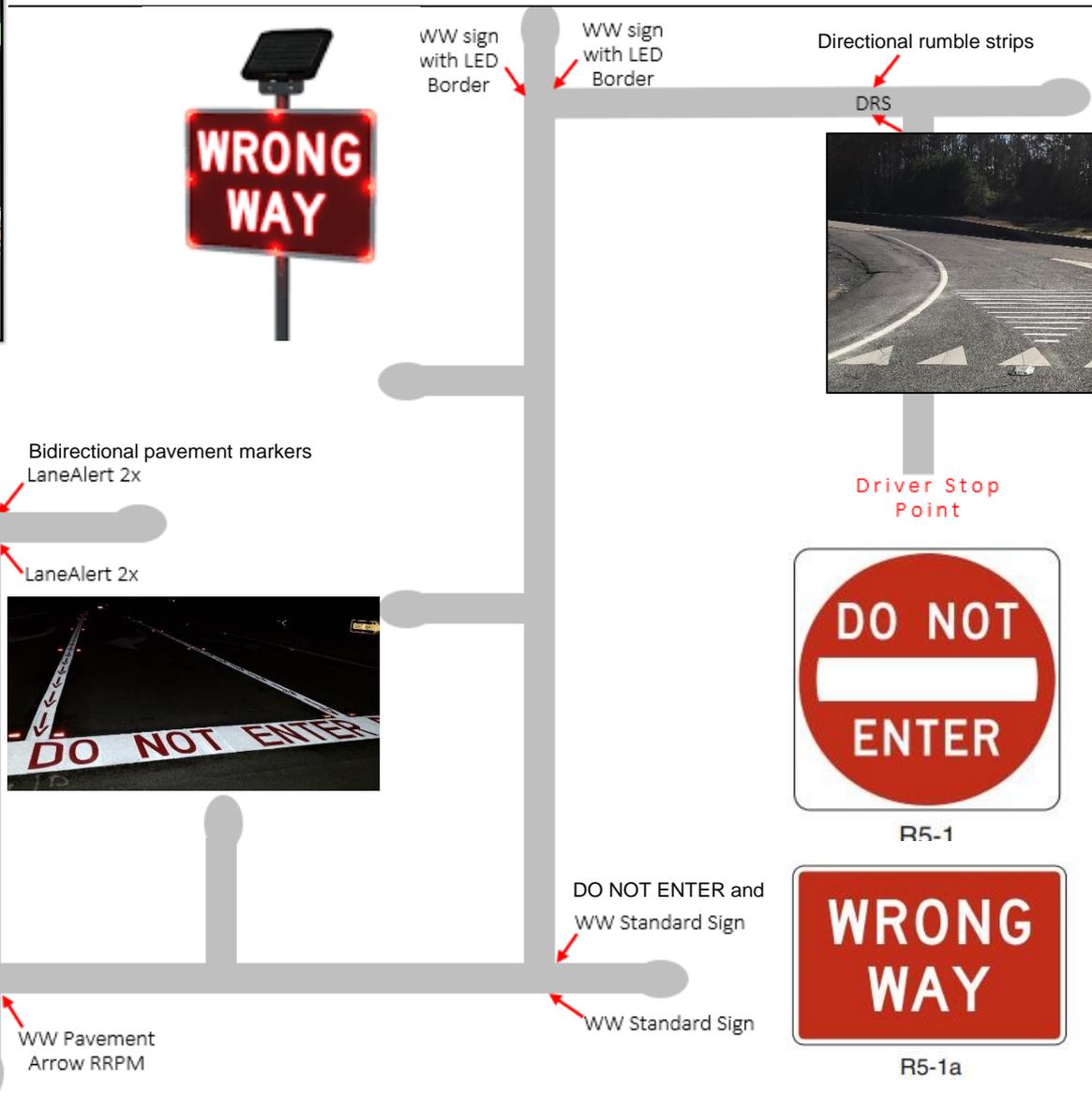- Directional rumble strips

