Are We Ready? State and Local Agency Preparations for Connected and Automated Vehicles

Robert Bertini, California Polytechnic State University

Haizhong Wang, Oregon State University

Tony Knudson, Oregon Department of Transportation

Kevin Carstens, California Polytechnic State University

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CV Infrastructure Deployment

- Roadside communications equipment (for DSRC or other wireless services), enclosures, mountings, power and network backhaul.
- Traffic signal controller interfaces for applications that require signal phase and timing (SPaT).
- Systems and processes required to support management of security credentials and ensure a trusted network.
- Mapping services that provide highly detailed roadway geometries, signage and asset locations for the various CV applications.
- Positioning services for resolving vehicle locations to high accuracy and precision.
- Data servers for collecting and processing data provided by vehicles and for distributing information, advisories and alerts to users.
Connected Vehicles: V2I

**Technology**
- DSRC + Wireless
- Roadside
- Vehicle/OBU
- Security Layer
- Location/GPS

**Management**
- Data Environment
- Management Strategies
- Application Engine

**Applications**
- Safety
- Mobility
- Environmental

Legend:
- PROGRAM FUNDED
- DMA SUPPORTED (NOT FUNDED)
- OPEN TO OTHER PROGRAMS AND RESEARCHERS
- *JOINTLY FUNDED BY DMA AND PUBLIC SAFETY PROGRAMS"
Survey Respondents

- Aviation: 1%
- Central Services: 1%
- Driver and Motor Vehicle: 1%
- Highway Division: 1%
- Motor Carrier Transportation: 9%
- Not ODOT: 3%
- Office of Civil Rights: 2%
- Office of the Director: 2%
- Planning: 3%
- Rail/Transit Division: 3%
- Research: 1%
- Traffic: 1%
- Transit/Transportation options: 2%
- Transportation Development Division: 9%
- Transportation Safety Division: 37%

n=115
### Connected Vehicle Benefits

- **No Answer**: 2%
- **Very Unlikely**: 1%
- **Somewhat Unlikely**: 3%
- **Somewhat Likely**: 28%
- **Very Likely**: 46%

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Very Likely</th>
<th>Somewhat Likely</th>
<th>Somewhat Unlikely</th>
<th>Very Unlikely</th>
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<td>55%</td>
<td>37%</td>
<td>5%</td>
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<td>2%</td>
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<tr>
<td>Reduced Crash Severity</td>
<td>48%</td>
<td>43%</td>
<td>6%</td>
<td>1%</td>
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<tr>
<td>Improved Emergency Response</td>
<td>36%</td>
<td>50%</td>
<td>11%</td>
<td>1%</td>
<td>3%</td>
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<tr>
<td>Less Traffic Congestion</td>
<td>21%</td>
<td>46%</td>
<td>23%</td>
<td>7%</td>
<td>3%</td>
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<tr>
<td>Lower Vehicle Emissions</td>
<td>16%</td>
<td>47%</td>
<td>30%</td>
<td>5%</td>
<td>3%</td>
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<tr>
<td>Shorter Travel Times</td>
<td>17%</td>
<td>48%</td>
<td>30%</td>
<td>3%</td>
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<tr>
<td>Better Fuel Economy</td>
<td>23%</td>
<td>57%</td>
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<tr>
<td>Lower Insurance Rates</td>
<td>13%</td>
<td>40%</td>
<td>34%</td>
<td>10%</td>
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<tr>
<td>Fewer Driver Distractions</td>
<td>11%</td>
<td>26%</td>
<td>38%</td>
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<tr>
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<td>Reduced Agency Costs</td>
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<td>30%</td>
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Connected Vehicle Issues

