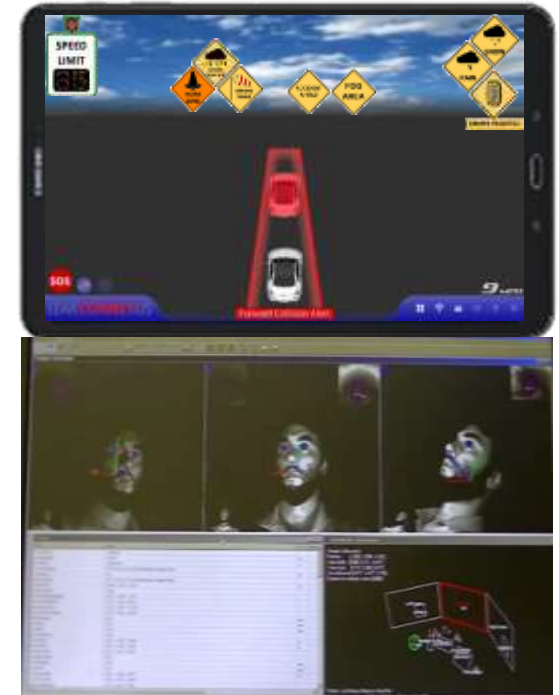# Connected Vehicle Training Framework and Lessons Learned to Improve Safety of Highway Patrol Troopers

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General

- 37,461 traffic fatalities in 2016 (US)
- 36% related to distraction and speeding
- Human factors are a leading cause of crashes

Specific

- Little/no studies to protect law enforcement
- Complex environment inside the cab
- Risky driving conditions
- (1980 - 2015) 943 crashes involving 948 law enforcement vehicles- 998 fatalities.
- (2015-2017) 95 LEO fatalities – motor vehicle crash.

Table 1. Driver-, Vehicle-, and Environment-Related Critical Reasons

Critical Reason Attributed to	Estimated	
	Number	Percentage* ± 95% conf. limits
Drivers	2,046,000	94% ±2.2%
Vehicles	44,000	2% ±0.7%
Environment	52,000	2% ±1.3%
Unknown Critical Reasons	47,000	2% ±1.4%
Total	2,189,000	100%

*Percentages are based on unrounded estimated frequencies
(Data Source: NMVCCS 2005–2007)

Table 2. Driver-Related Critical Reasons

Critical Reason	Estimated (Based on 94% of the NMVCCS crashes)	
	Number	Percentage* ± 95% conf. limits
Recognition Error	845,000	41% ±2.2%
Decision Error	684,000	33% ±3.7%
Performance Error	210,000	11% ±2.7%
Non-Performance Error (sleep, etc.)	145,000	7% ±1.0%
Other	162,000	8% ±1.9%
Total	2,046,000	100%

*Percentages are based on unrounded estimated frequencies
(Data Source: NMVCCS 2005–2007)

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WYOMING CONNECTED VEHICLE PILOT

Using Connected Vehicle (CV) Technology to enable equipped vehicles to transmit and receive data to other equipped vehicles and roadside infrastructure.

New York City, Tampa, and Wyoming selected as pilot deployment sites

- Competitive grant opportunity
- About $6 million funded 80% by the USDOT
- Freight focused
- DSRC/ SXMS based
- Intended to reduce the number and severity of crashes while improving mobility on the I-80 corridor

GOAL

Reduce crashes and crash severity on I-80.