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
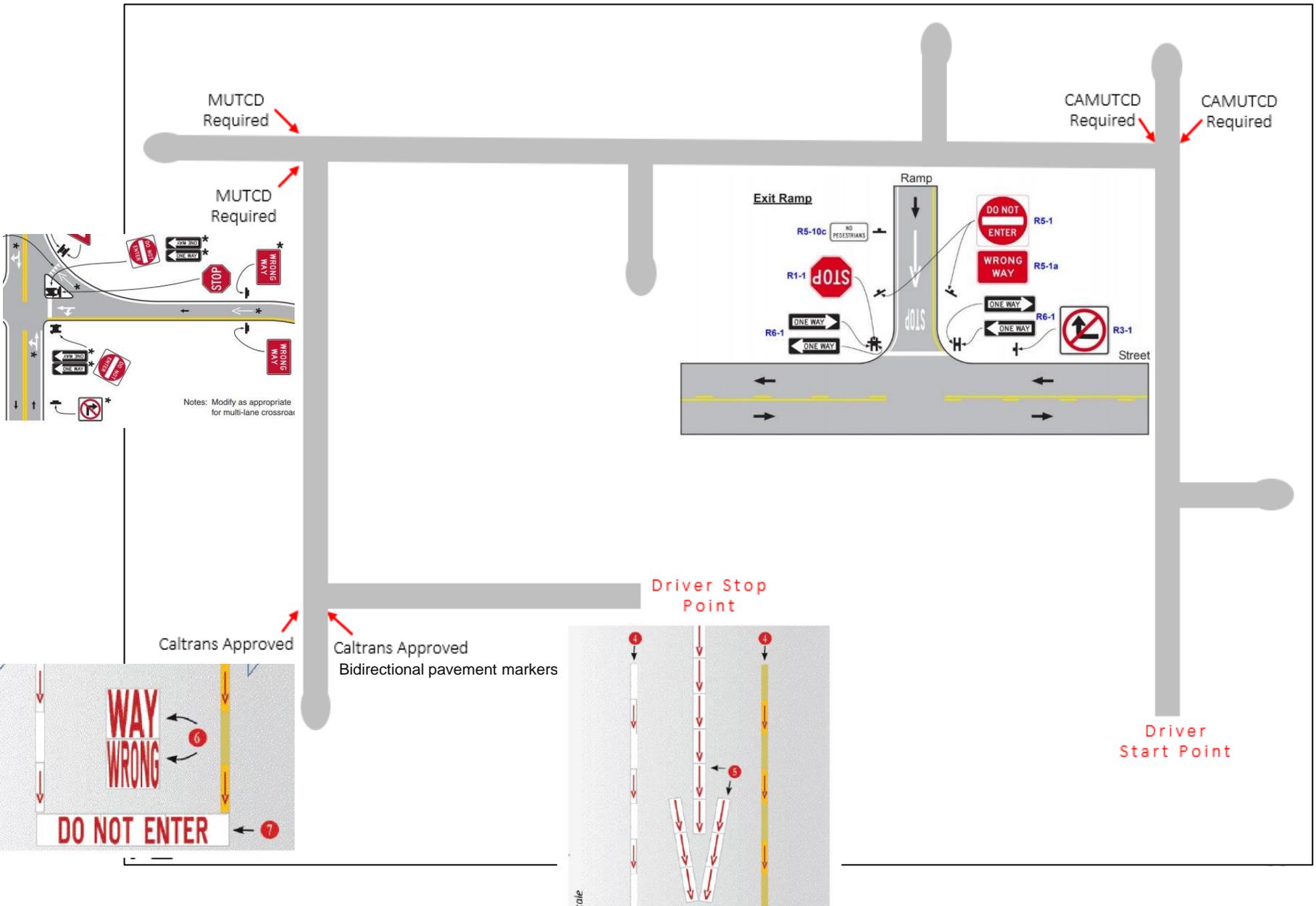

