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# Connected Vehicles and Rural Road Weather Management

Rhonda Young
*Gonzaga University*

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# Connected Vehicles and Rural Road Weather Management

**Rhonda Young,** P.E., PhD
**Gonzaga University**

**May 20, 2016**
**Portland State University**

# Weather and Roadways

- Safety
  - ~22% of US crashes are weather related
    - 6,000 fatalities and 445, injuries
- Mobility
  - Capacity Reductions
  - ~23% of non-recurrent delay on highways estimated to be due to snow, ice, and fog
- Economic
  - $2.3 billion spent annually on snow and ice removal
  - Weather related delay costs trucking companies $2.2-$3.5 billion annually

*Source: FHWA Road Weather Management Program Website*

# What is "normal" weather?

- Changing Climate
  - Increased temperatures and rising sea levels
- Extreme Events
  - Flooding, wildfire, blowing dust, unusual snow
- Transportation System Resiliency
  - How will our current transportation system adapt to new climate conditions?

*Source: USDOT Transportation System Resilience, Extreme Weather, and Climate Change*

# What is "normal" weather?

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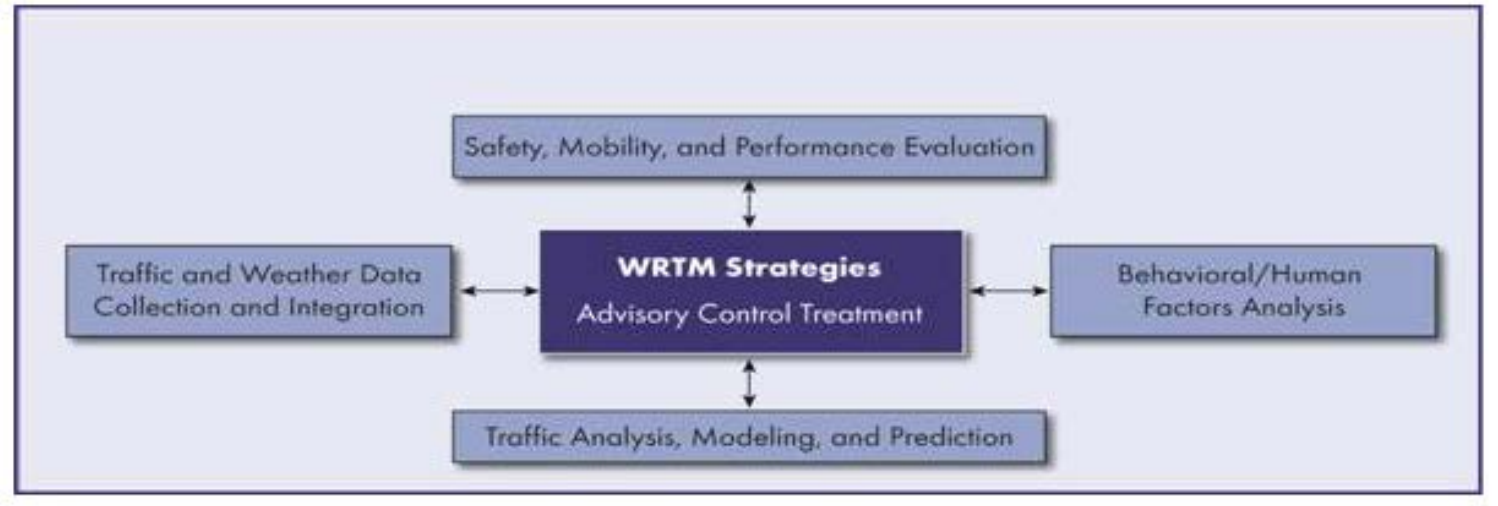
# Weather Responsive Traffic Management

- WRTM aims to manage the impacts of weather on travelers




*Source: ITS JPO Road Weather http://www.its.dot.gov/road_weather/weather_traffic_mang.htm*

# Weather Responsive Traffic Management

- WRTM Strategies
  1. Motorist Advisories, Alert and Warning
     - Passive or Active Warnings, Pretrip or En-route Alerts and Conditions
  2. Speed Management
     - Speed Advisories, Variable Speed Limits
  3. Vehicle Restrictions
     - Size/height/weight/profile restrictions, chain laws
  4. Road Restrictions
     - Lane-Use Restrictions, Parking Restrictions, Access Control and Facility Closures, Reversible Lane/Contra Flow [Evacuations]
  5. Traffic Signal Control
     - Weather-responsive signal timing plans, ramp metering control
  6. Incident Management
     - Service Patrols, quick clearance policies
  7. Asset Management
  8. Agency Coordination and Integration

*Source: Developments in Weather Responsive Traffic Management Strategies*

# Weather Responsive Traffic Management

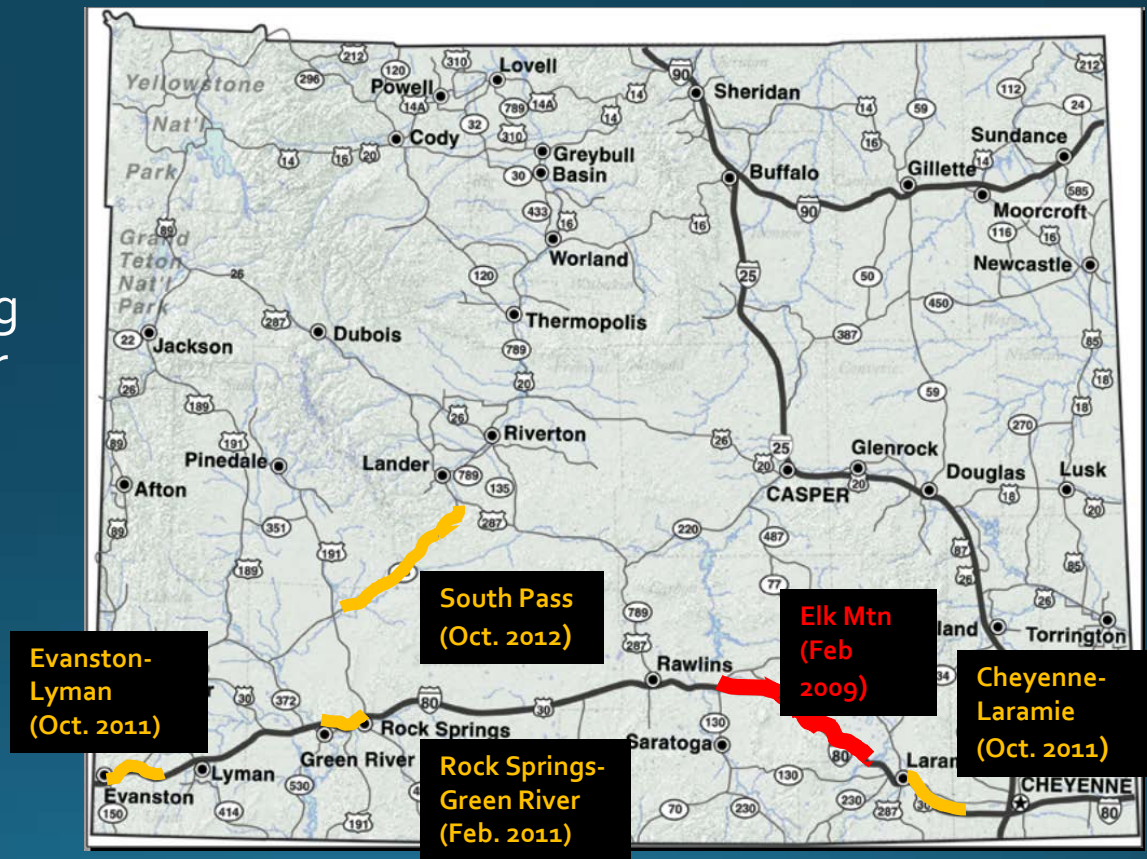
- Types of Weather
  - Road weather
  - Atmospheric weather
- Weather Information
  - Forecasting
  - Nowcasting
  - Current Conditions

