

University of Wyoming



Gonzaga University



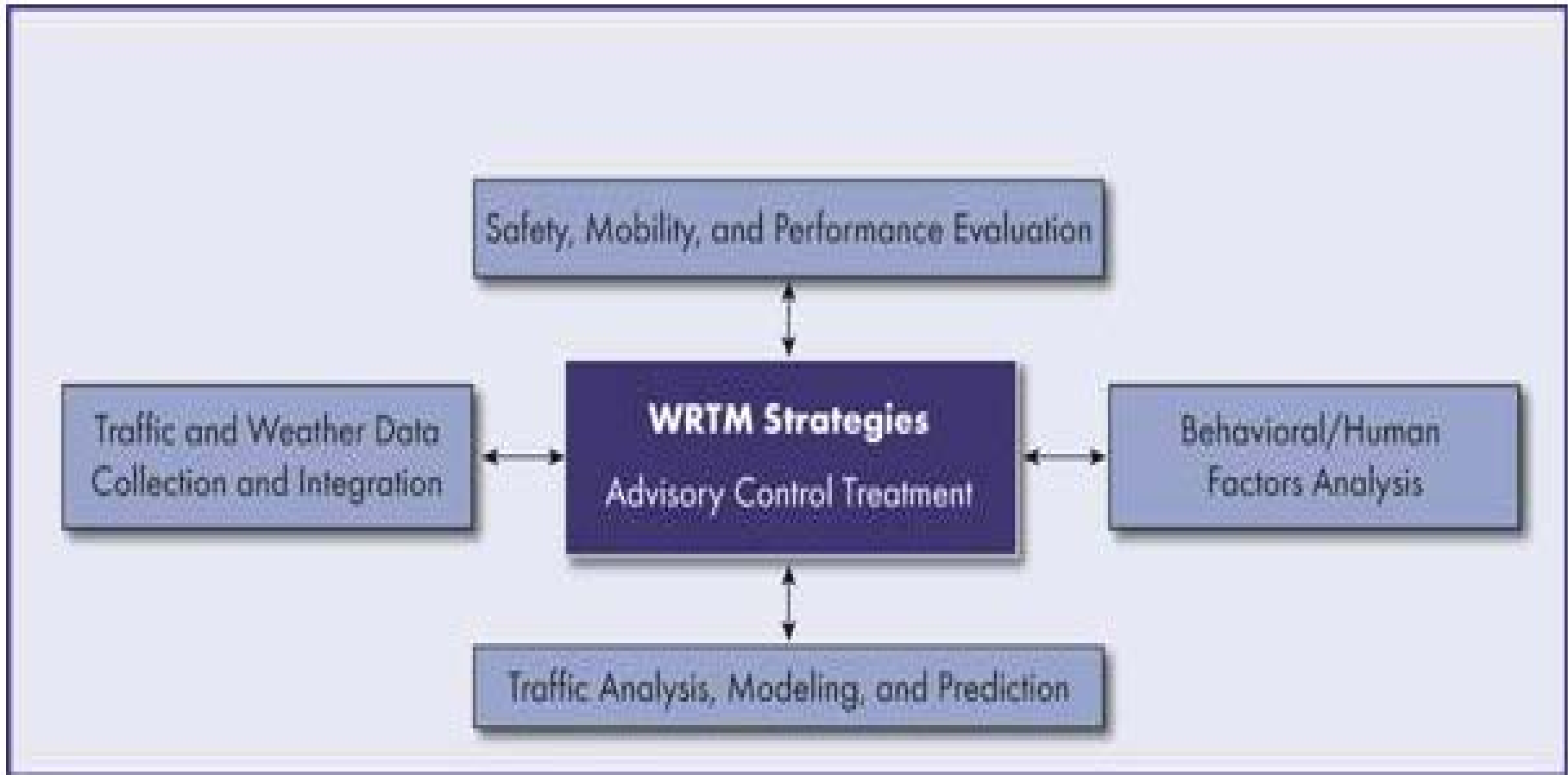
Weather Impact on Roadways

- Safety
 - ~22% of US crashes are weather related
 - 6,000 fatalities and 445,000 injuries
- Mobility
 - Capacity Reductions
 - Rain decreases travel speed 3-16%
 - Snow decreases travel speed 5-40%
 - ~23% of non-recurrent delay on highways caused by snow, ice, and fog
- Economy
 - \$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

Weather Responsive Traffic Management



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

Weather Responsive Traffic Management



WRTM Strategies: Motorists

Pre-Trip

Motorist Advisories,
Alert and Warning

En-Route



Source: Developments in Weather Responsive Traffic Management Strategies, <http://map.wyoroad.info/hi.html>

Weather Responsive Traffic Management

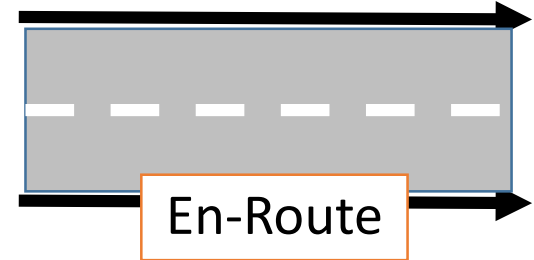
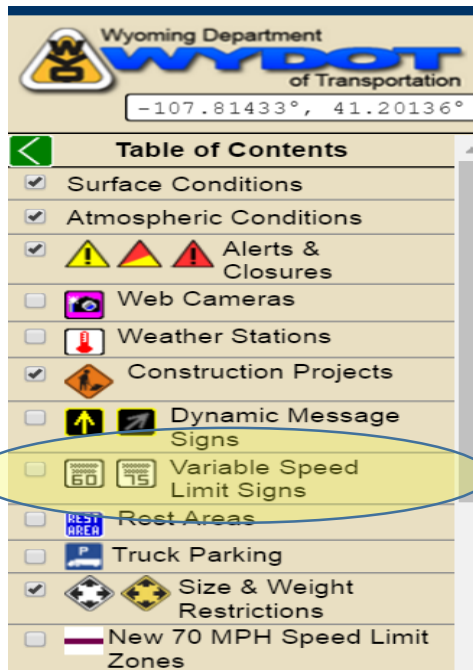