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<tr>
<th>Issue</th>
<th>Very Concerned</th>
<th>Moderately Concerned</th>
<th>Slightly Concerned</th>
<th>Not at All Concerned</th>
<th>No Answer</th>
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<tbody>
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<td>Impacts of Equipment/System Failure</td>
<td>39%</td>
<td>35%</td>
<td>20%</td>
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<tr>
<td>Legal Liability for Drivers/Owners</td>
<td>29%</td>
<td>34%</td>
<td>31%</td>
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<tr>
<td>System Cybersecurity</td>
<td>39%</td>
<td>40%</td>
<td>17%</td>
<td>4%</td>
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<tr>
<td>Vehicle Cybersecurity</td>
<td>37%</td>
<td>34%</td>
<td>23%</td>
<td>6%</td>
<td>0%</td>
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<tr>
<td>Data Privacy</td>
<td>37%</td>
<td>17%</td>
<td>32%</td>
<td>13%</td>
<td>1%</td>
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<tr>
<td>Interacting with Non-connected Vehicles</td>
<td>21%</td>
<td>40%</td>
<td>26%</td>
<td>12%</td>
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<tr>
<td>Interacting with Pedestrians/Bicyclists</td>
<td>35%</td>
<td>34%</td>
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<tr>
<td>Learning to Use Connected Vehicles</td>
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<td>42%</td>
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<tr>
<td>Increased Driver Distractions</td>
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<tr>
<td>System Performance in Poor Weather</td>
<td>24%</td>
<td>29%</td>
<td>33%</td>
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<td>Driver Overreliance on Technology</td>
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<td>29%</td>
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Connected Vehicle Infrastructure Development

- Very Promising: 34%
- Somewhat Promising: 39%
- Neutral: 22%
- Not Very Promising: 4%
- Not at all Promising: 0%
- No answer: 1%
Connected Vehicle Preparedness

**Cultural**
- Very Prepared: 25%
- Somewhat Prepared: 28%
- Neutral: 24%
- Somewhat Unprepared: 20%
- Very Unprepared: 2%
- No answer: 1%
- Total: n=115

**Technical**
- Very Prepared: 0%
- Somewhat Prepared: 16%
- Neutral: 27%
- Somewhat Unprepared: 24%
- Very Unprepared: 31%
- No answer: 2%
- Total: n=115
Connected Vehicle Division Priority

- All: 23%
- Central Services: 1%
- Don't Know: 7%
- Driver and Motor Vehicle: 6%
- Highway Division: 3%
- Motor Carrier: 3%
- None: 5%
- Office of the Director: 3%
- Operations: 5%
- Planning: 3%
- Policy: 5%
- Safety: 3%
- Transportation Development Division: 26%
- Transportation Safety Division: 1%

n=115
Urban Intersection Footprint

1. INTERSECTION INSTALLATION
   - Intersection equipment
   - Signal cabinets
   - Wireless communication

2. OPTIONAL MID-BLOCK PEDESTRIAN CROSSING
   - Mid-block equipment
   - Cellular communication

3. COMMUNICATION AND POWER SCHEMATIC
   - Typical backhaul communication
   - Existing mast arm and cabinets
   - DSRC radio and comm.

LEGEND
- Existing Mast Arm
- Existing Cabinets
- DSRC Radio
- DSRC Comm.

TYPICAL SETTING FEATURES
Urban intersections are junctions of two or more roads in a city setting; they typically include curbing, designated lane markings, traffic signals, and pedestrian crossings.

CONCEPT EXAMPLE
DSRC antennas communicate with vehicles on all approaches of the intersection and at an optional mid-block location.

OTHER EXAMPLE APPLICATIONS
- Red Light Violation Warning and Stop Sign Violation
- Driver Gap Assist at Signalized Intersections and Stop Signs
- Multimodal Intelligent Traffic Signal Systems
- Advanced Arterial Management and Operations
- Advanced Signal Operations

NOT FOR CONSTRUCTION
1955 Signals

805 ITS Equipment + 22 Weigh Stations

500 and 1000 ft diameter buffers
Potential Sites for V2I Devices (n=5453)

- ITS 808
- ATR 191
- WIM 25
- Signal 1958
- Rail Crossing 2371
- Maintenance 100
Highway Coverage (n=8300 miles)

- **ATR (191 sites)**
- **ITS (808 sites)**
- **Maintenance (100 sites)**
- **Railcrossings (2371 sites)**
- **Signals (1958 sites)**
- **WIM (25 sites)**
- **ATR+ITS+Maintenance+Railcrossing+Signals+WIM (5453 sites)**
Daily VMT Percentage (2014 n=54,196,986 vehicle miles)