Low-mounted and enlarged

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

DO NOT ENTER

R5-1

Driver Start Point

DO NOT ENTER and
WW Standard Sign

WW Standard Sign

WRONG WAY

R5-1a

WW Pavement Arrow RRPM

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

Exit Ramp

Ramp

R5-10c — NO PEDESTRIANS

R5-1 — DO NOT ENTER

R5-1a — WRONG WAY

R1-1 — STOP

R6-1 — ONE WAY

R3-1

Street

Notes: Modify as appropriate for multi-lane crossroad

Standard WWD signs or WWD signs with LED borders combined with arrows with RRPM or bidirectional pavement markers or directional rumble strips
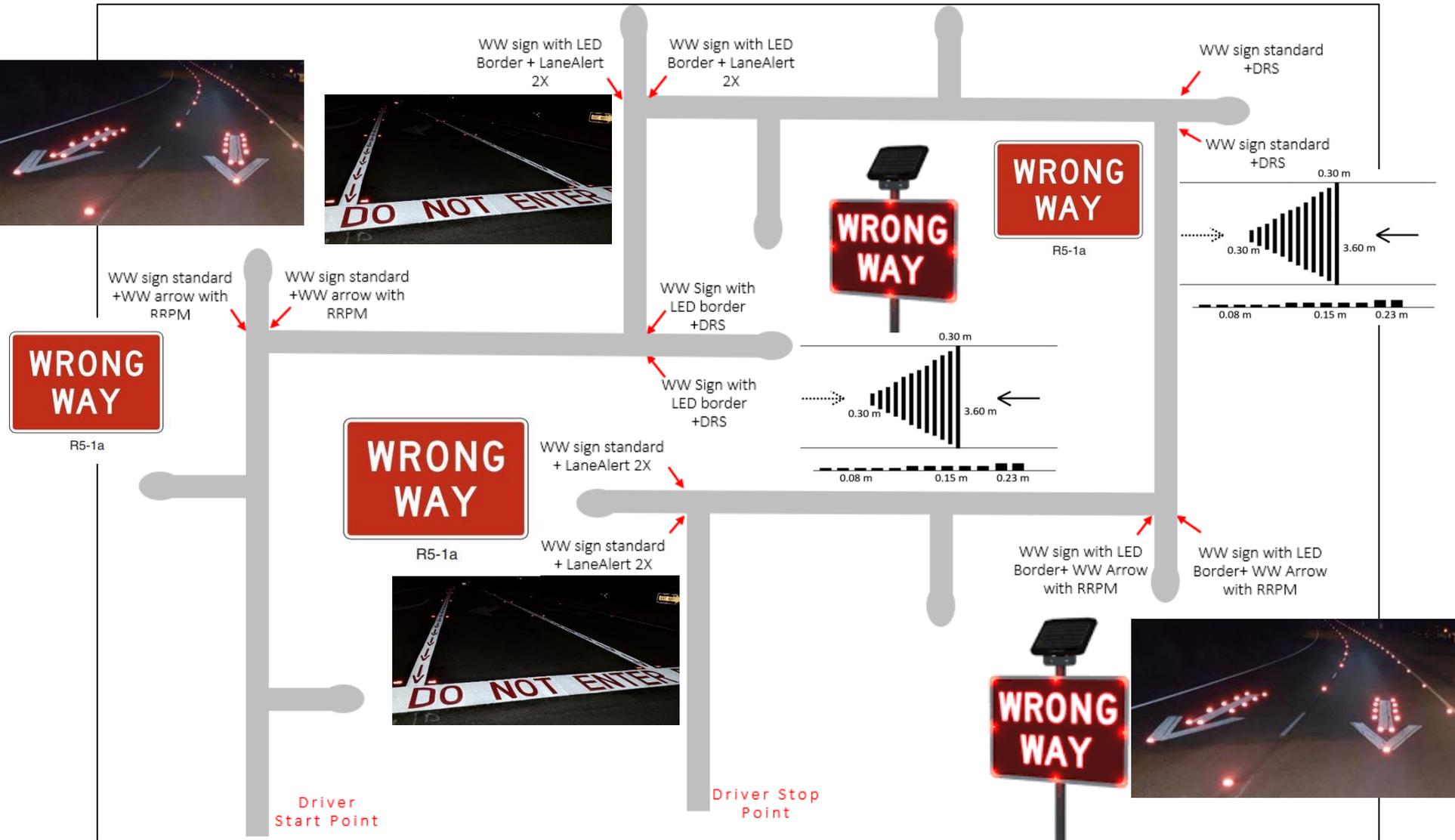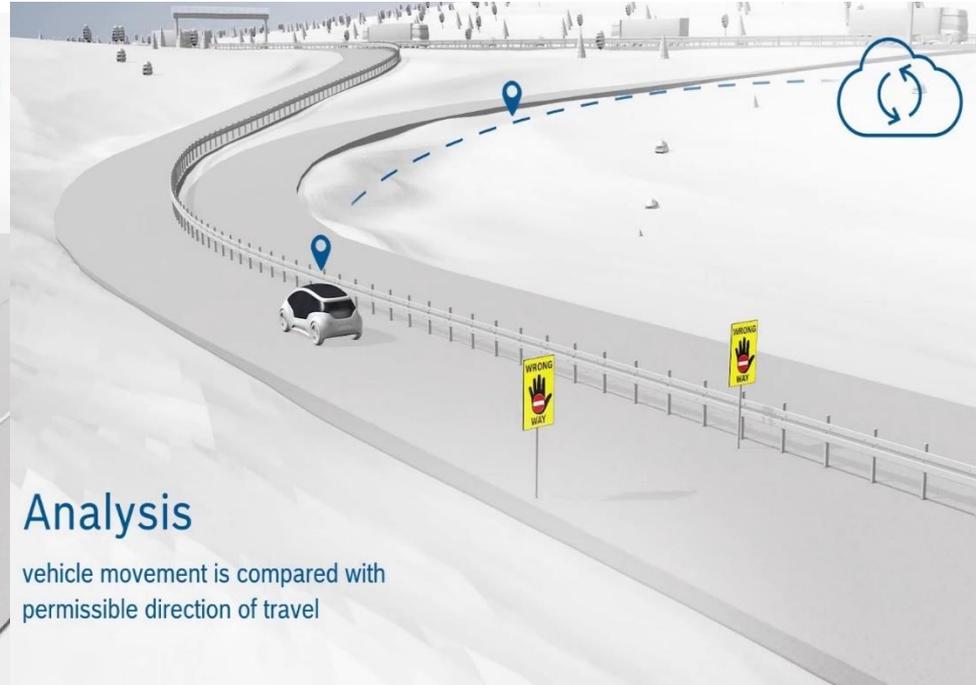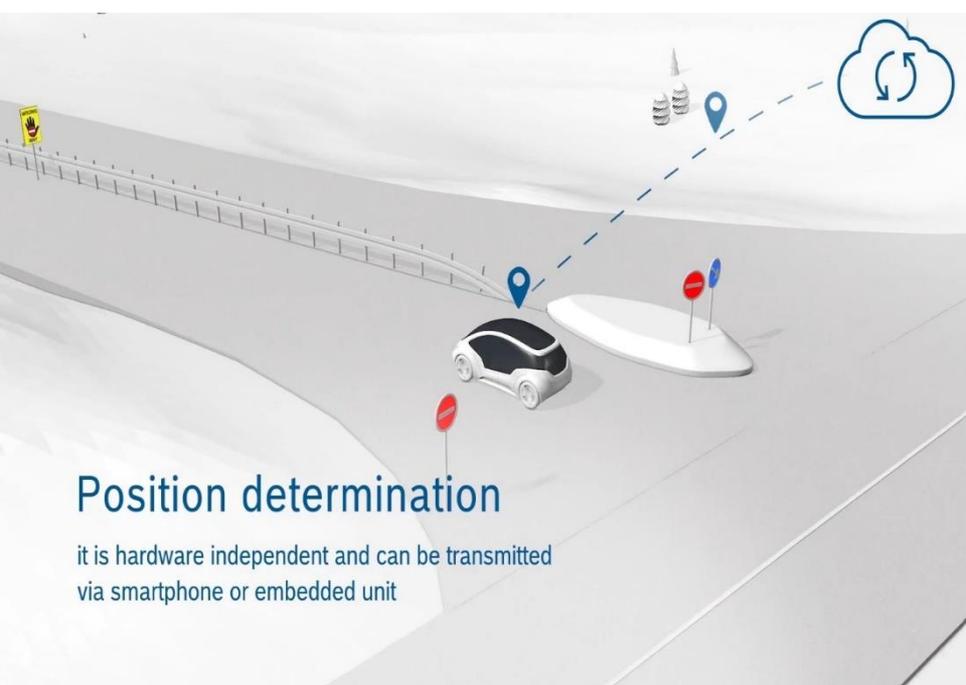
GPS mobile device to cloud Server wrong way driver detection and warning