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CONNECTED VEHICLE PILOT

Phase 1 (Planning) (09/2015 - 09/2016)

- Concept Development
- System Planning
- Deployment Plan

Phase 2 (Deployment) (10/2016 – Summer 2020)

- System Design
- System Build
- System Testing and Acceptance

Phase 3 (Demonstration) (Fall 2020 – 10/2022)

- Real-World Demonstration
- Evaluation
- Maintenance

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I-80 CORRIDOR

One of the most heavily instrumented rural corridors in the United States

- 136 Variable Speed Limit Signs
  supported by 94 speed sensors
- 54 Electronic Message Signs
- 44 Weather Stations
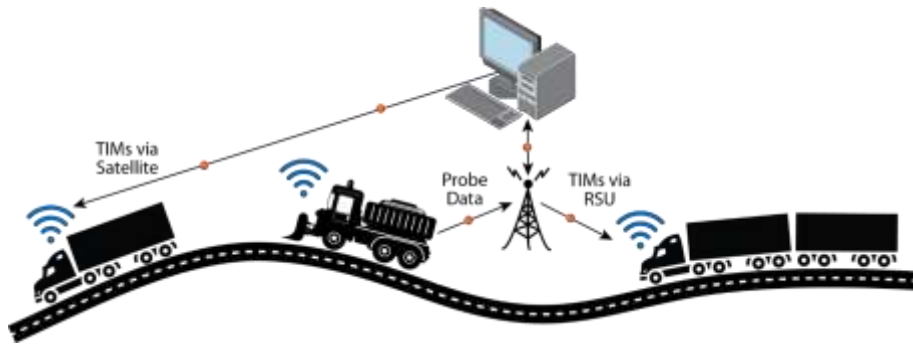- 52 Webcams

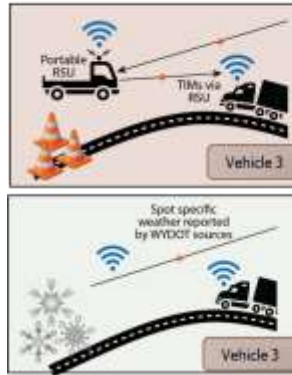UNIVERSITY of WYOMING

WYOMING CONNECTED VEHICLE PILOT

- Wyoming is paving the way for rural Connected Vehicle Applications
- Need for Effective Design for CV and ADAS
- Designing a safe implementable and Effective CV HMI for all Wyoming CV stakeholders
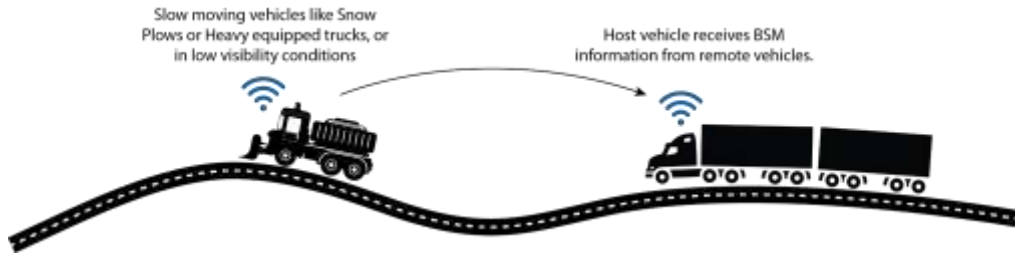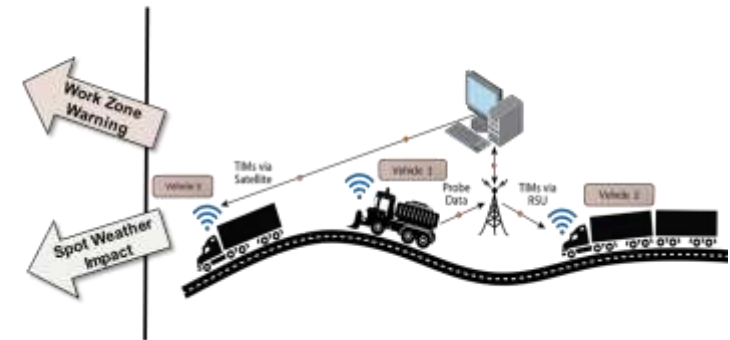
V2V Forward Collision Warning

I2V / V2I Situational Awareness (WZW, SWIS)

I2V / V2I Situational Awareness (TIM)

Distress Notification

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HUMAN MACHINE INTERFACE (HMI)