- ATR (191 sites)
- ITS (808 sites)
- Maintenance (100 sites)
- Railcrossings (2371 sites)
- Signals (1958 sites)
- WIM (25 sites)
- ATR+ITS+Maintenance+Railcrossing+Signals+WIM (5453 sites)
SPIS Sites (85-100) Within Range (n=14,936)

Percentage of 85%-100% SPIS

Buffer Distance (feet)

0% 10% 20% 30% 40% 50% 60% 70%

300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500

ATR (191 sites)
ITS (808 sites)
Maintenance (100 sites)
Railcrossings (2371 sites)
Signals (1958 sites)
WIM (25 sites)

ATR+ITS+Maintenance+Railcrossings+Signals+WIM (5453 sites)
SPIS Sites (95-100) Within Range (n=4,532)

- ATR (191 sites)
- ITS (808 sites)
- Maintenance (100 sites)
- Railcrossings (2371 sites)
- Signals (1958 sites)
- WIM (25 sites)

Buffer Distance (feet):

Percentage of 95-100 SPIS:
- 0%
- 10%
- 20%
- 30%
- 40%
- 50%
- 60%
- 70%
- 80%

Buffer Distance (feet):
- 300
- 400
- 500
- 600
- 700
- 800
- 900
- 1000
- 1100
- 1200
- 1300
- 1400
- 1500
Current Priority Coding

- **Priority 1:** Near Term Focus for ODOT

- **Priority 2:** ODOT Should Monitor, Possibly Collaborate, Leadership by Others

- **Priority 3:** Leadership by Others, ODOT Monitor
# CONNECTED VEHICLE APPLICATIONS

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<td>Eco-Traffic Signal Timing</td>
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<td>Stop Sign GapAssist</td>
<td>Eco-Traffic Signal Priority</td>
<td>Intelligent Traffic Signal System (I-SIG)</td>
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<td>Spot Weather Impact Warning</td>
<td>Connected Eco-Driving</td>
<td>Signal Priority (Transit &amp; Freight)</td>
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<td>Low Emissions Zone Management</td>
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<td>AFV Charging/Fueling Information</td>
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<td>Eco-Smart Parking</td>
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<td>Dynamic Eco-Routing</td>
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<td>Eco-ICM Decision Support System</td>
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<td>Vehicle Classification Traffic Studies</td>
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<tr>
<td>CV-enabled Turning/Intersection Analysis</td>
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<tr>
<td>CV-enabled O-D Studies</td>
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<tr>
<td>Work Zone Traveler Information</td>
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<tr>
<th>Road Weather</th>
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<tr>
<td>Motorist Advisories &amp; Warnings (MAW)</td>
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<tr>
<td>Enhanced Maintenance Decision Support</td>
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<tr>
<td>Vehicle Data Translator</td>
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<tr>
<td>Weather Response Traffic Info (WxTINFO)</td>
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<tr>
<th>Smart Roadside</th>
<th>Environment</th>
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<tbody>
<tr>
<td>Wireless Inspection</td>
<td></td>
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<tr>
<td>Smart Truck Parking</td>
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# Connected Vehicle Applications

## V2I Safety
- Signal Phase & Timing (SPAT)
- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Pedestrian Warning

## V2V Safety
- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning

## Agency Data
- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification Traffic Studies
- CV-enabled Turning/Intersection Analysis
- CV-enabled O-D Studies
- Work Zone Traveler Information

## Environment
- Eco-Approach/Departure Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority
- Connected Eco-Driving
- Wireless Inductive/Resonance Charging
- Eco-Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Traveler Information
- Eco-Ramp Metering
- Low Emissions Zone Management
- AFV Charging/Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing
- Eco-ICM Decision Support System