WRTM Strategies: Motorists

Pre-Trip

Speed Management

En-Route

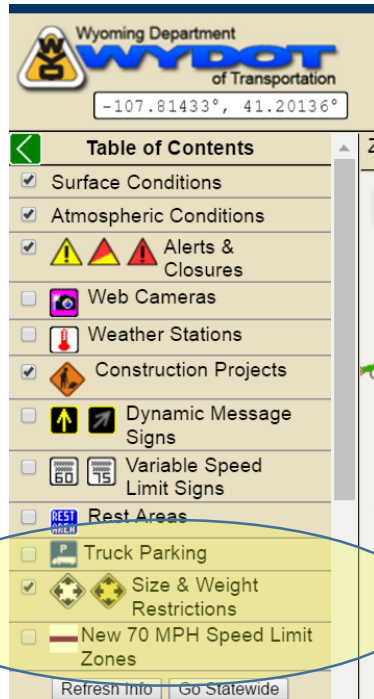


Source: Developments in Weather Responsive Traffic Management Strategies, <http://map.wyroad.info/hi.html>

Weather Responsive Traffic Management

WRTM Strategies: Motorists

Pre-Trip



Vehicle Restrictions

En-Route

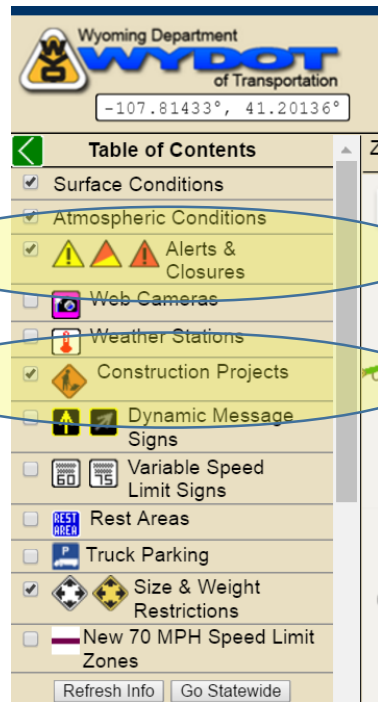


Source: Developments in Weather Responsive Traffic Management Strategies, <http://map.wyoroad.info/hi.html>

Weather Responsive Traffic Management

WRTM Strategies: Motorists

Pre-Trip



Road Restrictions

En-Route

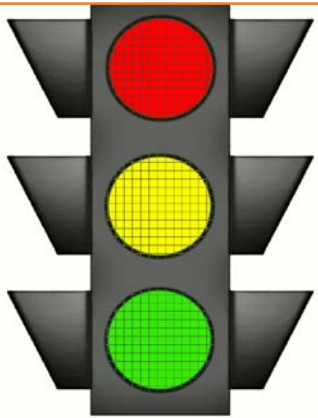


Source: *Developments in Weather Responsive Traffic Management Strategies*, <http://map.wyoroad.info/hi.html>

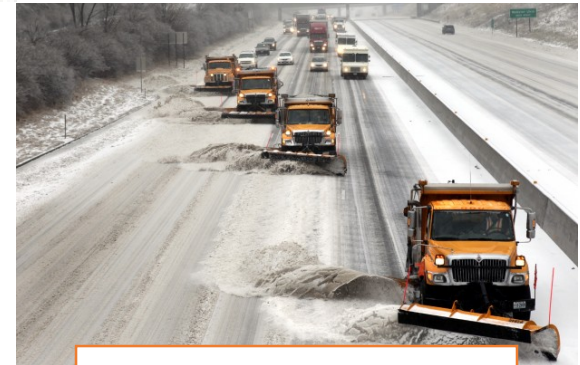
Weather Responsive Traffic Management

WRTM Strategies: Agencies

Traffic Signal Control



Incident Management



Asset Management

Source: *Developments in Weather Responsive Traffic Management Strategies*

Weather Responsive Traffic Management

Wyoming WRTM Strategies

- 143 miles of **weather-responsive VSLs** along 400-mile I-80 corridor



Weather Responsive Traffic Management

Wyoming WRTM Strategies

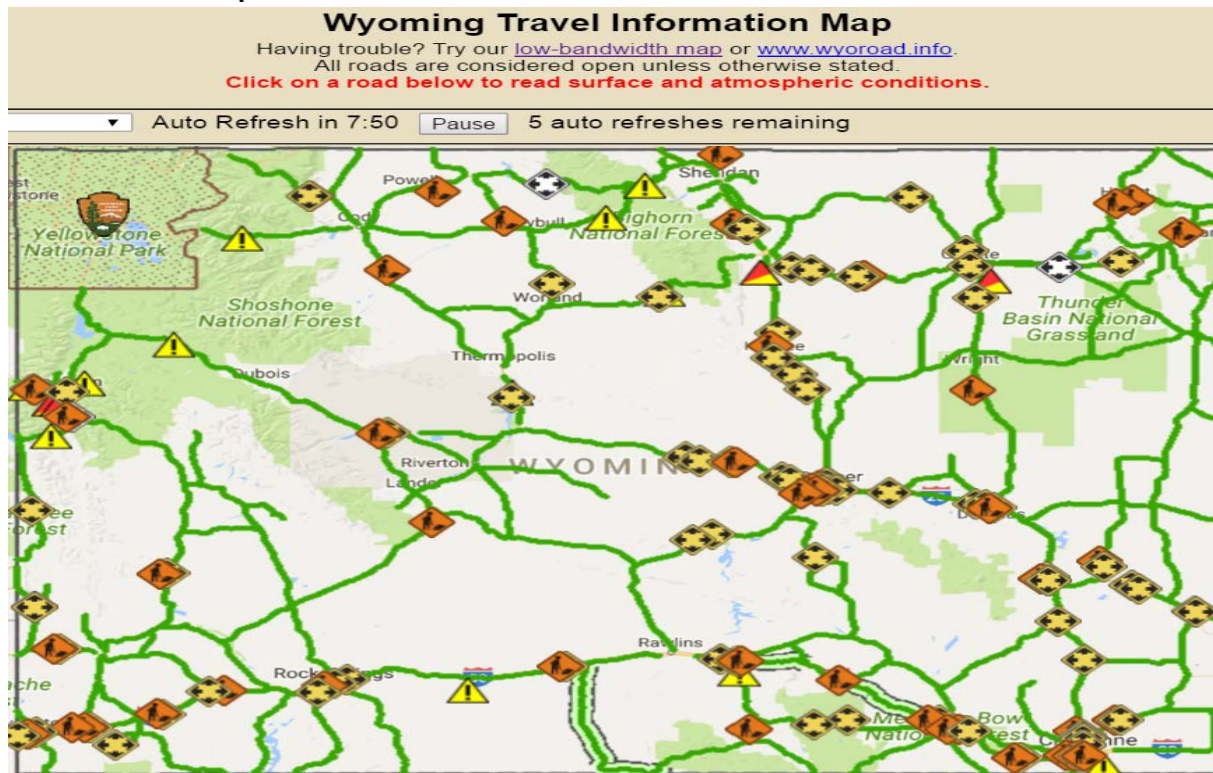
- 143 miles of **weather-responsive VSLs** along 400-mile I-80 corridor
- **High wind alerts** and **light-weight vehicle** closures