# Weather Responsive Traffic Management

- Technology needed for WRTM
  - Road Weather Information System (RWIS)
    - Depending on sensor configurations can provide air temperature, pavement temp, visibility, wind speed, surface condition, RH and dewpoint, camera for visual verification of conditions
    - Pros – real-time localized weather data
    - Cons – expense (capital and maintenance), point data only, locating correctly can be challenging
  - Mobile Weather Data
    - Vehicle mounted, weather sensors
    - Pros – real-time localized weather for continuous roadway stretches
    - Cons - require vehicles to be traveling, expensive

# Weather Responsive Traffic Management

- Wyoming WRTM Strategies
  - 143 miles of weather-responsive VSLs along 400-mile I-80 corridor
  - High wind alerts and light-weight vehicle closures



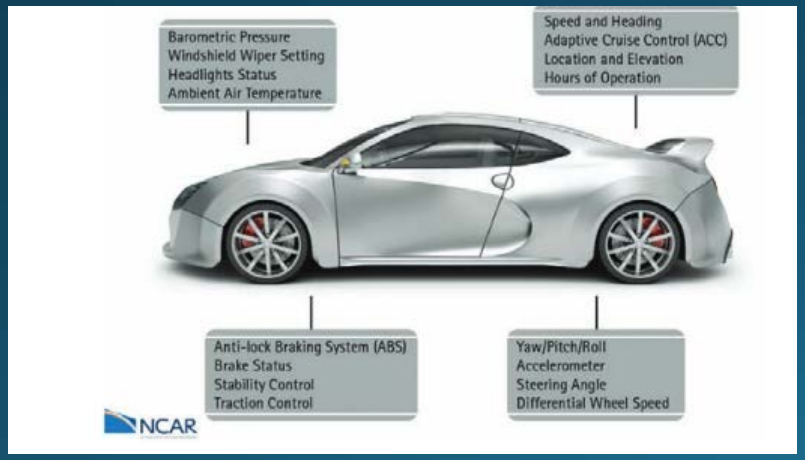
# Weather Responsive Traffic Management

- VSL Effectiveness
  - Annual VSL Safety Benefits
    - 27.7 annual crash reduction
    - $2.8 million per year in crash reduction benefits
  - Annual VSL Road Closure Benefits
    - 10.14 fewer closures per winter season (Oct-April)
    - $54.7 million per year in closure reduction benefits

*Source: Safety and Road Closure Benefits of Rural Interstate VSL System, ITSWC 2014*

# CV Road Weather Condition System

- Can Connected Vehicle Data be used to support WRTM?
  - Harness USDOT's Connected Vehicle Initiative to provide more and better weather data
  - Supplement or replace RWIS?



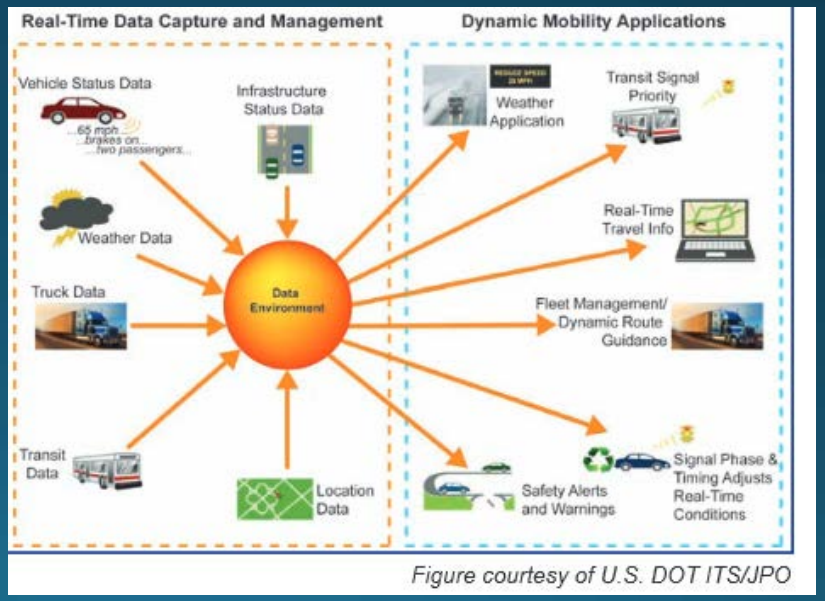
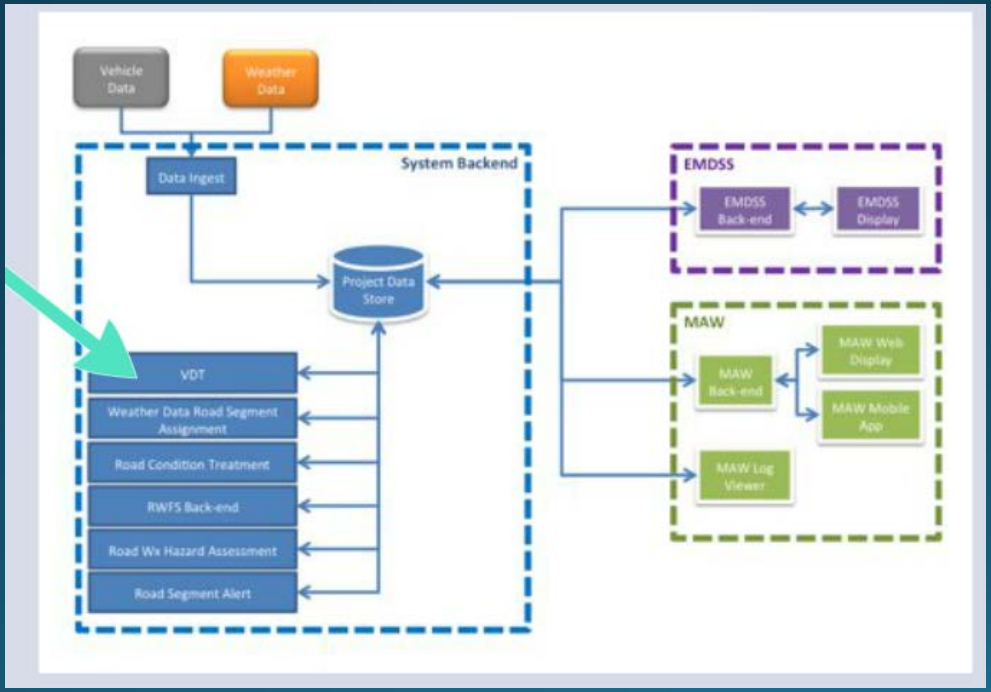