## Mobility
- Advanced Traveler Information System (EnableATIS)
- Multimodal Intelligent Traffic Signal (MMITSS)
- Intelligent Traffic Signal System (I-SIG)
- Signal Priority (Transit & Freight)
- Mobile Accessible Pedestrian Signal (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Intelligent Network Flow Optimization (INFLO)
- Dynamic Speed Harmonization (SPD-HARM)
- Queue Warning (Q-WARN)
- Cooperative Adaptive Cruise Control (CACC)
- Response, Incident, Emergency (RESCUME)
- Incident Guidance Emergency Response (RESP-STG)
- Incident Scene Work Zone Alerts (INC-ZONE)
- Emergency Communications/Evacuation (EVAC)
- Integrated Dynamic Transit Operations (IDTO)
- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (T-DISP)
- Dynamic Ridesharing (D-RIDE)
- Freight Advanced Traveler Information (FRATIS)
- Freight Dynamic Travel Planning & Performance
- Drayage Optimization

## Road Weather
- Motorist Advisories & Warnings (MAW)
- Enhanced Maintenance Decision Support
- Vehicle Data Translator
- Weather Response Traffic Info (WxTINFO)

## Smart Roadside
- Wireless Inspection
- Smart Truck Parking
## CONNECTED VEHICLE APPLICATIONS

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# Oregon Department of Transportation

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- Emergency Communications/Evacuation (EVAC)
- Integrated Dynamic Transit Operations (IDTO)
- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (T-DISP)
- Dynamic Ridesharing (D-RIDE)
- Freight Advanced Traveler Information (FRATIS)
- Freight Dynamic Travel Planning & Performance
- Drayage Optimization
## Close Look: Agency/BizOps Applications

<table>
<thead>
<tr>
<th>Agency Data</th>
<th>Smart Roadside</th>
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</thead>
<tbody>
<tr>
<td>Probe-based Pavement Maintenance</td>
<td>Wireless Inspection</td>
</tr>
<tr>
<td>Probe-enabled Traffic Monitoring</td>
<td>Smart Truck Parking</td>
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<tr>
<td>Vehicle Classification Traffic Studies</td>
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<tr>
<td>CV-enabled Performance Measures</td>
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<tr>
<td>CV-enabled Turning/Intersection Analysis</td>
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<tr>
<td>CV-enabled O-D Studies</td>
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<tr>
<td>Work Zone Traveler Information</td>
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</table>
## Near Term Focus for ODOT

<table>
<thead>
<tr>
<th>Number</th>
<th>Connected Vehicle Application</th>
<th>Impact/Benefit</th>
<th>Effort</th>
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<tbody>
<tr>
<td>1a</td>
<td>Advanced Traveler Information System (Enable/ATIS) Deliver</td>
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<tr>
<td>2</td>
<td>Dynamic Speed Harmonization (SPO-HARM)</td>
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<td>Freight Dynamic Travel Planning &amp; Response</td>
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<td>Signal Phase and Timing (SPAT)</td>
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<td>Curve Speed Warning</td>
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<td>23</td>
<td>Motorist Advisories &amp; Warnings (MAW)</td>
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<tr>
<td>Number</td>
<td>Connected Vehicle Application</td>
<td>Impact/Benefit</td>
<td>Effort</td>
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<td>1b</td>
<td>Advanced Traveler Information System (Enable/ATIS) gather access?</td>
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<td>Next Generation Ramp Metering (RAMP)</td>
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<td>Eco-ICM Decision Support System</td>
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<td>Congestion Pricing (with road user charge)</td>
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<td>SPOT Weather Impact Warning</td>
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<td>Smart Truck Parking</td>
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## Leadership by Others, ODOT Monitor

<table>
<thead>
<tr>
<th>Number</th>
<th>Connected Vehicle Application</th>
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<th>Effort</th>
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<td>3</td>
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<td>Wireless Inspection</td>
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CV Roadmap

94 Actions
12 Categories

- DSRC and Backhaul Communications
- Education and Outreach
- Policy and Communications/Collaboration
- Benefits/Business Case
- Data Management and Strategies
- Applications
- Try Things
- Research Questions/Challenges
- Planning and Equity
- Multimodal
- Design and Construction
- Operations and Maintenance
Outcomes

ODOT Intermodal Leadership Team approved three recommendations:

- New position: Policy Adviser for Connected, Automated and Electric Vehicles
- CAV Steering Team is forming
- CAV “Business Map” provides an initial taxonomy for actions by the Policy Adviser and the Steering Team
Thank You!

“These self-honking cars make it so much easier to focus on driving.”


rbertini@calpoly.edu