Forward Collision Warning
(FCW) – *V2V*

Situational Awareness
(SA) – *I2V*

Distress Notification
(DN) – *V2I & V2V*

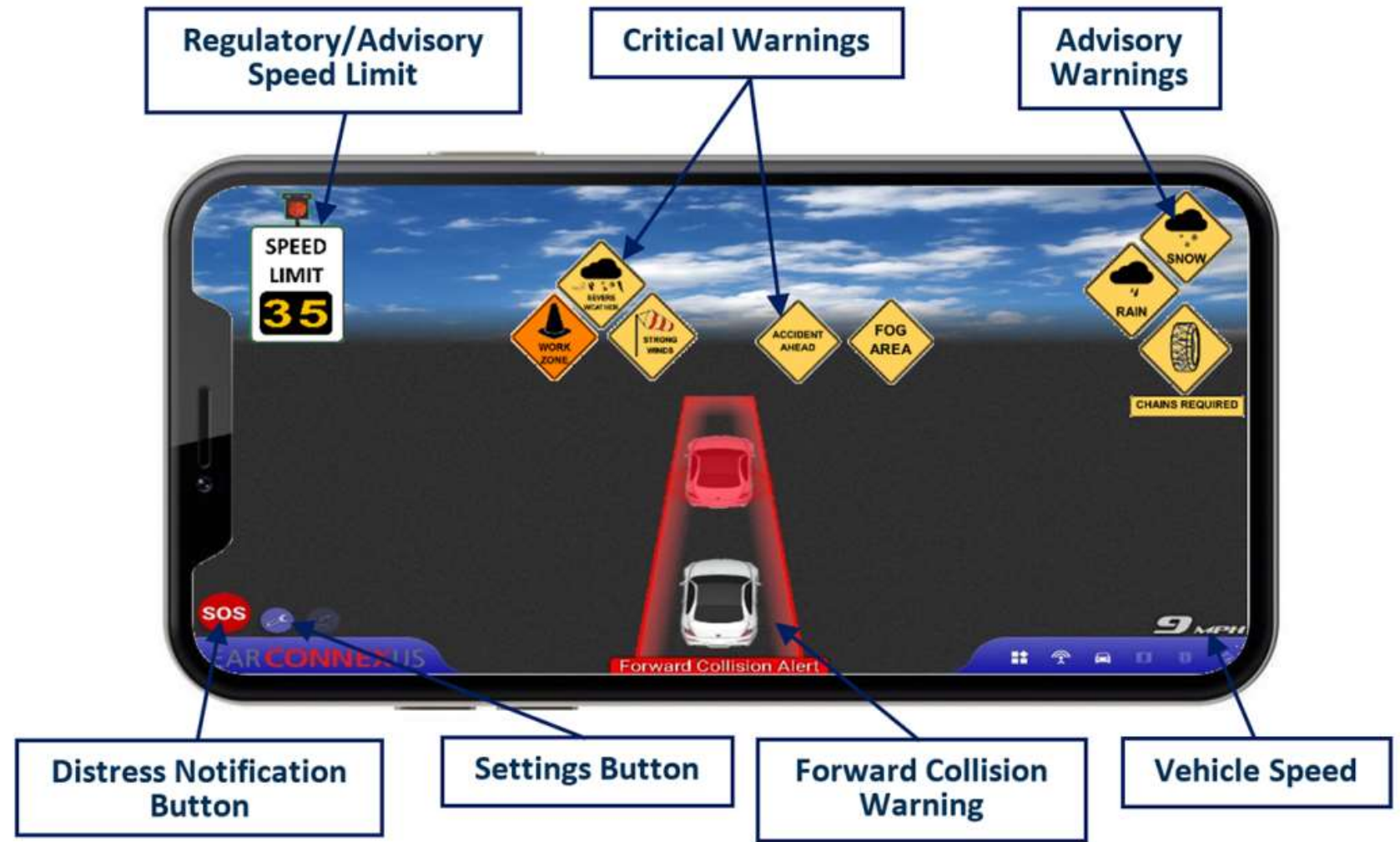Work Zones Warning
(WZW) – *I2V*

Spot Weather Impact Warning
(SWIW) - *I2V*

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HUMAN MACHINE INTERFACE

WYOMING HIGHWAY PATROL

- 210 Wyoming State Troopers
- Patrol 6800-mile state highway system
- Drive over 5 million miles a year
- Write 89,000 citations
- Investigate over 7,000 crashes
- Involved in an event every 30 miles he/she patrols