Weather Responsive Traffic Management

Wyoming WRTM Strategies

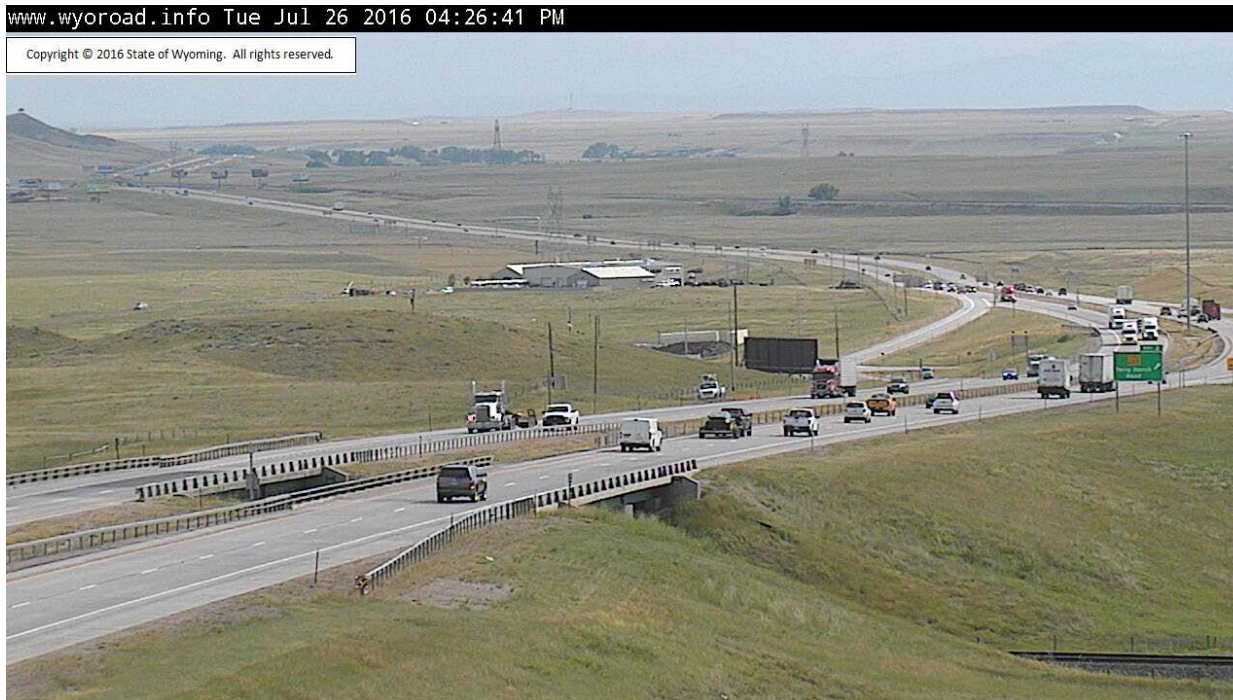
- 143 miles of **weather-responsive VSLs** along 400-mile I-80 corridor
- **High wind alerts** and **light-weight vehicle** closures
- Interactive User Map



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
- Interactive User Map
- Still Camera Photos



Wyoming WRTM Strategies

- 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

Data Collection 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 dew point, camera for visual verification of conditions
- Pros – real-time localized weather data
- Cons – expense (capital and maintenance), point data only
 - \$25,000-50,000 Capital Costs, highly dependent on *sensor package* and availability of *power and communication* (Wyoming)



Data Collection Technology needed for WRTM

- Mobile Weather Data
 - Internal vehicle data and externally mounted sensors
 - Pros – real-time localized weather for continuous roadway stretches
 - Cons - require vehicles to be traveling, expensive



USDOT Connected Vehicles Initiative

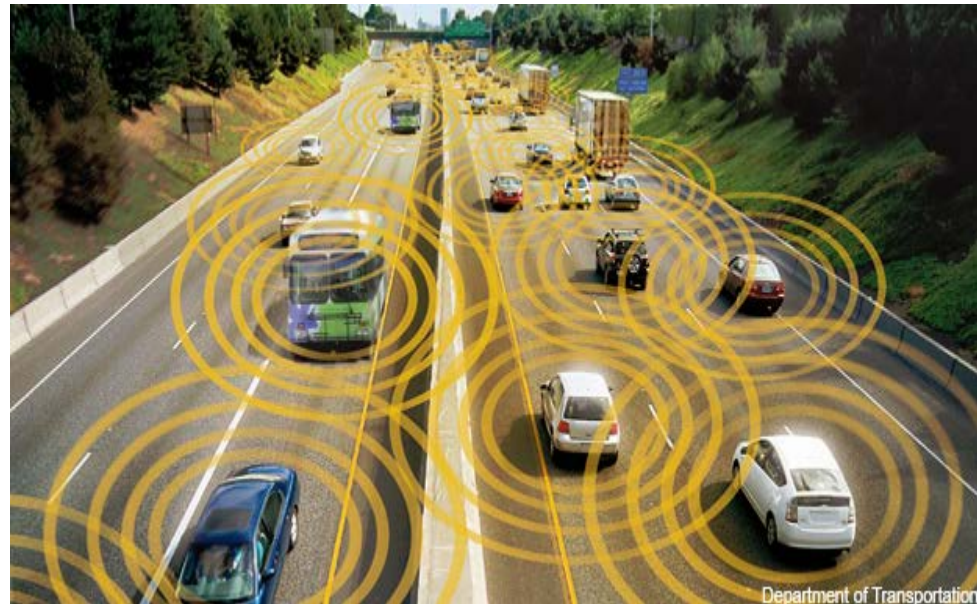
Goals:

- Crash Prevention
- Improved Safety and Mobility
- Continuous and Reliable Traveler Information



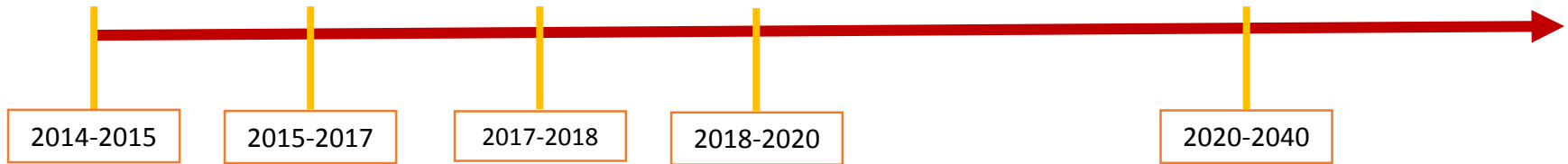
Types of Communication:

