WYDOT Connected Vehicle Pilot Project

NATIONAL RURAL ITS CONFERENCE
OCTOBER, 5 2016

WYOMING DEPARTMENT OF TRANSPORTATION
AND
McFarland Management, LLC
Agenda

Wyoming CV Pilot Demonstration Project Overview
  ◦ Solving a Real Need
  ◦ Deployment Summary
  ◦ Partnership Framework

Wyoming CV Pilot Performance Measurement
  ◦ Measures
  ◦ Evaluation Designs
  ◦ Data
  ◦ Confounding Factors
The Connected Vehicle Pilot

**Phase 1**
12 Months
- Planning *(COMPLETED)*

**Phase 2**
20 Months
- Designing
- Building
- Testing

**Phase 3**
18 Months
- Maintenance and Operation
Wyoming CV Pilot: Solving a Real Need

- 250 hours
  - Full Closure
  - Road Closure
  - Closure to Light, High-Profile Vehicles

- ~180 hours
  - High Profile Vehicle Restriction

- 37 Days
  - Inclement weather

Driving a light truck between Rawlins and Laramie, I-80 drivers would have experienced a total of more than 2 weeks with closures in this 10 month period.
Wyoming CV Pilot: Solving a Real Need

September 2015 through September 2016

655 incidents involving commercial vehicles on I-80

**Interstate 80 Incidents**
09/04/15 - 08/16/16

- **Fatal (8)***
  - Westbound: 5 (Weather Present: 1)
  - Eastbound: 3 (Weather Present: 0)

- **Injury (105)***
  - Westbound: 63 (Weather Present: 15)
  - Eastbound: 42 (Weather Present: 20)

- **Property Damage Only (541)***
  - Westbound: 282 (Weather Present: 140)
  - Eastbound: 259 (Weather Present: 135)

Westbound total: 350
Eastbound total: 304
The need for actionable information is growing

WYDOT’s Commercial Vehicle Operator Portal (CVOP)
Created for trucking community and designed with their input. Includes:
- Road weather forecasts (surface conditions, visibility, wind)
- Pre-event forecast information through FHWA’s RWMP’s Pathfinder initiative

150

800

26,443

Estimated Firms Subscribed to WYDOT Commercial Vehicle Operator Portal
Downloads of WYDOT 511 App

*Downloads since Feb 2016 when app was released
The Wyoming Connected Vehicle Pilot

- DSRC Based
- Freight-Focused
- Integrated with TMC
- Integrated with WYDOT Fleets
- Forward Looking
The Wyoming Connected Vehicle Pilot

- 75 Roadside Units on I-80
- 400 Vehicles with DSRC Connectivity

CV Environment

V2V Applications
- Forward Collision Warning
- Distress Notification

V2I Applications
- Situational Awareness
- Spot Weather
- Work Zone Warning

DSRC Based
On-Board Applications

The pilot will develop five on-board applications that will provide key information to the drivers of equipped vehicles.

- **Forward Collision Warning (FCW)**
- **Infrastructure-to-Vehicle (I2V) Situational Awareness (SA)**
- **Distress Notification (DN)**
- **Work Zone Warning (WZW)**
- **Spot Weather Impact Warning (SWIW)**
Forward Collision Warning

Application Summary: V2V communication-based safety feature that issues a warning to the driver of the connected host vehicle in case of an impending front-end collision with a connected remote vehicle ahead in traffic in the same direction of travel on both straight and curved geometry roadways.

Relevant Standards: J2945/1 March 2016 Section 4.2.4

Slow moving vehicles like Snow Plows or Heavy equipped trucks, or in low visibility conditions receive BSM information from remote vehicles.
Distress Notification

Application Summary: enables connected vehicles to communicate a distress status when the vehicle’s sensors detect an event that might require assistance from others or the vehicle’s operator manually initiates a distress status. The vehicle generates and broadcasts a distress message (e.g., Mayday) to the nearest RSU. When an RSU is not within communication range, the message is received by connected vehicles that are in the vicinity and forwarded other connected vehicles that are headed towards the event and then to an RSU. Messages drop off after specified spatial and temporal criteria.

Relevant Standards: Application is loosely based on the Mayday application description from J3067 Section 3.5.9.2.1, it is built on a higher priority TIM communication using J2736 March 2016, Section 5.16, Part 3, Integrated Transport Information System (ITIS) advisory elements.
CV Data will support several TMC functions for traffic management and traveler information on I-80. All these applications will be enabled by external interfaces to the existing TMC Systems from the Wyoming CV System.