*Figure courtesy of U.S. DOT ITS/JPO*

# CV Road Weather Condition System

- FHWA's Vehicle Data Translator (VDT) and Pikalert ® System

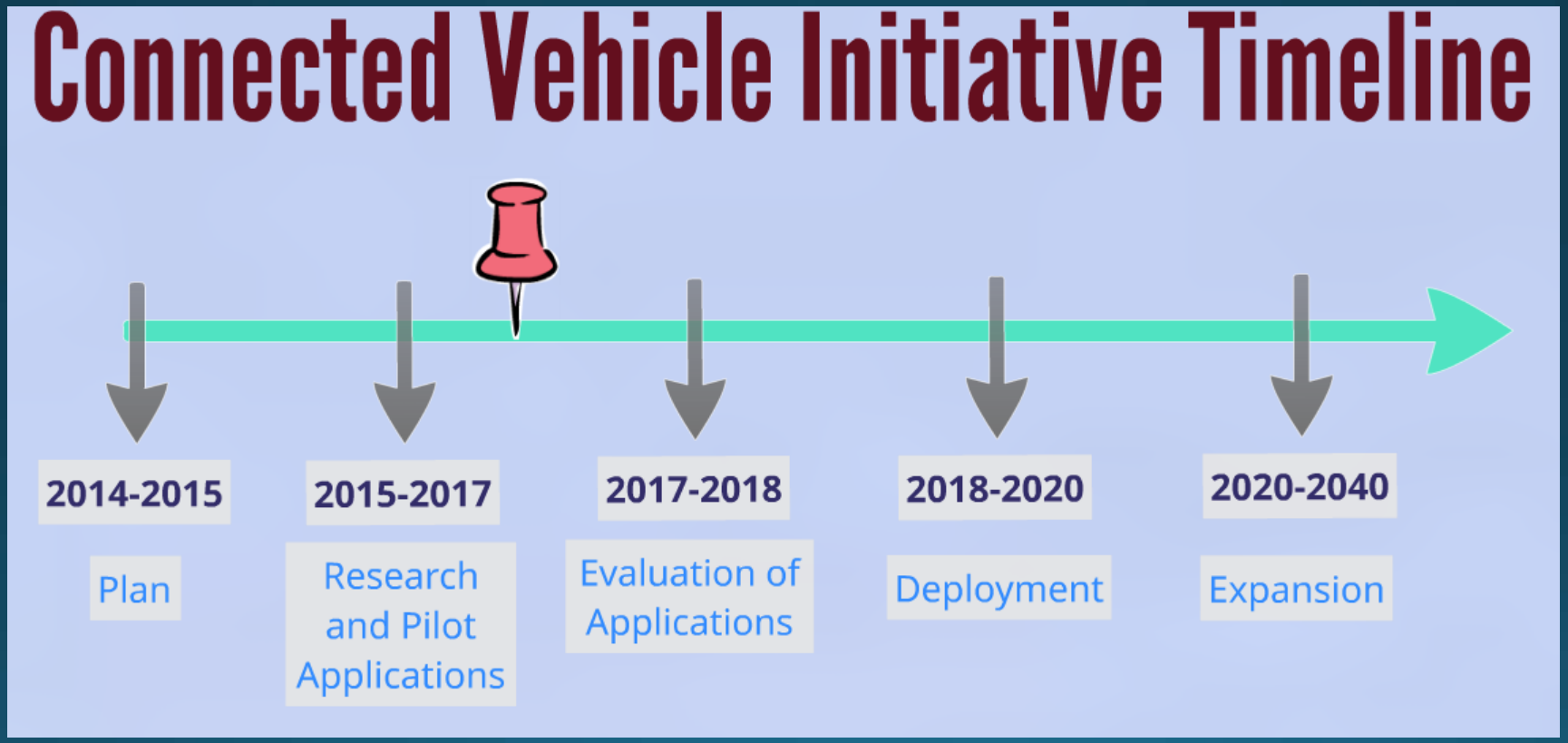
Vehicle Data Translator




Enhanced Maintenance Decision Support System

Motorist Advisory and Warning

# CV Road Weather Condition System

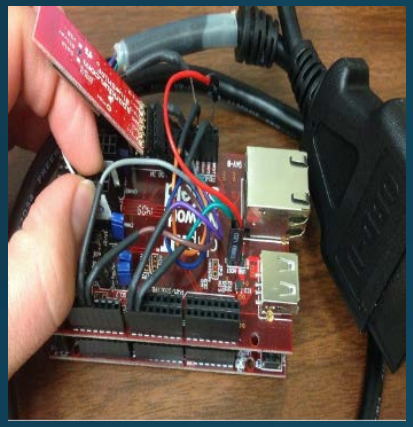


# CV Road Weather Condition System

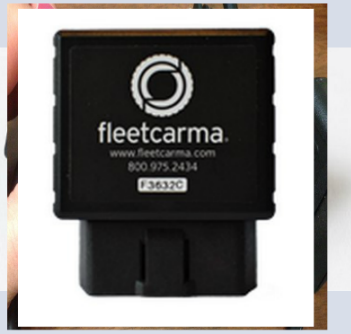
- Winter of 2014-2015 ran a small CV project along I-80

*Connected Vehicle Weather Data for Operation of Rural Variable Speed Limit Corridors*
Britton Hammit and Rhonda Young
MPC-15-299
http://www.ugpti.org/resources/reports/details.php?id=835&program=mpc

# CV Road Weather Condition System



## Vehicle Data Collection




### Equipment Selection

OBD Link

Ford Reference OBE

Chip-Kit Handmade OBE

Cross Chasm C4

### Data Collected

| Vehicle Parameter | |
|---|---|
| Steering Wheel Angle | Vehicle Speed |
| Engine Speed | Fuel Consumed Since Restart |
| Transmission Gear Position | Door Status |
| Ignition Status | Windshield Wiper Status |
| Brake Pedal Status | Odometer |
| Headlamp Status | High Beam Status |
| Accelerator Pedal Position | Fuel Level |
| Torque At Transmission | Latitude & Longitude |