- Vehicle to Vehicle
- Vehicle to Infrastructure
- Vehicle to X



USDOT Connected Vehicles Initiative

Timeline: AASHTO's National Footprint Analysis

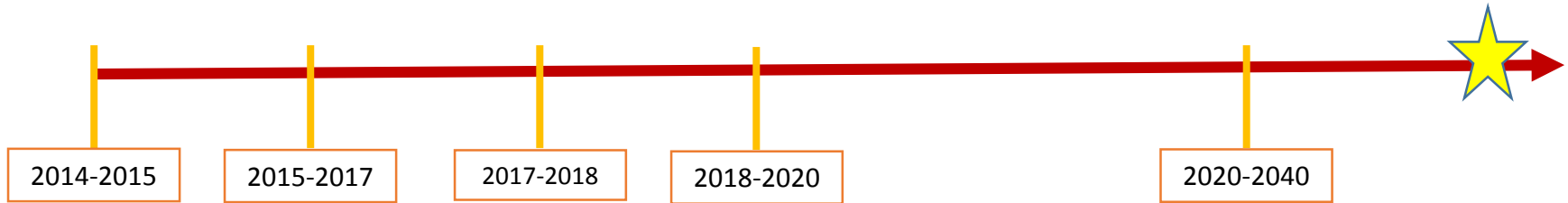


- Plan
- Research and Pilot Projects
- Evaluation of Applications
- Deployment
- Expansion



Source: AASHTO. (2014, May 22). National Connected Vehicle Field Infrastructure Footprint Analysis. T3 Webinar Series.

Timeline: AASHTO's National Footprint Analysis



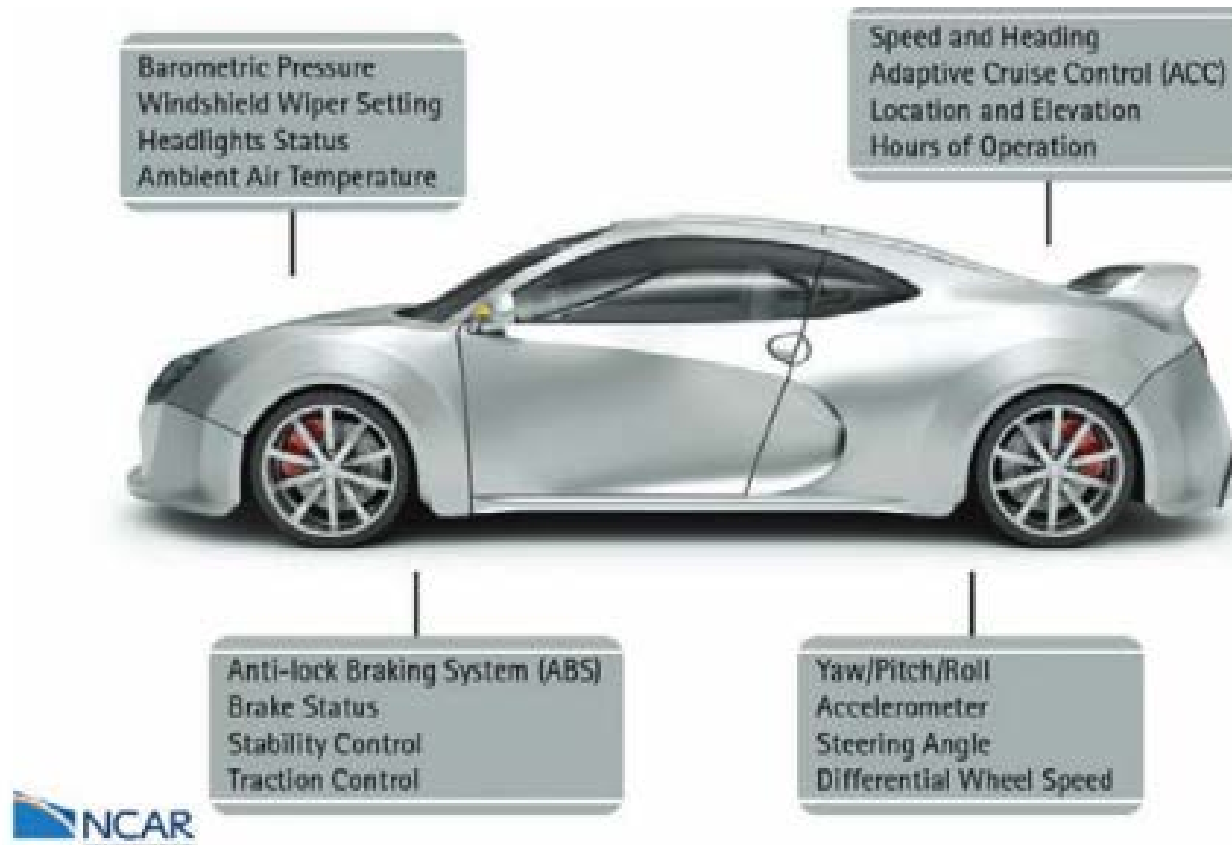
2040:

- 80% of Signalized Intersections equipped with V2I Technology
- 25,000 Other Roadside Applications in Use (CCTV, Toll Readers, etc...)
- 90% of all Road Miles equipped with Real-Time Localized Information

Source: AASHTO. (2014, May 22). National Connected Vehicle Field Infrastructure Footprint Analysis. T3 Webinar Series.