- **Support Variable Speed Limit, Closures, Restriction Management**
- **Support Wyoming Traveler Information (WTI) Updates**
- **Support Commercial Vehicle Operators Portal Updates**
- **Support Third-Party Interface**
The Wyoming Connected Vehicle Pilot

Freight-Focused

- ~150-200 are large trucks
- ~ 100 are small/medium trucks

CV Trucks

- Trucking Companies of various sizes

Fleet Partners

- CVOP Users (800 firms)
- Wyoming Trucking Association
- Third Party Intermediaries

Freight Partners
The Wyoming Connected Vehicle Pilot

Integrated with TMC

Supports I-80 Trav Info

Supports VSL and other TM

Integrated with TMC Management Systems

WYDOT’s VSL, 511 and other services will rely on CV data for updates
The Wyoming Connected Vehicle Pilot

Leverage existing technology

~100 DSRC-enabled Snow Plows and Highway Patrol Vehicles

Environmental Probe Data Collection

WYDOT’s use of its own fleets in CV pilot allows continued operations post pilot

Integrated with WYDOT Fleets
The Wyoming Connected Vehicle Pilot

- Standards-Driven
- Integration with Third-Party Intermediaries
- Integration with Satellite Delivery of TIMs
- Close coordination with other CV sites
Partnership Plan

**Freight Partners**
- CVOP Subscribers
- Third Party Services
- Trucking Fleets
- Freight Distribution Centers

**Subcontractors**
- Technical and Program Support
- System Developers and Integrators
- Human Use and Training

**Vendors**
- CV equipment
- Installation and support
- Other hardware and software

**Other Stakeholders**
- Independent Evaluator
- IRB
- Trucking Association
- Other CV Pilot Sites

**Internal Partnerships**
Wyoming CV Pilot – Performance Measures

Purpose
◦ Measure project impacts and benefits
◦ Contribute to CV Program benefits database

Activities
◦ Establish Baseline
◦ Collect, manage data
◦ Analyze Performance during Demonstrations
◦ Report

Other
◦ Collect and share data with USDOT
◦ Support Independent Evaluators
Wyoming CV Pilot – Performance Measures

<table>
<thead>
<tr>
<th>Road Weather Condition Input</th>
<th>TMC Information Dissemination</th>
<th>Vehicle/Roadside Alerts &amp; Advisories</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve road weather condition reports received into the TMC</td>
<td>Improve ability of the TMC to generate alerts and advisories</td>
<td>Effectively transmit and receive V2V messages</td>
<td>Improve speed adherence and reduce speed variation</td>
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<td>Efficiently disseminate broad area traveler information</td>
<td>Automate emergency notifications of a crash</td>
<td>Reduce vehicle crashes</td>
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<tr>
<td></td>
<td>Effectively disseminate and receive I2V or V2I alert/advisory messages from TMC</td>
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<td>Improve information to commercial vehicle fleet managers</td>
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Wyoming CV Pilot – Performance Measures

1. Number of road weather condition reports per road segment/day pre and post CV Pilot (quantity)

2. Miles with at least one reported road condition per hour pre and post CV Pilot (coverage)

3. Average refresh time of road condition reports in each segment pre and post CV Pilot (latency)

4. Pikalert™ generated alerts and advisories that were accepted by TMC operators

5. TMC staff time to disseminate broad area traveler information. Activities include log/process road condition reports and activate/update VSL, DMS, and HAR systems

6. Qualitative improvements in 0-6 hour road weather forecasting accuracy due to enhanced road condition data
7. Alerts/advisories sent from the TMC and received by the RSU
8. Alerts/advisories sent and received between the RSU and OBU
9. Connected vehicles that took action following receipt of an alert
   a. Parked
   b. Reduced Speed
   c. Came to a stop safely
   d. Detoured

10. Number of operational changes made by fleet managers due to information from TMC during CV Pilot
    a. Routing
    b. Timing
    c. Parking availability
    d. Canceled trips

11. Commercial vehicle managers are satisfied with information provided by the TMC during the CV Pilot
    a. Road conditions
    b. Road weather forecasts
    c. Parking information
12. V2V alerts properly received in surrounding vehicles from sending vehicle
13. Connected vehicles that took action following receipt of a V2V alert
   a. Parked
   b. Reduced Speed
   c. Came to a stop safely
   d. Detoured

14. Number of emergency notifications that are first received in the TMC from connected vehicles (compared to alternate traditional methods, such as 911 caller)
15. Total vehicles traveling at no more than 5 mph over the posted speed (compare before and after CV Pilot)

16. Total vehicles traveling within +/− 10 mph of 85th percentile speed (compare before and after CV Pilot)

17. Speed of applicable connected vehicles are closer to posted speed when compared to non-connected vehicles

18. Reduction of total and truck crash rates of along the corridor *

19. Reduction of the number of vehicles involved in a crash *

20. Reduction of total and truck crash rates within a work zone area *

21. Reduction of critical (fatal or incapacitating) total and truck crash rates in the corridor *

22. Number of connected vehicles involved in a crash
   a. Initial crashes
   b. Secondary crashes

* Compare a 5-year average before Pilot to CV Pilot data and track connected versus non-connected vehicles
Evaluation Designs