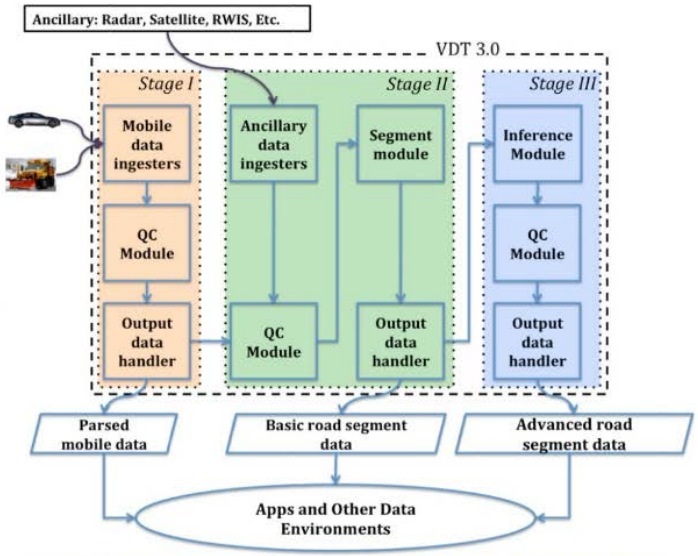
# CV Road Weather Condition System

OpenXC Android Application

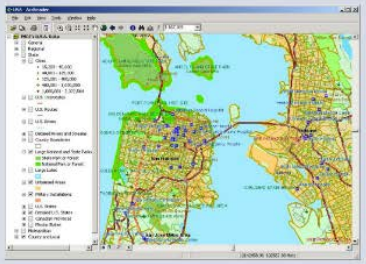
# CV Road Weather Condition System

## Data Processing and Analysis

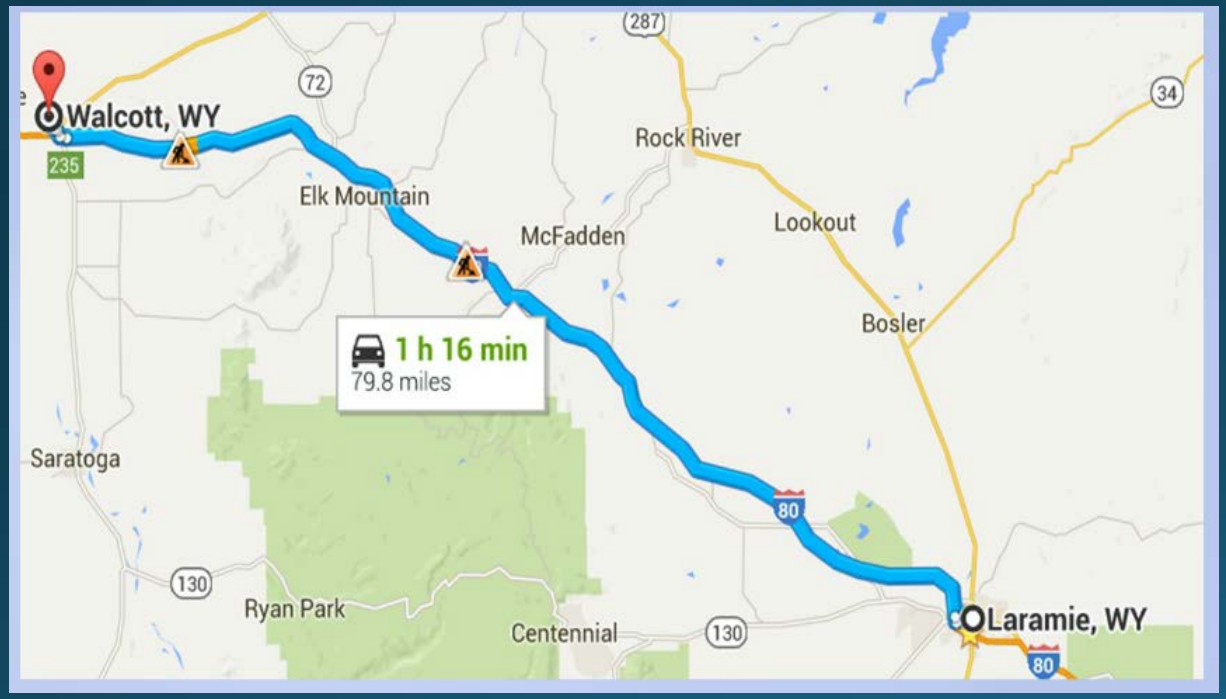
### NCAR's Pikalert System




### ArcGIS



# CV Road Weather Condition System




- Data transmitted at 60 HZ
- Each 80 mile trip at 75 mph resulted in over 200,000 observations for each of the 16 variables
- 16 trips, over 52 million data points

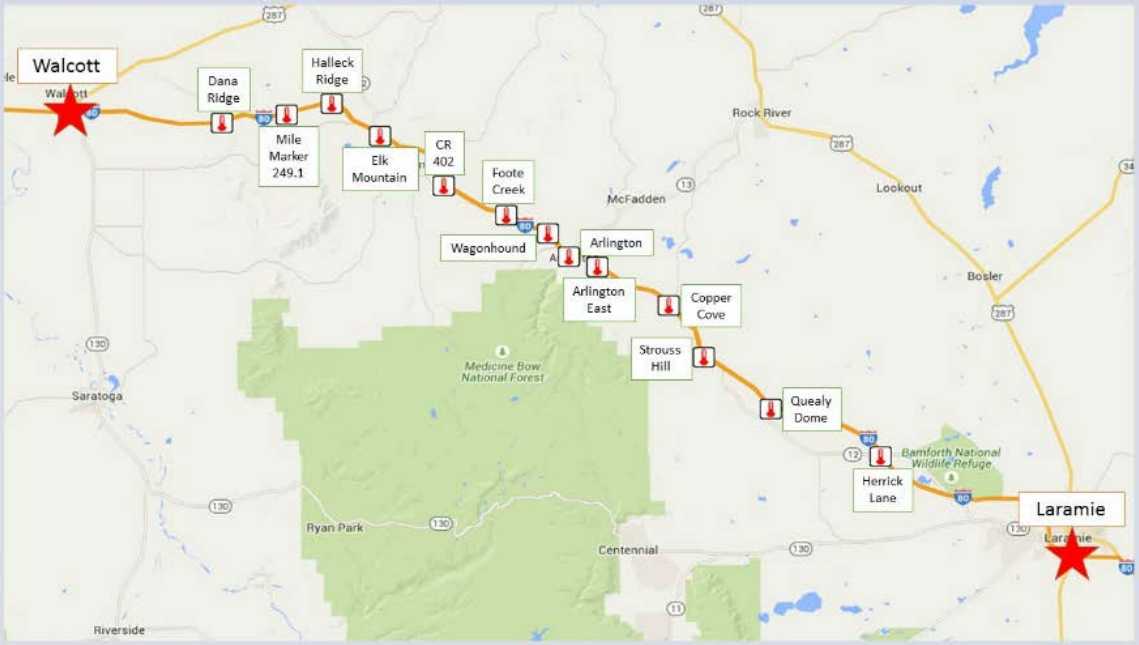
# CV Road Weather Condition System

| TripIDNumber | Date | Origin | Departure Time | Destination | Arrival Time | Distance Traveled | Driver | Passenger | Vehicle |
|---|---|---|---|---|---|---|---|---|---|
| CC1 | 2/6/2015 | Laramie | 9:00 | Walcott | 10:30 | 78miles | B.Hammit | H. Smith | 2014 Ford Fusion |
| CC2 | 2/6/2015 | Walcott | 10:30 | Laramie | 12:00 | 78miles | B.Hammit | H. Smith | 2014 Ford Fusion |
| CC3 | 2/6/2015 | Laramie | 13:00 | Walcott | 14:30 | 78miles | B.Hammit | H. Smith | 2014 Ford Fusion |
| CC4 | 2/6/2015 | Walcott | 14:30 | Laramie | 16:00 | 78miles | B.Hammit | H. Smith | 2014 Ford Fusion |
| CC5 | 2/15/2015 | Laramie | 12:00 | Walcott | 13:30 | 78miles | B.Hammit | L. Johnson | 2014 Ford Fusion |
| CC6 | 2/15/2015 | Walcott | 13:30 | Laramie | 15:00 | 78miles | B.Hammit | L. Johnson | 2014 Ford Fusion |
| CC7 | 2/16/2015 | Laramie | 8:15 | Walcott | 9:45 | 78miles | B.Hammit | S. Ganley | 2014 Ford Fusion |
| CC8 | 2/24/2015 | Laramie - I-80 & Grand | 12:15 | Boulder | 14:35 | 145miles | R. Young | B. Hammit | 2014 Ford Fusion |
| CC9 | 2/26/2015 | Laramie | 15:45 | Walcott | 17:00 | 78miles | B.Hammit | -- | 2014 Ford Fusion |
| CC10 | 2/26/2015 | Walcott | 17:30 | Laramie | 19:00 | 78miles | B.Hammit | -- | 2014 Ford Fusion |
| CC11 | 3/3/2015 | Laramie | 18:40 | Herrick Lane | 19:10 | 16miles | B.Hammit | H. Smith | 2014 Ford Fusion |
| CC12 | 3/3/2015 | Herrick Lane | 19:10 | Laramie | 19:35 | 16miles | B.Hammit | H. Smith | 2014 Ford Fusion |
| CC13 | 3/4/2015 | Laramie | 9:20 | Walcott | 10:40 | 78miles | B.Hammit | -- | 2014 Ford Fusion |
| CC14 | 3/4/2015 | Walcott | 10:40 | Laramie | 12:05 | 78miles | B.Hammit | -- | 2014 Ford Fusion |
| CC15 | 3/25/2015 | Laramie | 9:15 | Walcott | 10:30 | 78miles | B.Hammit | -- | 2014 Ford Fusion |
| CC16 | 3/25/2015 | Walcott | 10:30 | Laramie | 11:45 | 78miles | B.Hammit | -- | 2014 Ford Fusion |