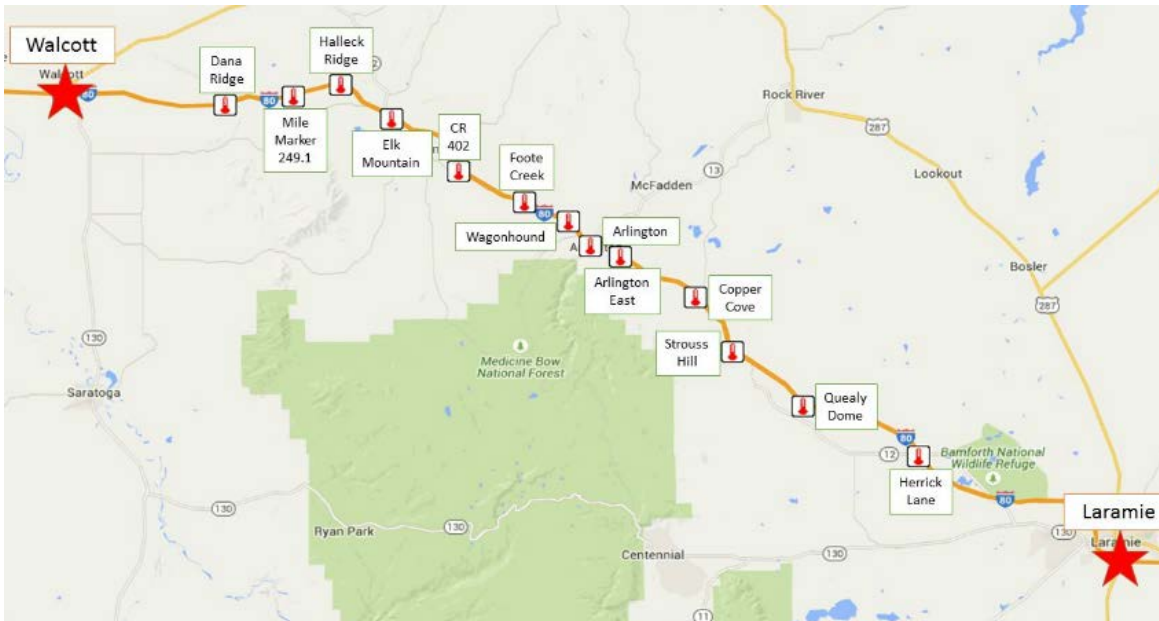
CV Road Weather Condition System

Can Connected Vehicle Data be used to support WRTM?



CV Road Weather Condition System

- Winter of 2014-2015: conducted a small CV project along I-80 at the University of Wyoming
 - *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>



- Route Chosen because of existing RWIS Infrastructure
- 13 RWIS Stations along Route

CV Road Weather Condition System

System Overview



CV Road Weather Condition System

Vehicle Data Collection



- Commercially Available
 - OBD Link Mx (WiFi)
- Open XC Platform (Open Source)
 - Ford Reference OBE
 - Chip-Kit Handmade OBE
 - Cross Chasm C4

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

Data Communication

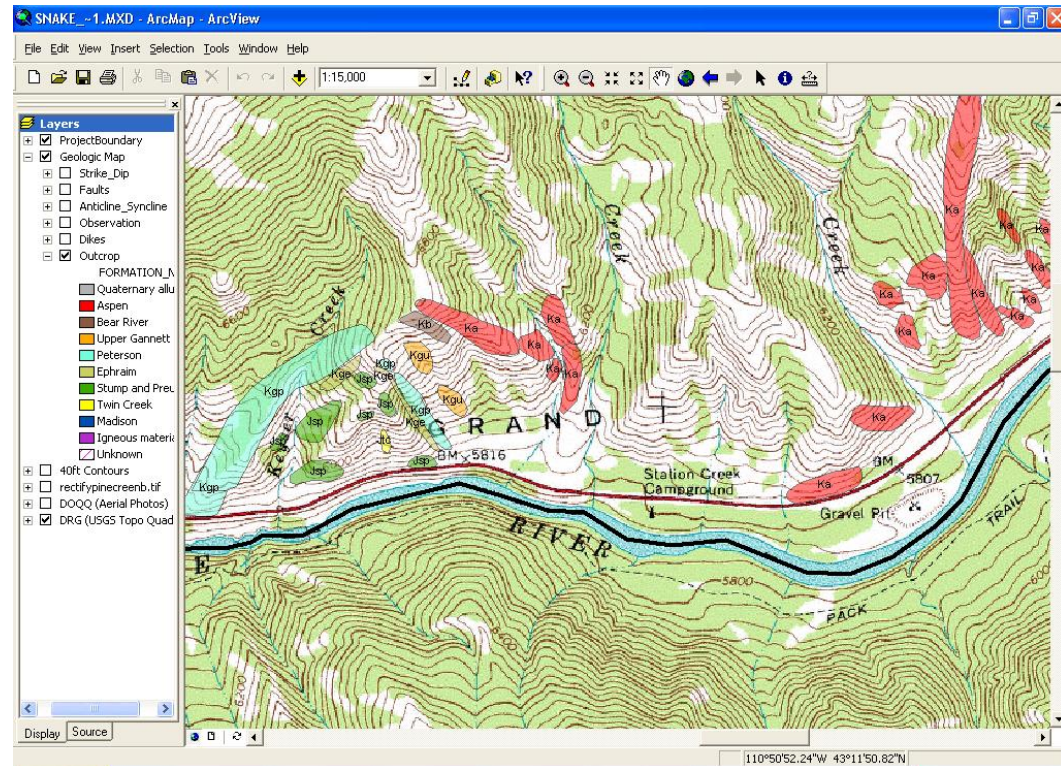


XC OpenXC Enabler	
Status	Dashboard
Accelerator Pedal	0.0 %
Brake Pedal	off
Engine Speed	774.0 RPM
Fuel Consumed	0.212475 L
Fuel Level	92.282906 %
Headlamp	off
High Beams	off
Ignition Status	RUN
Latitude	41.301464 °
Longitude	-105.583359 °
Odometer	43886.507812 km
Parking Brake	off
Steering Wheel	12.700073 °
Transmission Torque	5.0 Nm
Transmission Gear	NEUTRAL
Vehicle Speed	0.0 km / h
Windshield Wiper	off