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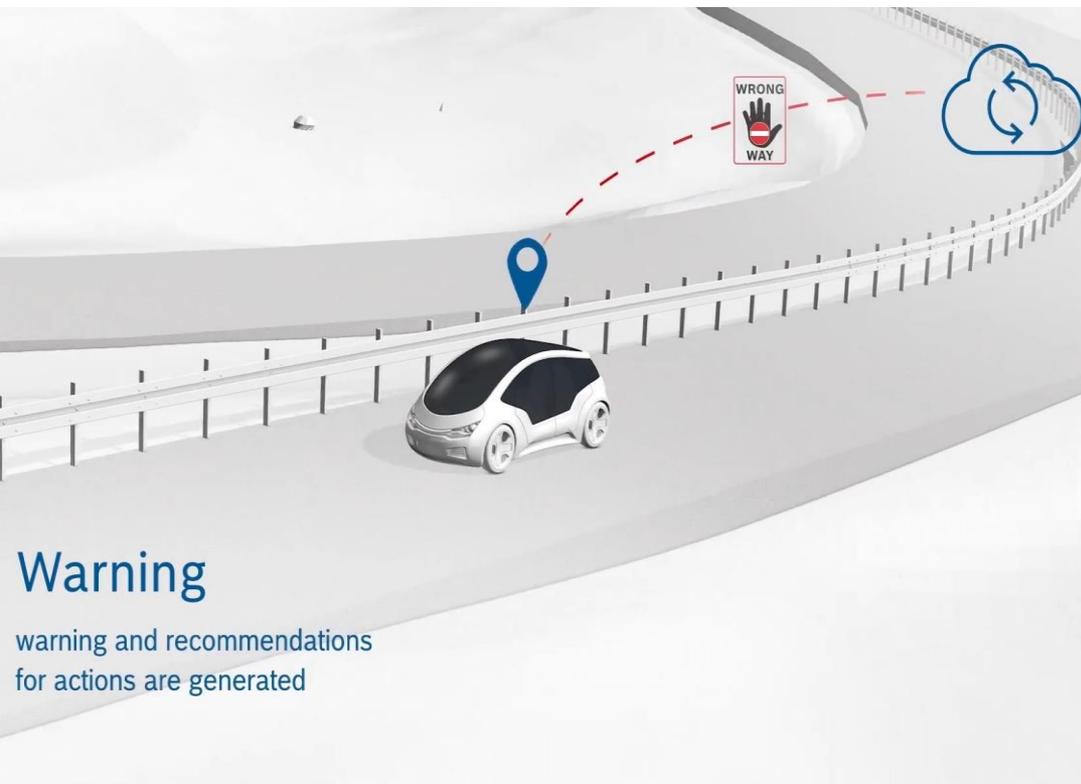
Bosch's software integrates into a third-party provider's existing mobile device app and uses the devices' GPS