Source: https://mylocalradio.com/

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WYOMING HIGHWAY PATROL

- Drive at high speeds under enormous workload regardless of the road and weather conditions.

- Spend hundreds of hours patrolling the highways.

- Connected Vehicle can communicate timely road and Traveler Information Messages (TIMs) to troopers which can significantly reduce the frequency and/or severity of crashes.

- About 75 highway patrol vehicles will be equipped with the CV technology.

Source: Wyoming Highway Patrol (WHP)-2019

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1. Design Training Framework

- Literature Review
- Ride Along with WHP, Expert Review, Mockup Trainings.
- Questionnaire Surveys
- Design E-training module and Driving Simulator Experiment.

2. Evaluation of HMI

- Driving Simulator Study
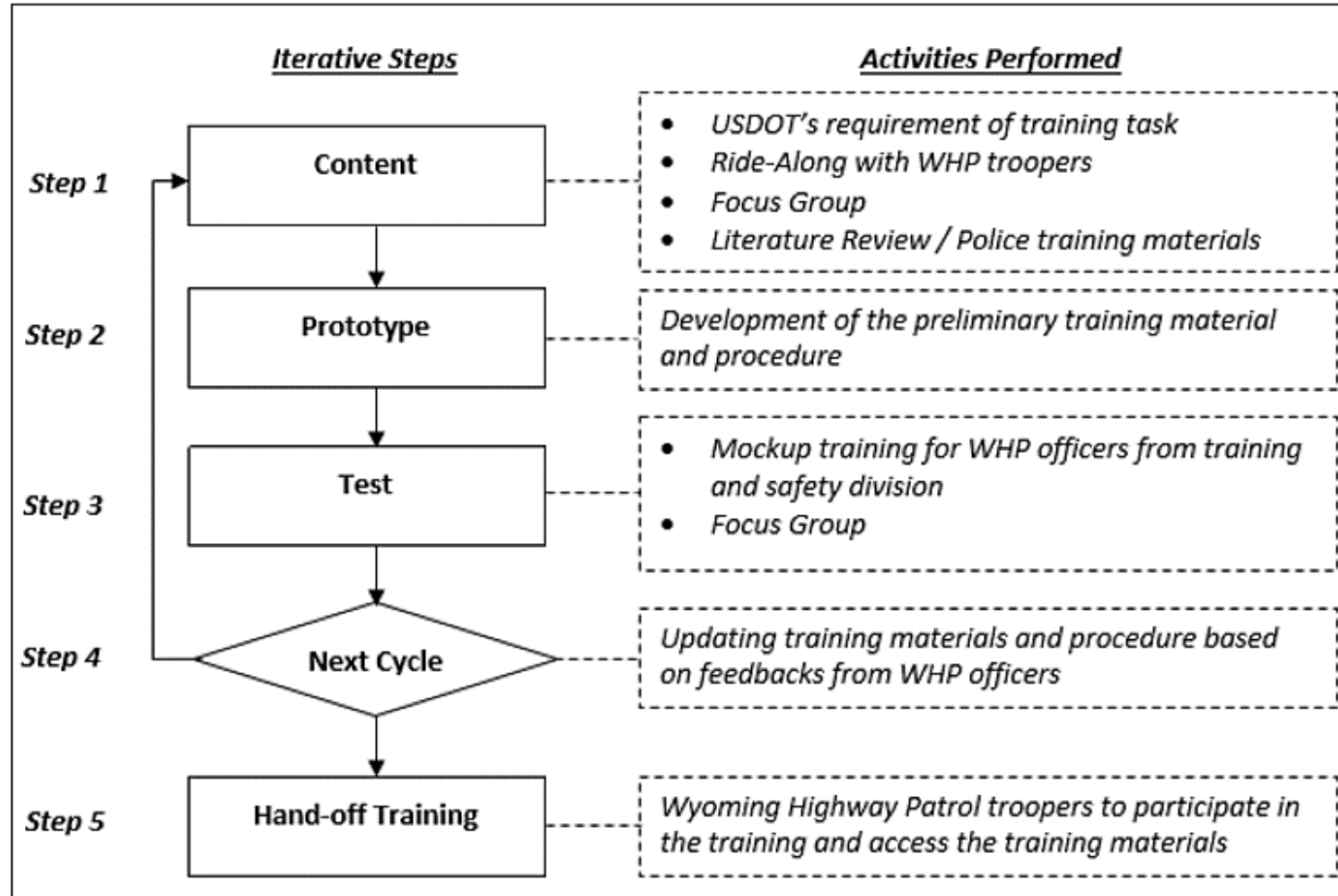- Post Drive Questionnaires
- Vehicle Dynamics Data
- Eye Tracking Study