# CV Road Weather Condition System

## RWIS Data Summary for Test Trips

### 13 RWIS Stations

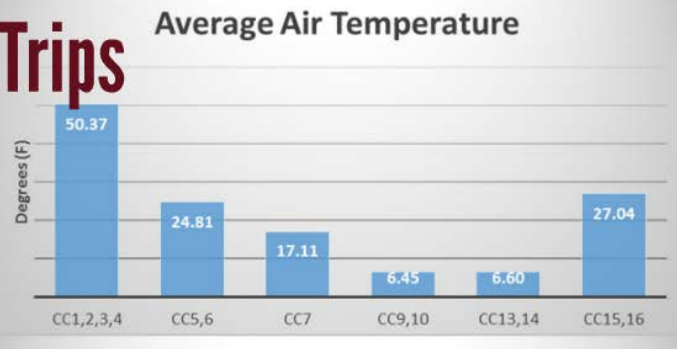


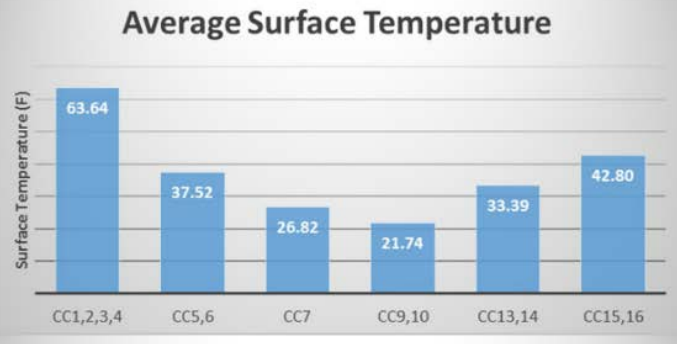
# CV Road Weather Condition System

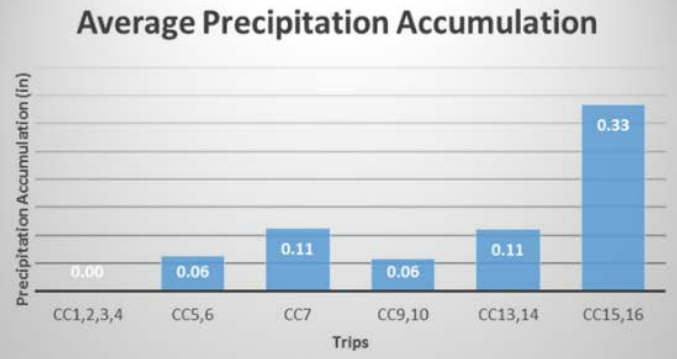
## RWIS Data Summary for Test Trips

**13 RWIS Stations**

| RWIS Weather Data | |
|---|---|
| Air Temp | Precipitation Rate |
| Relative Humidity | Visibility |
| Dew Point | Surface Temperature |
| Average Wind Speed | Precipitation Type |
| Gust Wind Speed | Precipitation Intensity |
| Precipitation Accumulation | Surface Status |