CV Road Weather Condition System

Data Processing, Analysis, and Visualization

- ArcGIS

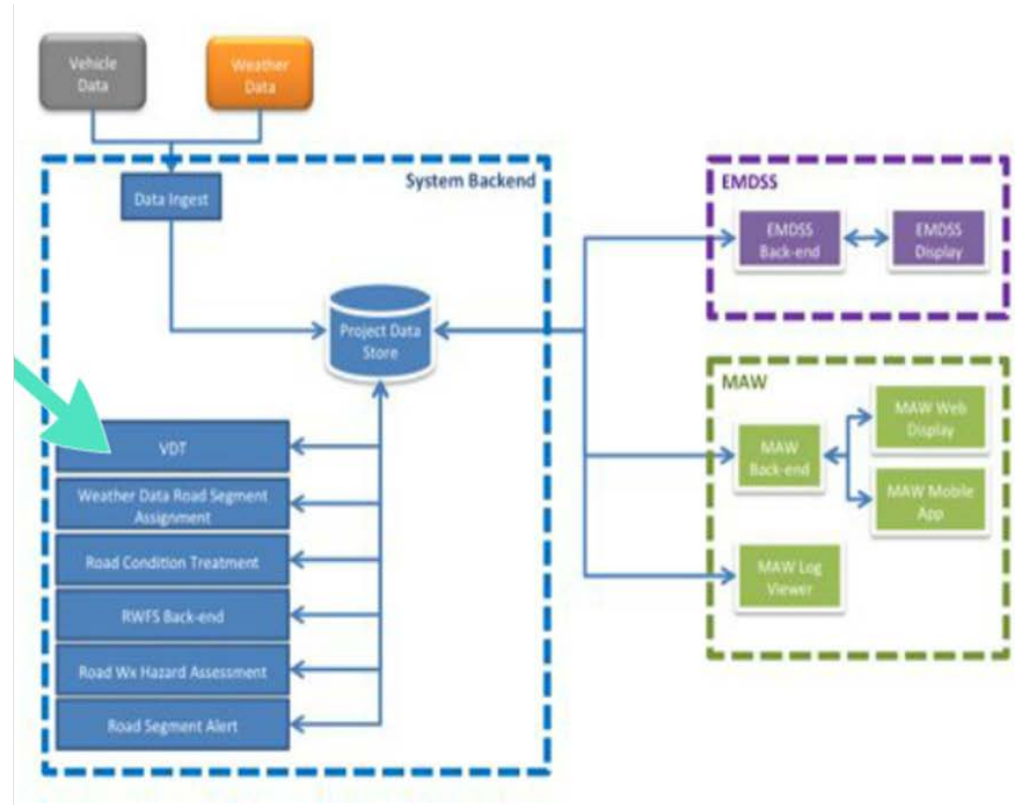


CV Road Weather Condition System

Data Processing, Analysis, and Visualization

- ArcGIS
- FHWA's Open Source Pikalert® System

Vehicle Data
Translator



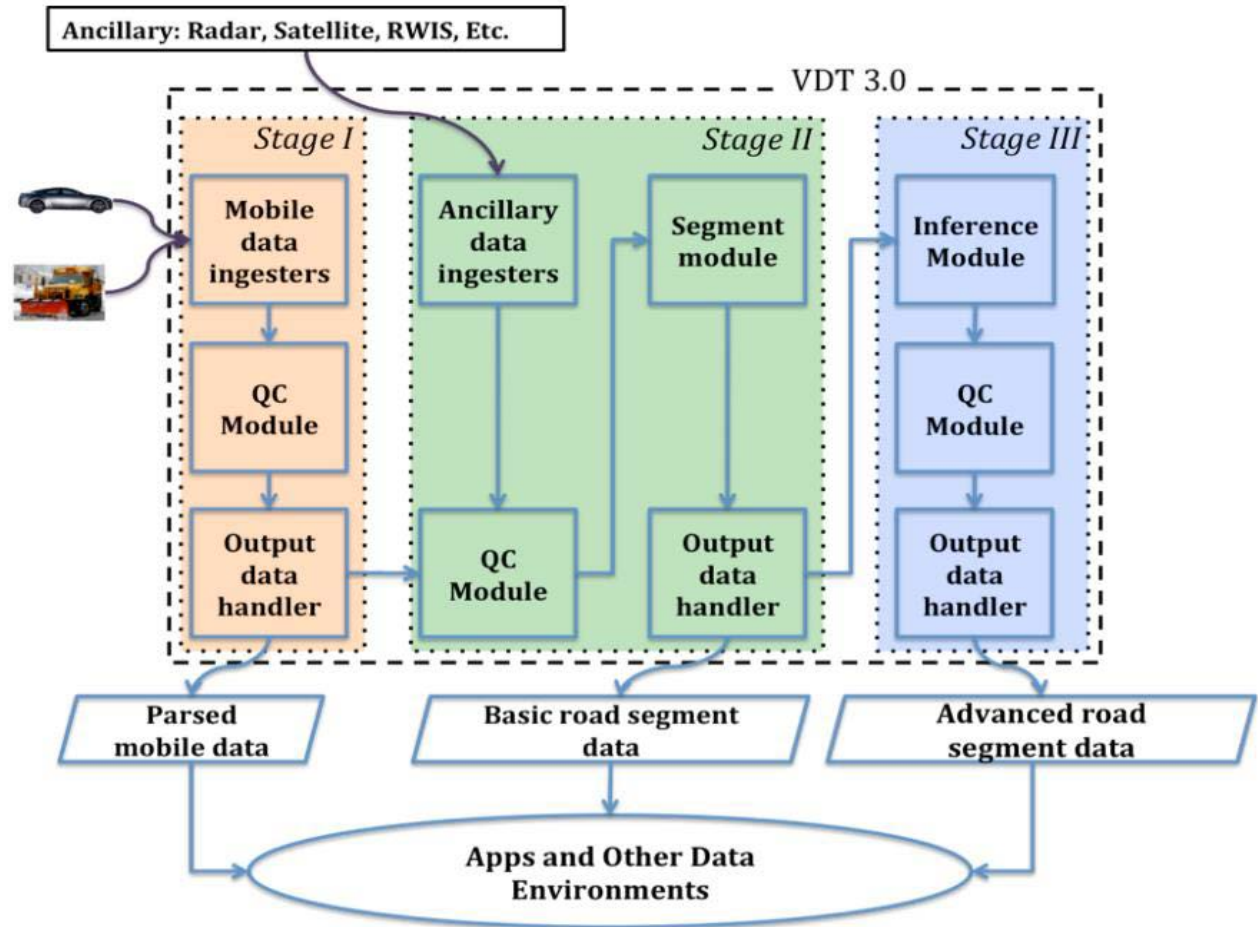
Enhanced
Maintenance
Decision Support
System