3. Recommendations

- Provide Recommendations for Best HMI Design

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RIDE ALONG WITH WYOMING HIGHWAY PATROL

Table: Summary of activities performed during an 18-minute (1,080 s) ride-along event

| Activities	Time (s)	% of Total time
MDT glance	25	2.25
Radio: listening	40	3.60
Radio: talking	22	1.98
MDT interaction (button press)	2	0.18
Cell phone interaction	10	0.90
Cell phone hands-free talk	33	2.97
Interacting with siren box	335	30.18
One-hand driving (including all activities that require a hand)	630	56.76

DRIVING SCENARIOS

Initial Training Phase		Comprehensive Training Phase	
	Mini Scenarios	Slippery Road	Work Zone
Warmup Scenario	1. Forward Collision Warning (FCW)	1. Baseline	1. Baseline
	2. Variable Speed Limit (VSL)	2. EVoice	2. EVoice
		3. EBeeps	3. EBeeps
		4. SBeeps	4. SBeeps
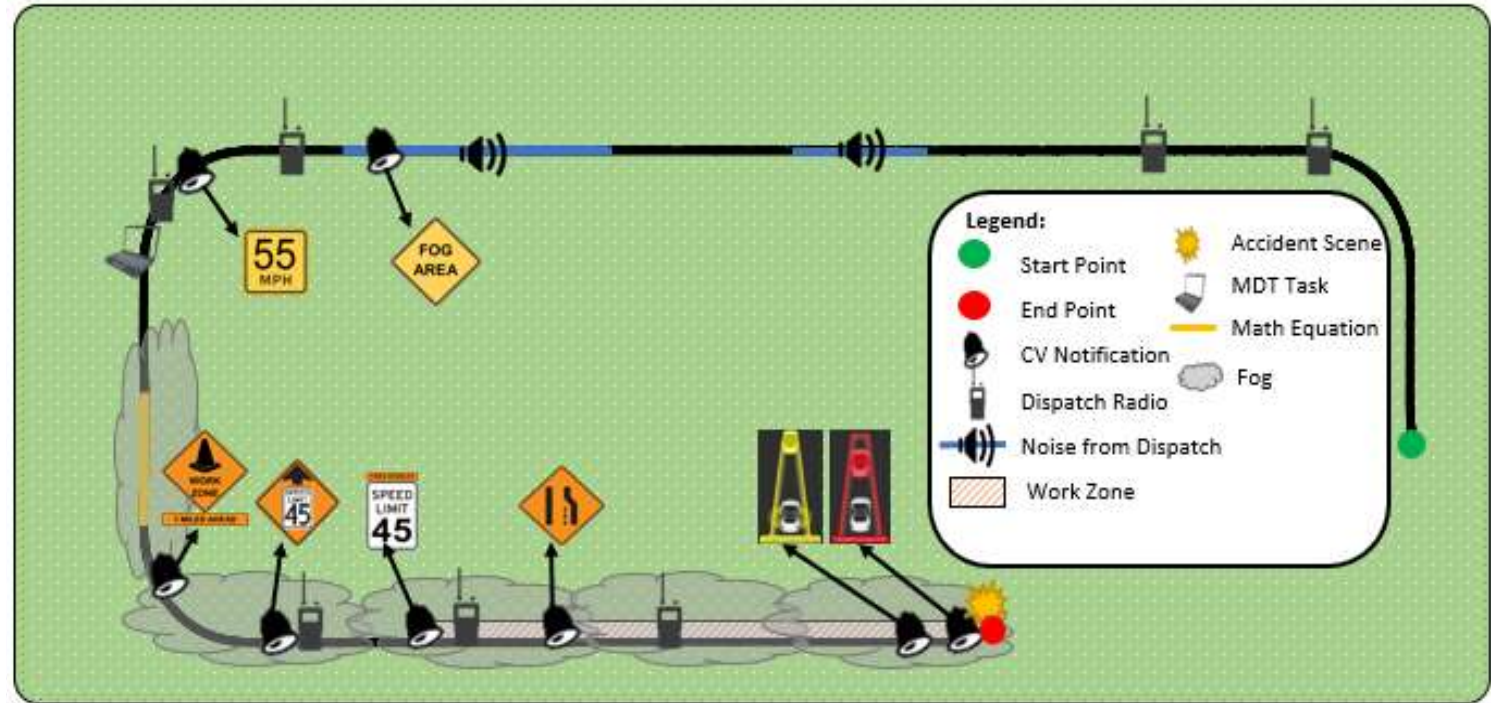
Work Zone Scenario

