Connected Vehicle Human-Machine Interface: Development and Assessment

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The Problem

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

Critical Reason is “the last failure in the causal chain of events leading up to the crash”
USDOT CV Pilot Project

- 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.
Wyoming Connected Vehicle Pilot

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

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

**Phase 2**
- Deployment
- (10/2016 – Summer 2018)

**Phase 3**
- Demonstration
- (Fall 2018 – 10/2019)

- Concept Development
- System Planning
- Deployment Plan

- System Design
- System Build
- System Testing and Acceptance

- Real-World Demonstration
- Evaluation
- Maintenance

University of Wyoming
Wyoming’s I-80 Corridor
Wyoming’s I-80 Corridor

Heavy Freight Traffic
- Major E/W freight corridor
- Freight = over half of annual traffic

Severe Weather Conditions
- Roadway elevation
- Heavy winds, heavy snow and fog
- Severe blowing snow and low visibility

Adverse Impacts on Trucks
- Higher than normal incident rates
- Multi-vehicle crashes
- Fatalities

Source: WYDOT (Dec 17, 2015)
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
Interstate 80 Corridor
Interstate 80 Corridor

https://www.youtube.com/watch?v=Pe83hj8nUhl
On I-80 in Wyoming

- **IN 1 YEAR PERIOD ALONE**
  - 700 commercial vehicle accidents
  - 906 non-commercial vehicle accidents
  - 1,552 hours road closures

- **1600+ CRASHES IN 1 YEAR**
  - 18 fatalities
  - 271 injuries
  - 1,317 property damage

**GOAL**

Reduce crashes and crash severity on I-80.
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 (TIM)

I2V / V2I Situational Awareness (WZW, SWIS)

Distress Notification

Source: WYDOT CV Pilot
Human Machine Interface

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
University of Wyoming Simulation and Human Factors Lab (WYOSAFE SIM)
23 WYDOT professional snowplow and truck drivers; all the participants were MALE.  
58% High School, 34% College, 8% Postgraduate.
Scenario #1: Work zone with Forward Collision Warning in fog
CV Applications tested: WZW & FCW
Scenario #2: Slippery Road Surface due to snowy weather

CV Applications tested: SWIW & DN
Scenario #3: Road Closure due to accident in severe weather

CV Applications tested: SWIW & SA
Work Zone in Fog Scenario
Usefulness of CV under Various Driving Conditions
## Participants Assessment of CV HMI

<table>
<thead>
<tr>
<th>Scale Items</th>
<th>Mean</th>
<th>SE</th>
<th>Positive</th>
<th>Neutral</th>
<th>Negative</th>
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<tbody>
<tr>
<td><strong>(a) Readability of CV Warnings (~84% Positive)</strong></td>
<td></td>
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<tr>
<td>CV warnings easy to understand?</td>
<td>6.1</td>
<td>0.80</td>
<td>96.2%</td>
<td>3.8%</td>
<td>0%</td>
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<tr>
<td>CV warnings are NOT confusing?</td>
<td>5.5</td>
<td>0.95</td>
<td>80.8%</td>
<td>19.2%</td>
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<td>CV warnings are NOT distracting?</td>
<td>5.2</td>
<td>1.37</td>
<td>73.1%</td>
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<td>CV warnings clear conveyed messages?</td>
<td>5.7</td>
<td>0.93</td>
<td>84.6%</td>
<td>15.4%</td>
<td>0%</td>
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<tr>
<td><strong>(b) Usefulness of CV Technology (~71% Positive)</strong></td>
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<td>CV system provided improved roadway information?</td>
<td>5.8</td>
<td>1.14</td>
<td>85.7%</td>
<td>9.5%</td>
<td>4.8%</td>
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<tr>
<td>CV applications increased traffic safety?</td>
<td>5.9</td>
<td>1.14</td>
<td>88.5%</td>
<td>7.7%</td>
<td>3.8%</td>
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<td>Dependent on the CV applications?</td>
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<td>1.61</td>
<td>42.3%</td>
<td>30.8%</td>
<td>26.9%</td>
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<tr>
<td>Desirability of CV system?</td>
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<td>1.67</td>
<td>65.4%</td>
<td>23.1%</td>
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<td>CV Applications</td>
<td>Readability</td>
<td>Usefulness</td>
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<td>SE</td>
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<tr>
<td>FCW</td>
<td>5.9</td>
<td>0.99</td>
<td>84.6%</td>
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<td>DN</td>
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<td>Road Surface</td>
<td>6.1</td>
<td>0.80</td>
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<td>Re-Routing</td>
<td>6.1</td>
<td>1.13</td>
<td>92.3%</td>
<td>3.8%</td>
<td>3.8%</td>
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<td>WZW</td>
<td>6.2</td>
<td>0.97</td>
<td>88.5%</td>
<td>11.5%</td>
<td>0%</td>
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<tr>
<td>SWIW</td>
<td>5.9</td>
<td>0.91</td>
<td>92.3%</td>
<td>7.7%</td>
<td>0%</td>
</tr>
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</table>
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.
Ongoing Work

• Eye Tracking and Driving Data
• HMI/ Warning Modality (i.e., visual, auditory (voice message, beeps), or a combination of visual and auditory)
• Optimum Number of Alerts
• Early Warnings and Duration
• Warning Prioritization
• Real-world Assessment
References


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Visit CV Pilot and Pilot Site Websites for more Information:

- CV Pilots Program: http://www.its.dot.gov/pilots  
- Wyoming DOT: https://wydotcvp.wyoroad.info/