Motorist Advisory
and Warning

CV Road Weather Condition System

Data Processing, Analysis, and Visualization

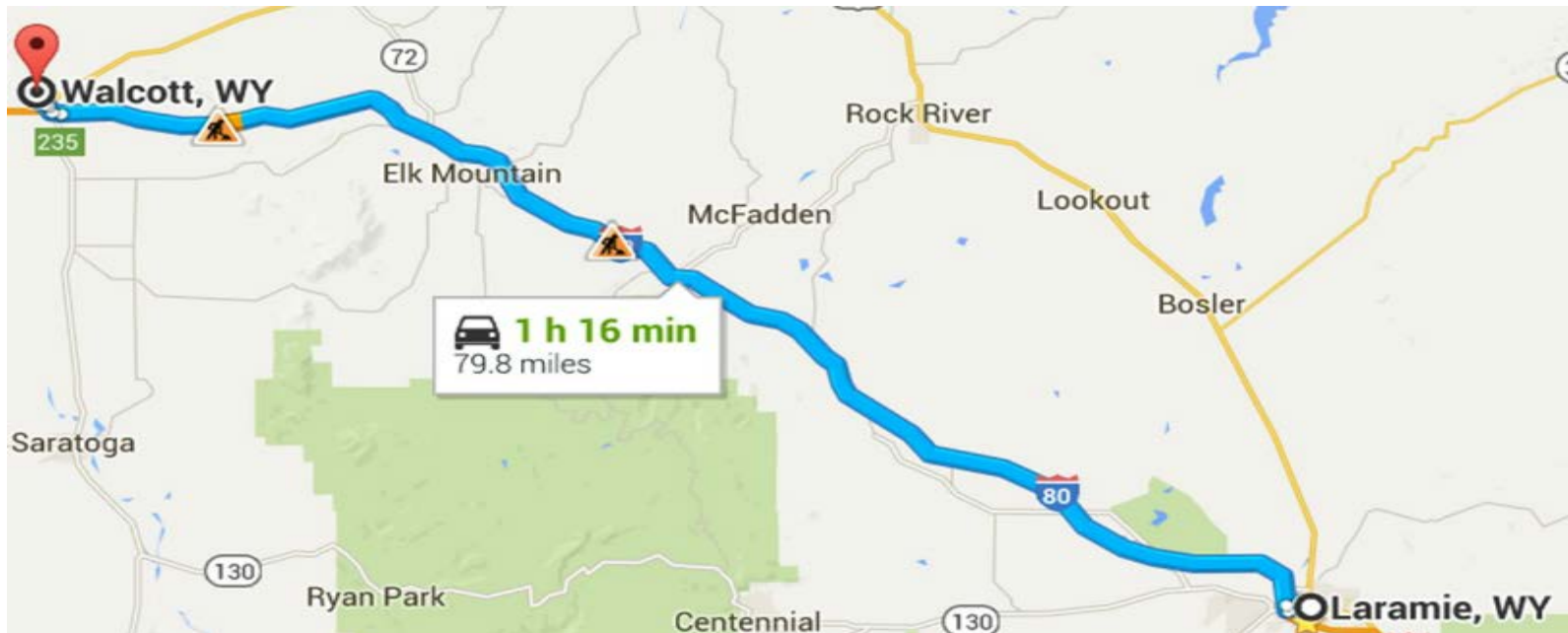
- ArcGIS
- FHWA's Open Source Pikalert® System