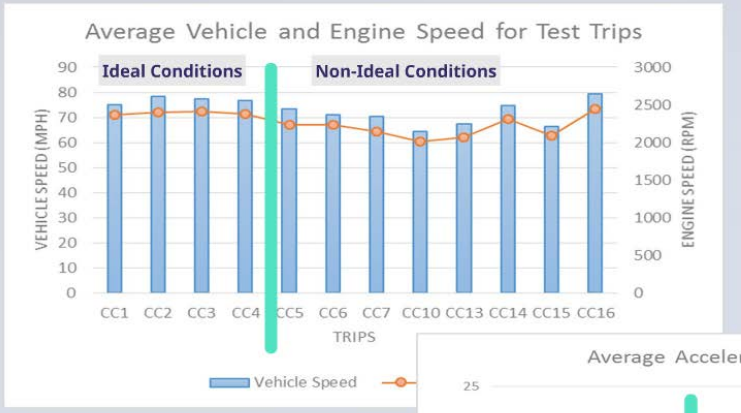


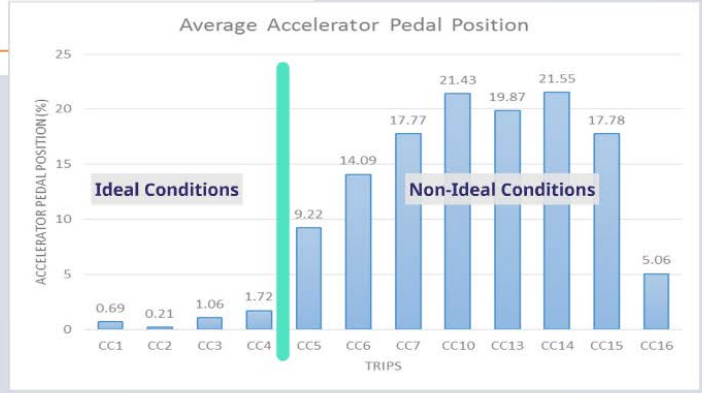



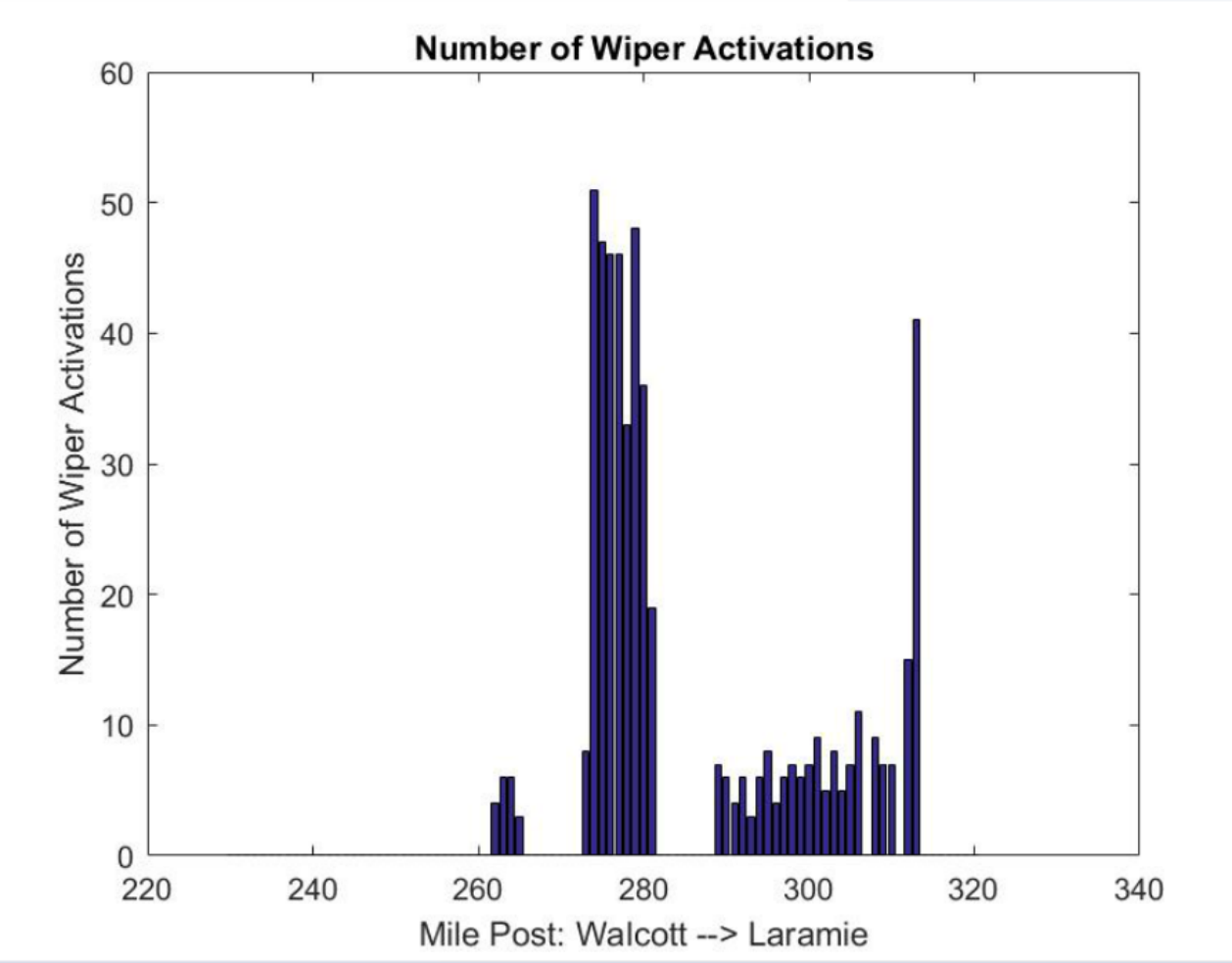
# CV Road Weather Condition System

## Vehicle Data Summary for Test Trips



# CV Road Weather Condition System



# CV Road Weather Condition System

## NCAR's VDT/ Pikalert System

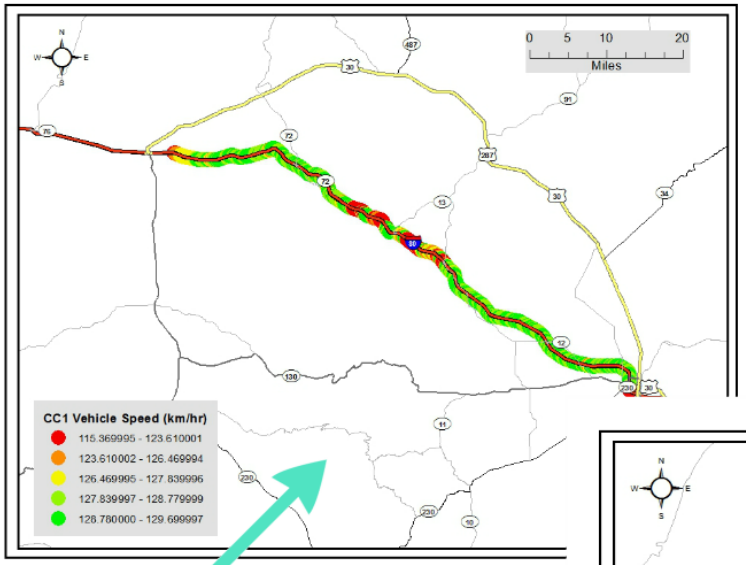
- **Difficulty setting up Pikalert System**
- **Contact with NCAR**