Before – After
  ◦ Comparison of pre and post deployment
  ◦ Key: documented baseline (planned in Phase II)

With – Without
  ◦ Compare with and without technology deployment during same conditions
    ◦ Equipped vehicles compared to non-equipped vehicles at same time, location

System Performance
  ◦ Evaluate how well system worked
    ◦ Alerts/advisories created, sent, received (I2V, V2I, V2V)

Behavior Assessment
  ◦ Measure driver’s actions that result from CV technology application

Qualitative Assessment
  ◦ Surveys and Interviews with key stakeholders
  ◦ Supplemental to quantitative analyses
    ◦ Learn details regarding perceptions, likes/dislikes, and the why, when, and how’s
## Evaluation Design Application

### Connected Vehicle (CV) Pilot Deployment Program – Phases 2 and 3

<table>
<thead>
<tr>
<th>Evaluation Category</th>
<th>Before – After</th>
<th>With – Without</th>
<th>System Performance</th>
<th>Behavior Assessment</th>
<th>Qualitative</th>
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<td>Improved road weather reports</td>
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<td>Improved alerts - advisories</td>
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<td>Disseminated broad area Traveler info</td>
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<td>Sent, received V2I alerts-advisories</td>
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<td>Information to CVO fleet managers</td>
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<td>Sent, received V2V alerts-advisories</td>
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<td>Automated emergency notifications</td>
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<td>Improved speed adherence/variation</td>
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Contextual PM data needs

Connected Vehicle Location at all times (time, location, direction)

Estimated connected vehicle penetration rate

Weather event and road condition characteristics at all times

Alert/advisory message details (number, type, content, time stamp, and location)

Connected vehicle incidents

Equipment reliability and up-time
Confounding Factors

CV Technology Penetration Rate
- 400 – 500 connected vehicles – known location and time
- Estimate penetration rate – support understanding evaluation results
- Simulation modeling will provide additional insights

CV Technology Adoption
- New technology = CHANGE (process, equipment, etc.)
- Myriad agencies, users, stakeholders
- Significant system training, follow-up
- Qualitative assessments will help to understand technology adoption

Freight and Passenger Vehicle Demand
- Freight demand dependent on economic conditions, fuel prices, construction, etc.
- Alternate routes are generally not practical
- Numbers of trucks and cars will be tracked throughout demonstration
Confounding Factors

Weather Condition Variability
- Need to conduct evaluation analysis during like conditions
- Before/after and with/without analysis methods
- Weather events will be logged and categorized (baseline and demonstration)
- Data comparisons will be for like weather events

Availability of Sensing in the Corridor
- Weather, speed sensing – focused in VSL corridors (35% of corridor)
- Roughly 6-7 mile spacing (heavily instrumented Interstate corridor)
- Supplement: Proposing mobile sensor trailers (budget permitting)

Limited Duration of Evaluation Activities
- Primarily focus on weather events – mostly winter seasons
- Aggressive project schedule allowing for two evaluation periods
  - 2017-2018 winter season
  - 2018-2019 winter season

Questions?

VINCE GARCIA
VINCE.GARCIA@WYO.GOV
307-777-4231

ALI RAGAN
ALI.RAGAN@WYO.GOV
307-777-2985

FRED M KITCHENER
FRED@MCFARLANDMGMT.COM
208-331-0072
Application Summary: Relevant downstream road condition information including weather alerts, speed restrictions, vehicle restrictions, road conditions, incidents, parking, and road closures to be broadcast from a roadside unit and received by the connected host vehicle. Information can be also provided by remote communications to vehicles equipped with Satellite Receivers from the Wyoming CV System. Probe data is collected via RSUs from fleet vehicles and use to generate alerts and advisories.

Relevant Standards: J3067 August 2014 Section 2.9.3.6.
Application Summary: Similar to situational awareness, this application enables relevant road condition information, such as fog or icy roads, to be received by the connected host vehicle. This application, however, is distinct from situational awareness in that it provides more localized information (i.e., at the segment level instead of area wide or region wide).

Relevant Standards: This application will follow the TIM advisory content from part 3 defined in J2735 Section 6.142 for ITIS data elements 6.54 for weather conditions and 6.55 for winds defined in J2540_2.
Work Zone Warning (WZW)

Application Summary: This application provides information about the conditions that exist in a work zone toward which the vehicle is approaching. This capability provides approaching vehicles with information about work zone activities that could present unsafe conditions for the vehicle, such as obstructions in the vehicle’s travel lane, lane closures, lane shifts, speed reductions or vehicles entering/exitng the work zone.

Relevant Standards: TIM work zone warning described in J2735 part 3 in Section 6.142.