data to detect wrong way movements and send out a warning to the driver, proximate vehicles and interested government agencies.
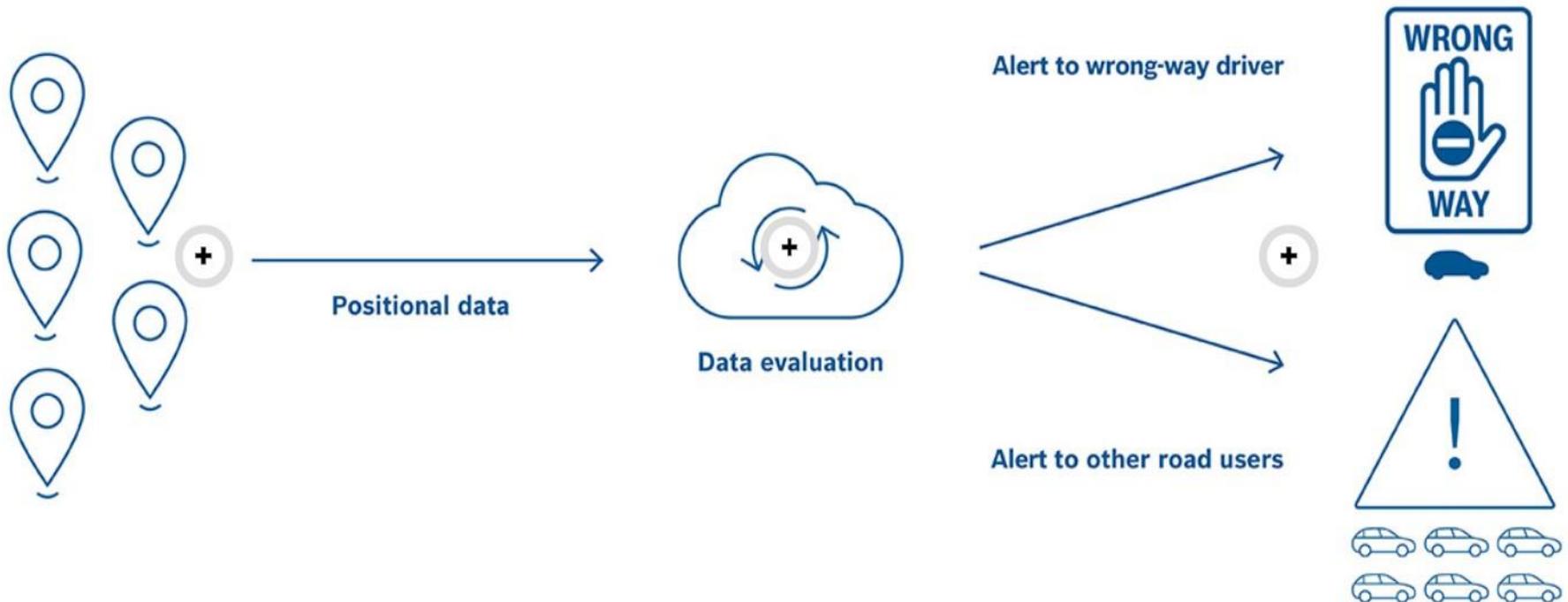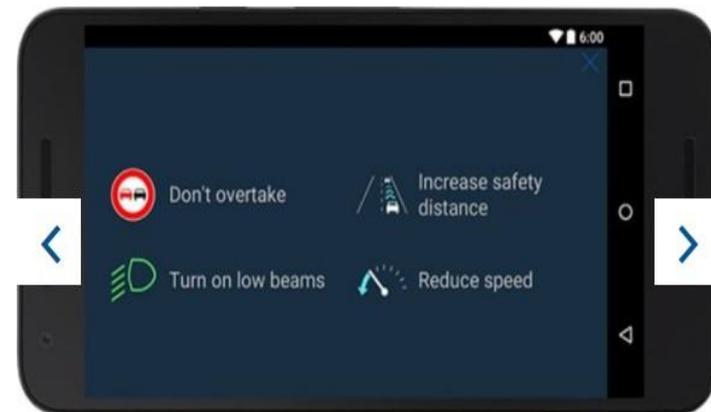