  Crucial vehicle data missing from data sets

Traction and Stability Control Readings

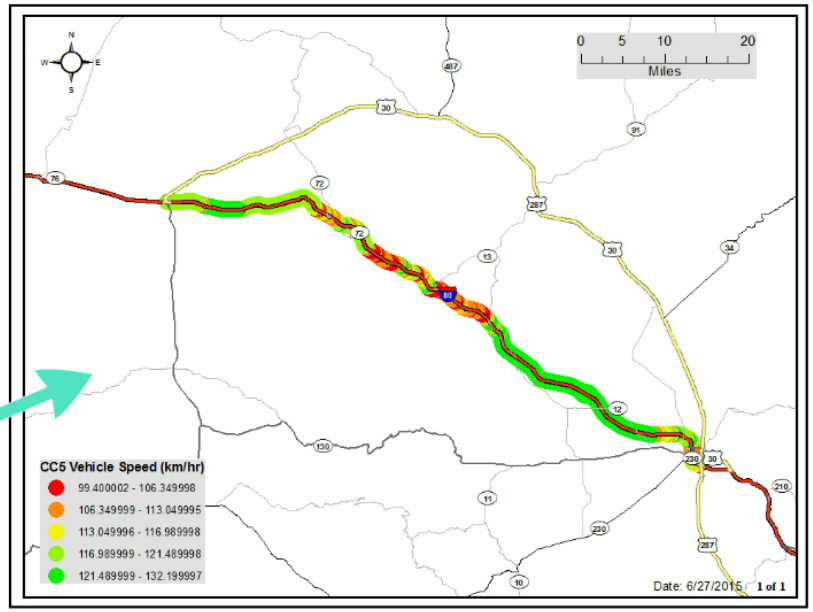
Ambient Temp

# CV Road Weather Condition System



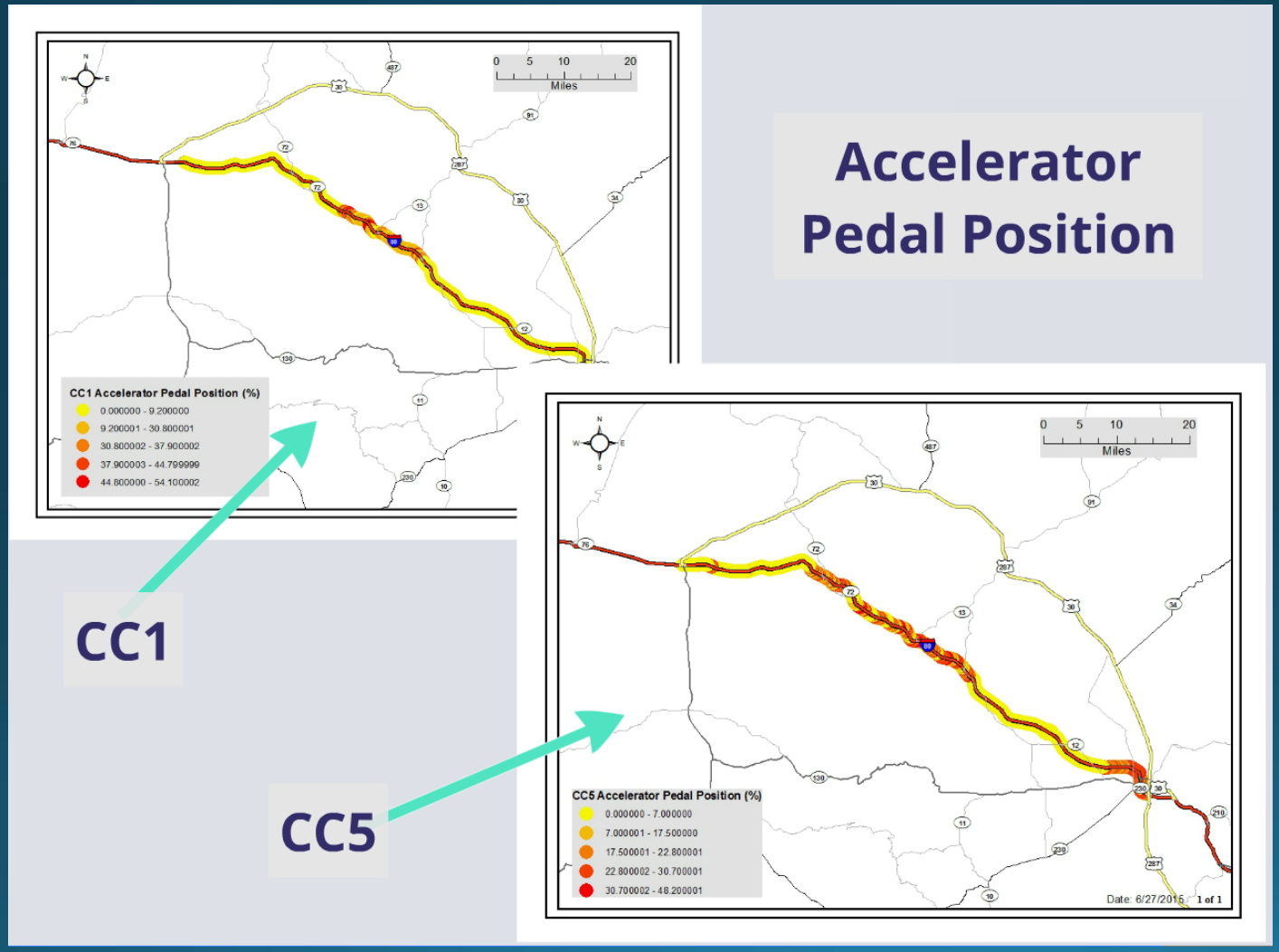

Vehicle Speed

CC1



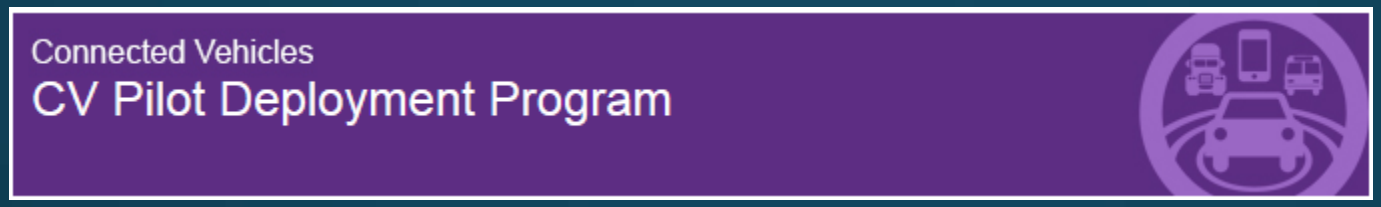

CC5

# CV Road Weather Condition System



# CV Road Weather Condition System

# CV Pilot Deployment Program




- Three Wave 1 Sites
  - Wyoming's I-80 Corridor
    - Rural, freight and weather focus
  - New York City
    - 10,000 city and other fleet vehicles
    - Safety focus
  - Tampa-Hillsborough Expressway Authority
    - Lee Roy Selmon Expressway
    - Congestion and safety focus

*Source: http://www.its.dot.gov/pilots/index.htm*

# Wyoming CV Pilot Deployment Program

## Wyoming DOT Connected Vehicle Pilot Deployment Program

ICF INTERNATIONAL

WYDOT

NCAR

CATT

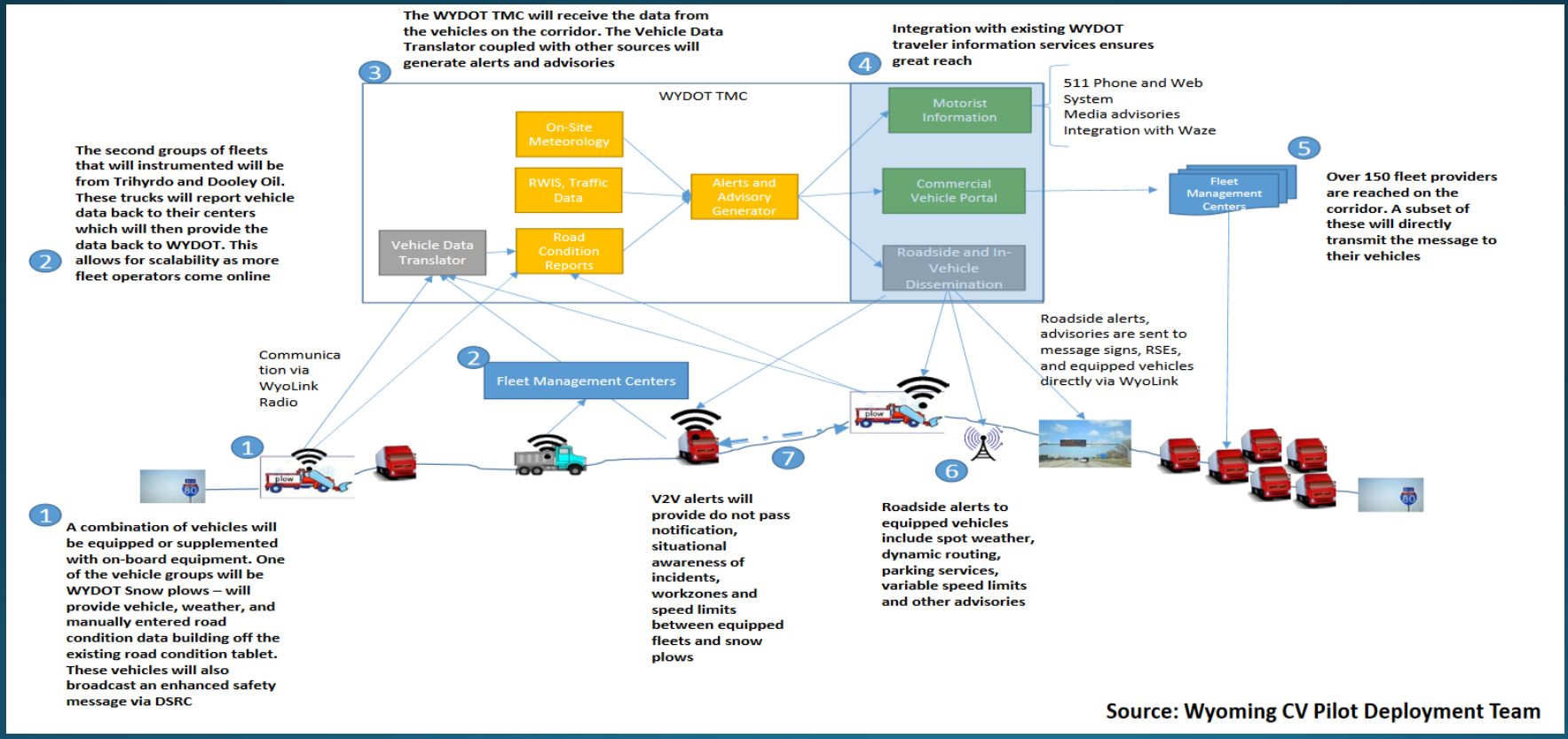
Trihydro

UNIVERSITY of WYOMING

McFARLAND MANAGEMENT, LLC

http://www.its.dot.gov/pilots/

# Wyoming CV Pilot Deployment Program



# Wyoming CV Pilot Deployment Program

- Proposed Applications
  - Road Weather Advisories for Trucks
  - Automatic Alerts for Emergency Responders
  - CV-enabled Weather-Responsive Variable Speed Limits
  - Spot Weather Impact Warning
  - WorkZone Warnings
  - Situational Awareness
  - Freight-Specific Dynamic Travel Planning

*Source: Concept of Operations* http://ntl.bts.gov/lib/56000/56900/56997/FHWA-JPO-16-287.pdf

# Wyoming CV Pilot Deployment Program

- Basic Safety Message (BSM)
  - SAE J2735
  - BSM Part 1:
    - Core data elements such as vehicle size, position, speed, heading acceleration, brake system status
    - Transmitted at 10 HZ
  - BSM Part 2:
    - Added to part 1 depending on events (e.g. ABS brakes activated)
    - Contains variable set of data elements
    - Transmitted less frequently
  - Transmitted over DSRC (~1000 meters)

*Source: http://www.its.dot.gov/itspac/october2012/PDF/data_availability.pdf*

# Wyoming CV Pilot Deployment Program

## Weather Priority Vehicular Data

BSM Part 1

- Brake system status
  - Brake applied status
  - Traction control status
  - Anti-lock brake status
  - Stability control status

BSM Part 2

- Vehicle status
  - Exterior lights
  - Wipers
  - Brake system status
  - Roadway friction
  - Rain sensor
  - Ambient air temperature
  - Ambient pressure
  - Yaw rate