DRIVING SCENARIOS

Modalities Tested:

1. Baseline (Non-CV)

2. Enlarged Icons with Beeps (EBeeps)

3. Enlarged Icons with Voice (EVoice)

4. Small Icons with Beeps (SBeeps)

The EBeeps and EVoice are presented in a salient fashion: enlarged icons for about 5 s and then overland on the main screen.

No HMI

Presented with Beeps

Presented with Voice

Presented with Beeps

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DRIVING SCENARIOS

Participants:

- 10 Wyoming Highway Patrol (WHP) troopers (5 percent of overall WHP population).

- Working for WHP for an average of 7.8 years.

- Average annual mileage over the past 5 years: 30,000 miles.

- Two troopers reported having been involved in a crash on I-80 while on duty.

High Fidelity Car Simulator – WYOSAFESIM
University of Wyoming

Design of Experiment

- Each participant drove 11 scenarios including warmup, mini scenarios and comprehensive scenarios (3-4 hours)

E-TRAINING/ ONLINE TRAINING MODULE

- Information followed by questions format.

- Includes introduction, components of CV system, suite of applications and appropriate behaviors.

- Online Training for troopers who cannot make it to the lab.

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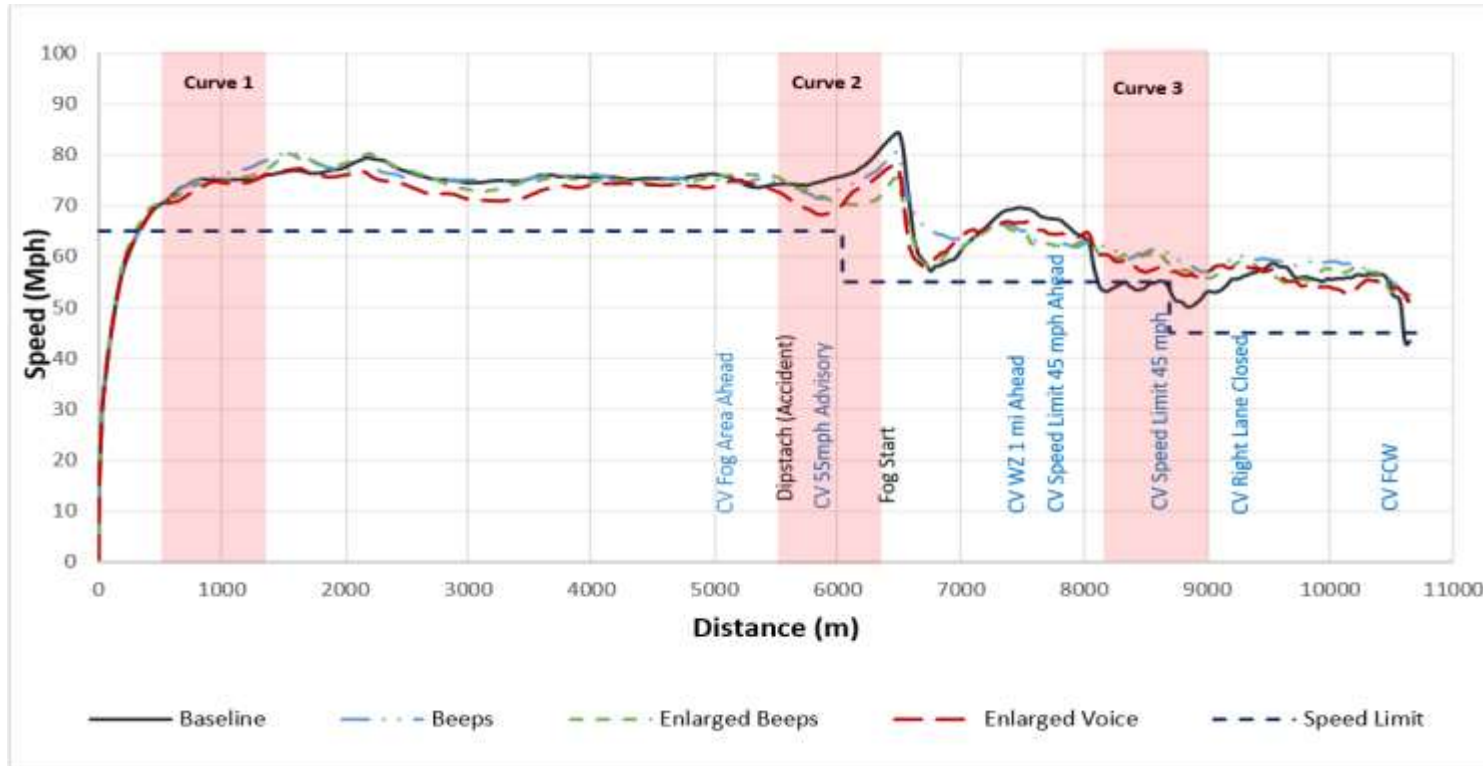
- Allowing lower 45 MHz of DSRC spectrum for unlicensed use might cause a safety issue.

- WYDOT partnering with SiriusXM, for communicating CV notifications via satellite.

- Layout designed by SiriusXM.

- Training module developed according to the new layout.

Work Zone Scenario

Summary of Training/Scenario Assessment

- WHP troopers are very different from normal drivers – Behavior and driving settings.

- The scenarios had to be modified several times – Increasing difficulty level.

- Troopers cannot be mandated to follow each and every TIM - Attending emergency events.

- Training takes about 3 h to complete - Attractive and interactive.

- The training materials need to be kept updated - Evolving technologies and practices

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Summary of Preliminary Participants Assessment

- CV technology was most favorable under poor-visibility driving conditions

- FCW and Re-Routing were the most useful CV applications

- Approximately a quarter of the participants indicated that CV HMI might introduce distraction.

Recommendations

- Some CV warnings should be provided during adverse weather or limited visibility conditions only (WZW).

- User Customization Capability.

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Connected Vehicle Training Framework and Lessons Learned to Improve Safety of Highway Patrol Troopers

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