Positional data

Data evaluation

Alert to wrong-way driver

Alert to other road users

WRONG WAY

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.

Position determination

it is hardware independent and can be transmitted via smartphone or embedded unit

Analysis

vehicle movement is compared with permissible direction of travel

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.
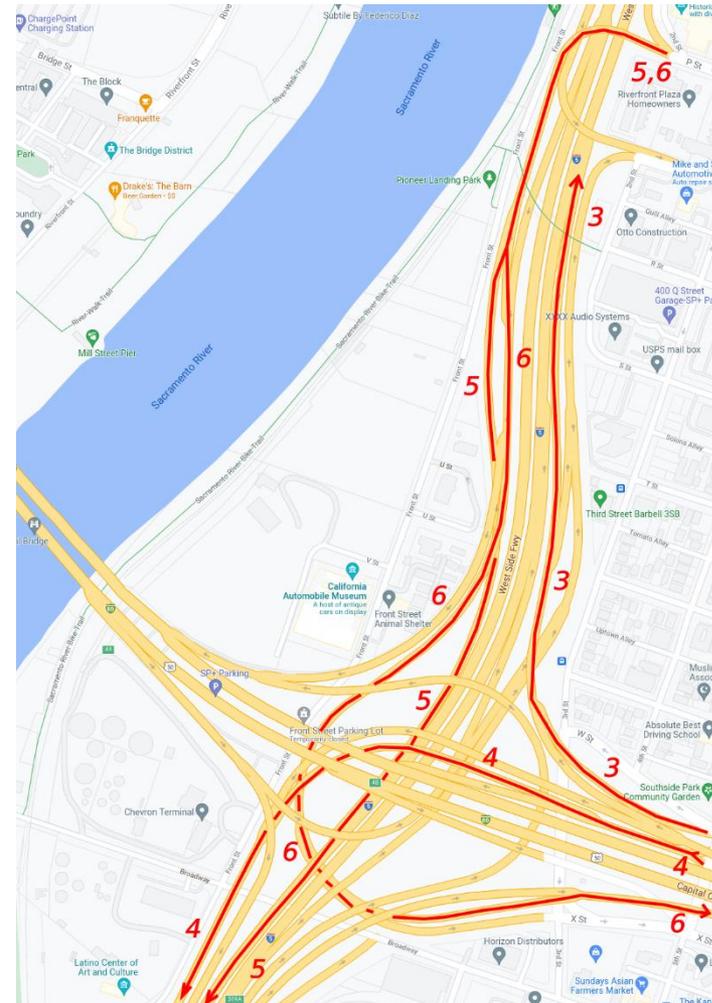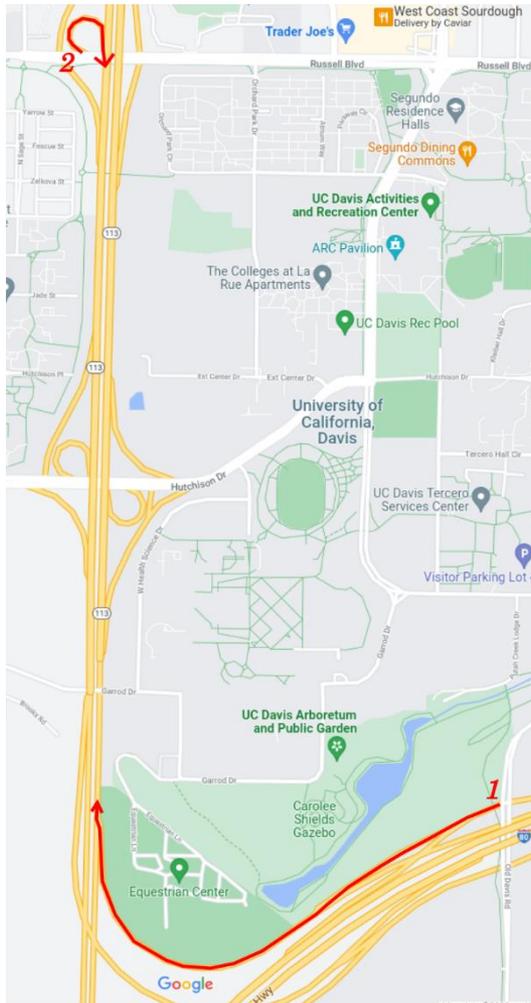

Warning

warning and recommendations
for actions are generated

Check your direction of travel!
Stop on the nearest hard shoulder, only!

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.

Alerting

endangered road users receive warning
and recommendations for actions

Beware! Wrong-way driver nearby!
Reported 4 minutes ago

Don't overtake   Increase safety distance
Turn on low beams   Reduce speed

UC Davis has signed a non-disclosure agreement with Bosch, which will supply a stand-alone version of its app for researchers to install on their cell phones. Bosch will reverse the permitted directions of travel in its database for the ramps shown below, and UC Davis will log any "false negatives," in which wrong way warnings are not sent to the Bosch app when UC Davis test drivers traverse the ramps.

Thanks for Listening