Source: http://www.its.dot.gov/itspac/october2012/PDF/data_availability.pdf

# Wyoming CV Pilot Deployment Program

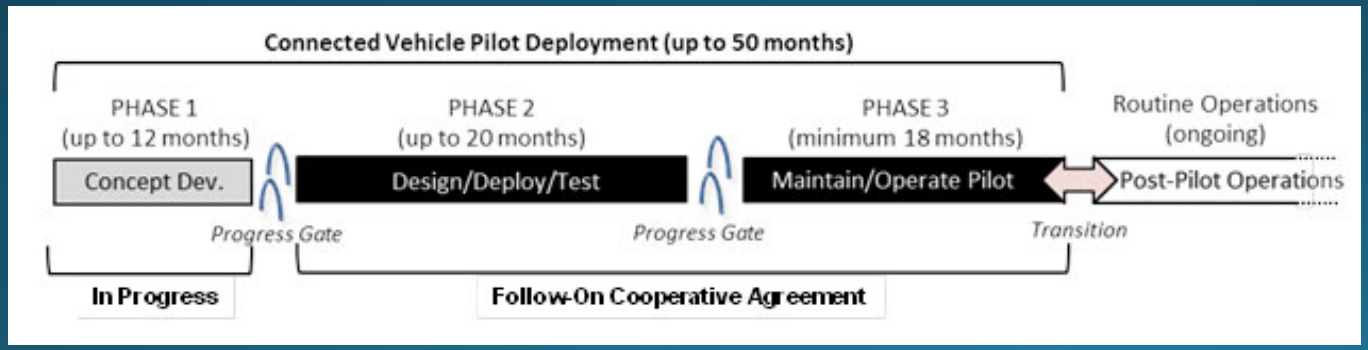
- Wyoming Pilot will likely have:
  - CV instrumented vehicles, mainly WYDOT fleet and freight partners
  - Subset of vehicles will be instrumented with external weather sensors
  - Pikalert system embedded in WYDOT TMC
  - Wide area weather alert dissemination

# Wyoming CV Pilot Deployment Program

- Phase 1 Timeline

| Timeline | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task | Sep-15 | Oct-15 | Nov-15 | Dec-15 | Jan-16 | Feb-16 | Mar-16 | Apr-16 | May-16 | Jun-16 | Jul-16 | Aug-16 |
| Task 1 - Program Mgt. | | | | | | | | | | | | |
| Task 2 - ConOps | | | | | | | | | | | | |
| Task 3 - Security Concept | | | | | | | | | | | | |
| Task 4 - Safety Plan | | | | | | | | | | | | |
| Task 5 - Perf. Measurment | | | | | | | | | | | | |
| Task 6 - SyRs | | | | | | | | | | | | |
| Task 7 - App Planning | | | | | | | | | | | | |
| Task 8 - Human Use Appr | | | | | | | | | | | | |
| Task 9 - Training Plan | | | | | | | | | | | | |
| Task 10 - Partnership | | | | | | | | | | | | |
| Task 11 - Outreach Plan | | | | | | | | | | | | |
| Task 12 - Deployment Plan | | | | | | | | | | | | |
| Task 13 - Readiness Summary | | | | | | | | | | | | |
| | | | webinar | | | | | | | | | |

- Phase 2 and 3

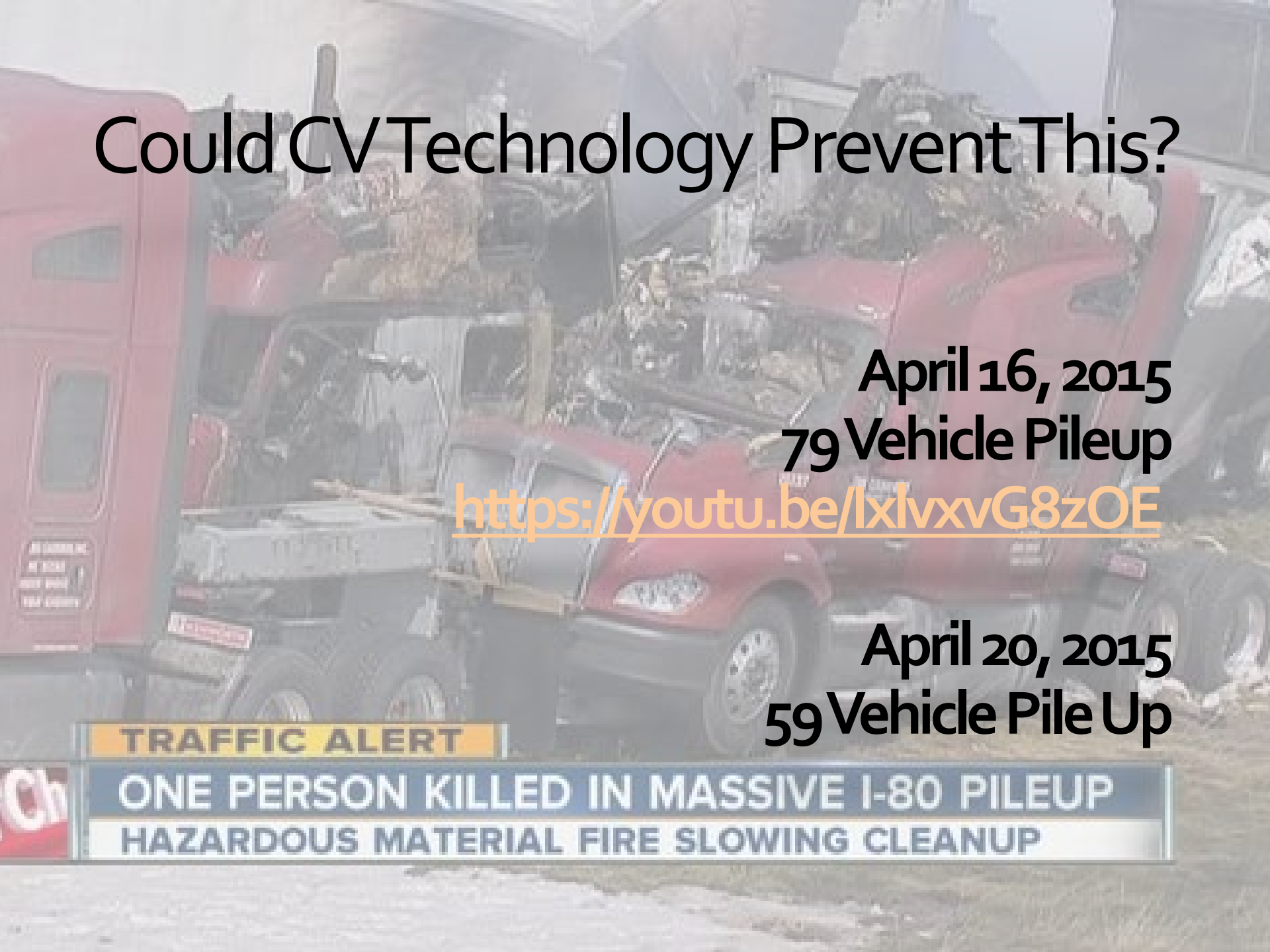



Source: http://www.its.dot.gov/pilots/index.htm

# The future?

- Considerable interest in the area of road weather management will lead to a better understanding of driver behavior and vehicle performance in non-ideal conditions
- New knowledge will enable operation of roadways that are more adaptive to current conditions, increasing system resiliency

# Could CV Technology Prevent This?

**April 16, 2015**
**79 Vehicle Pileup**
https://youtu.be/IxlvxvG8zOE

**April 20, 2015**
**59 Vehicle Pile Up**