CV Road Weather Condition System

Project Overview

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




CV Road Weather Condition System



Project Overview

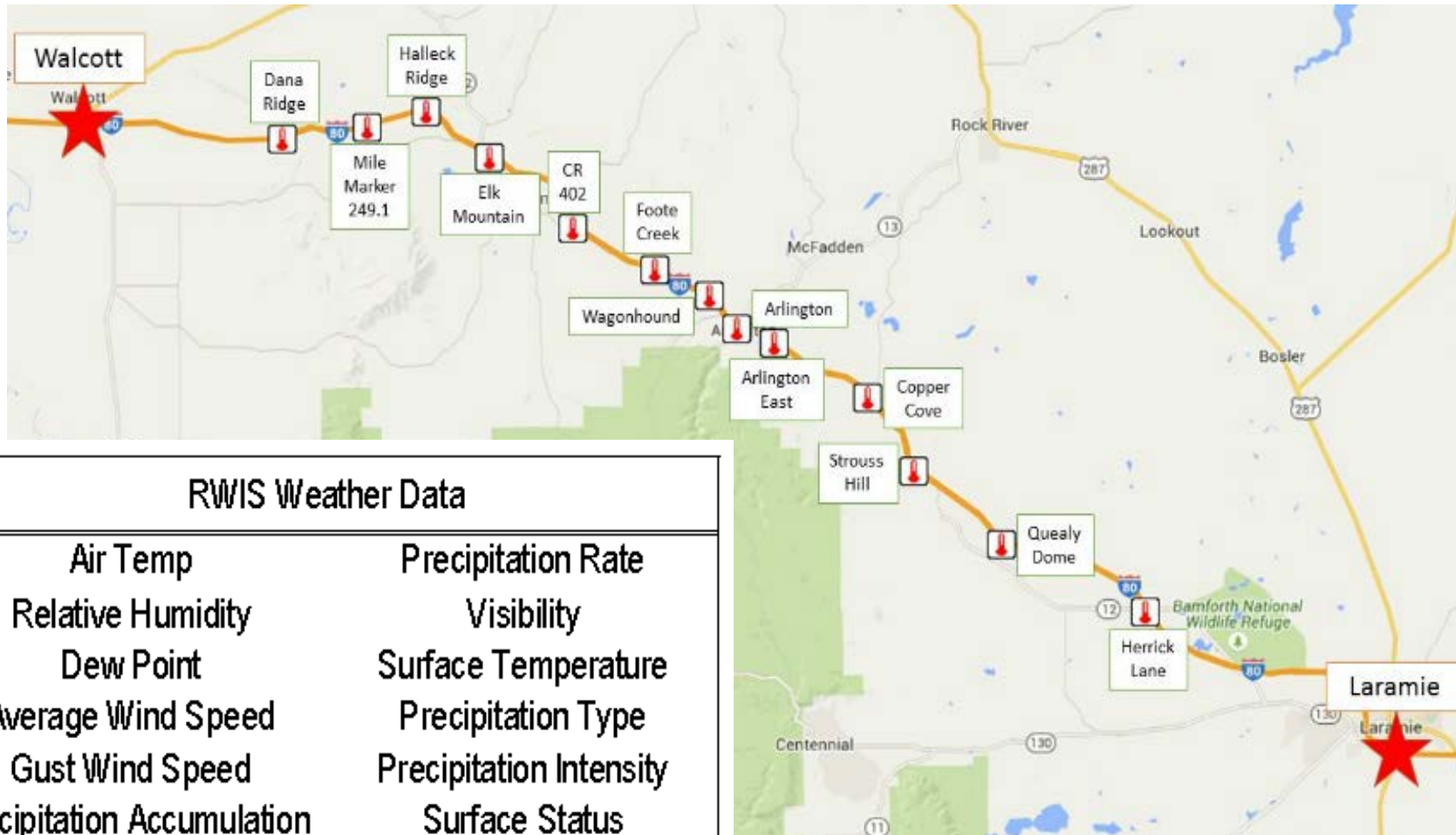
- 16 trips, over 52 million data points



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

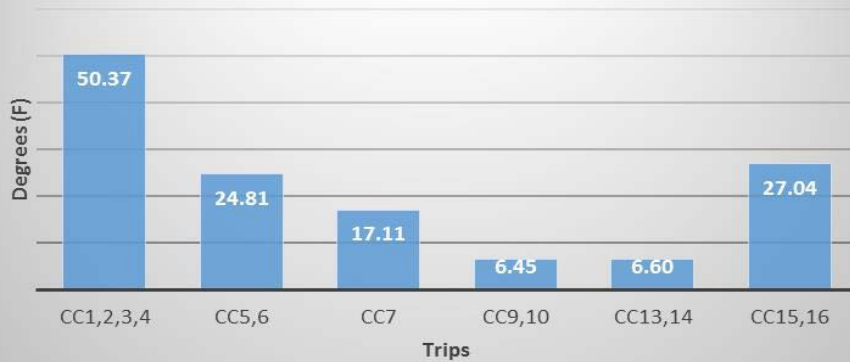


CV Road Weather Condition System

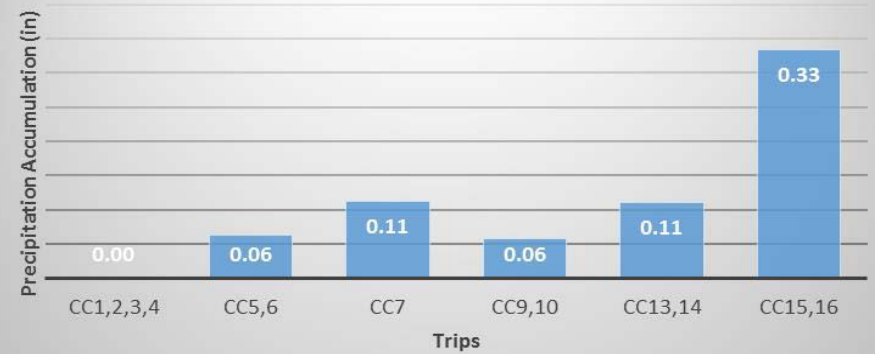


RWIS Data Summary

Average Air Temperature



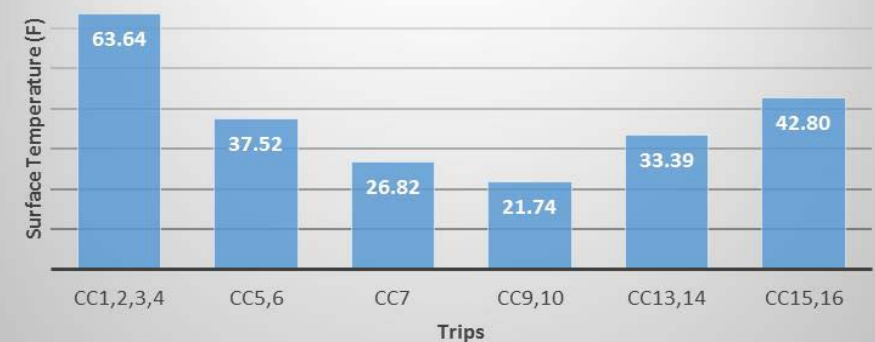
Average Precipitation Accumulation



Average Wind Speed



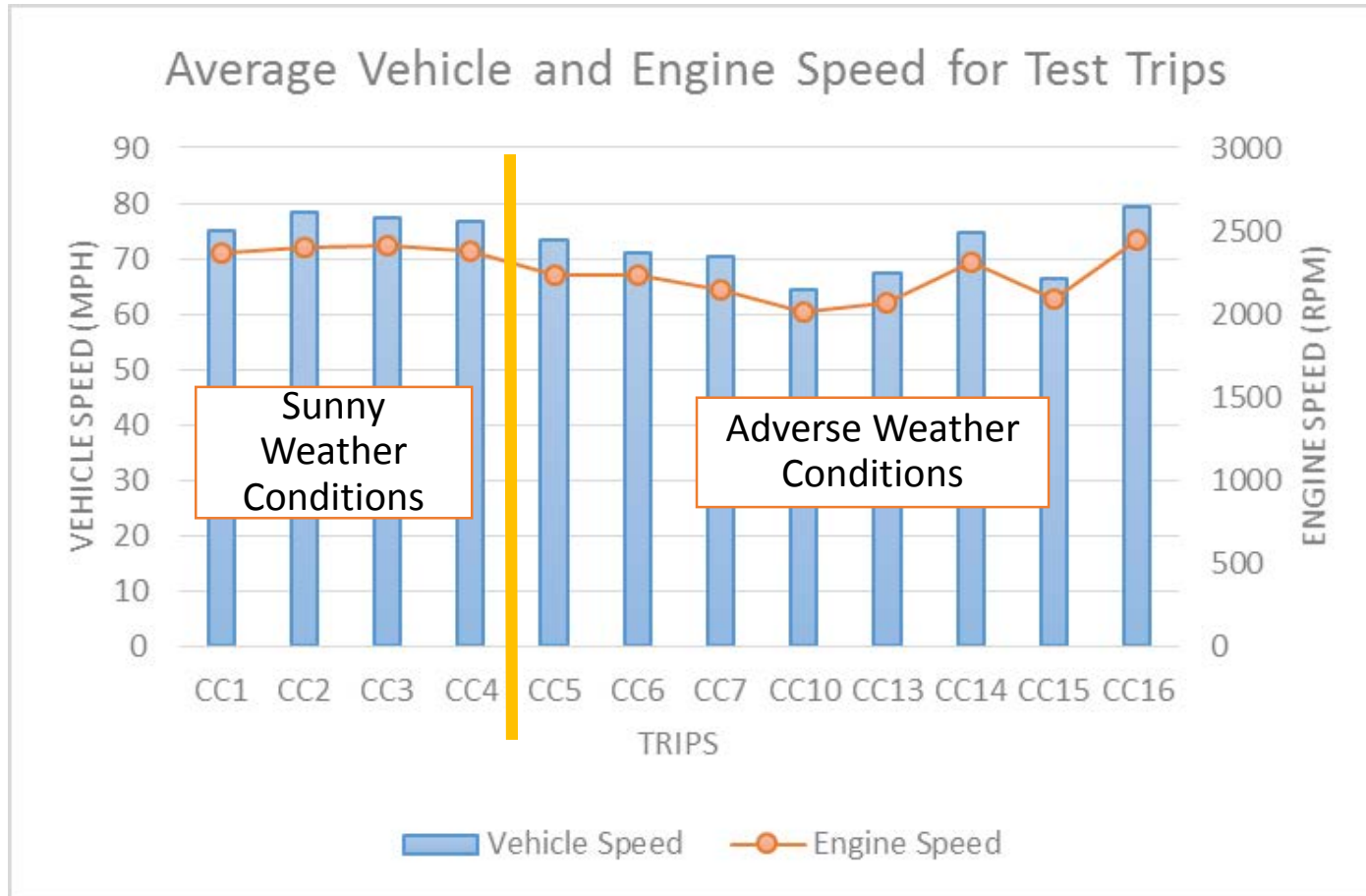
Average Surface Temperature



CV Road Weather Condition System

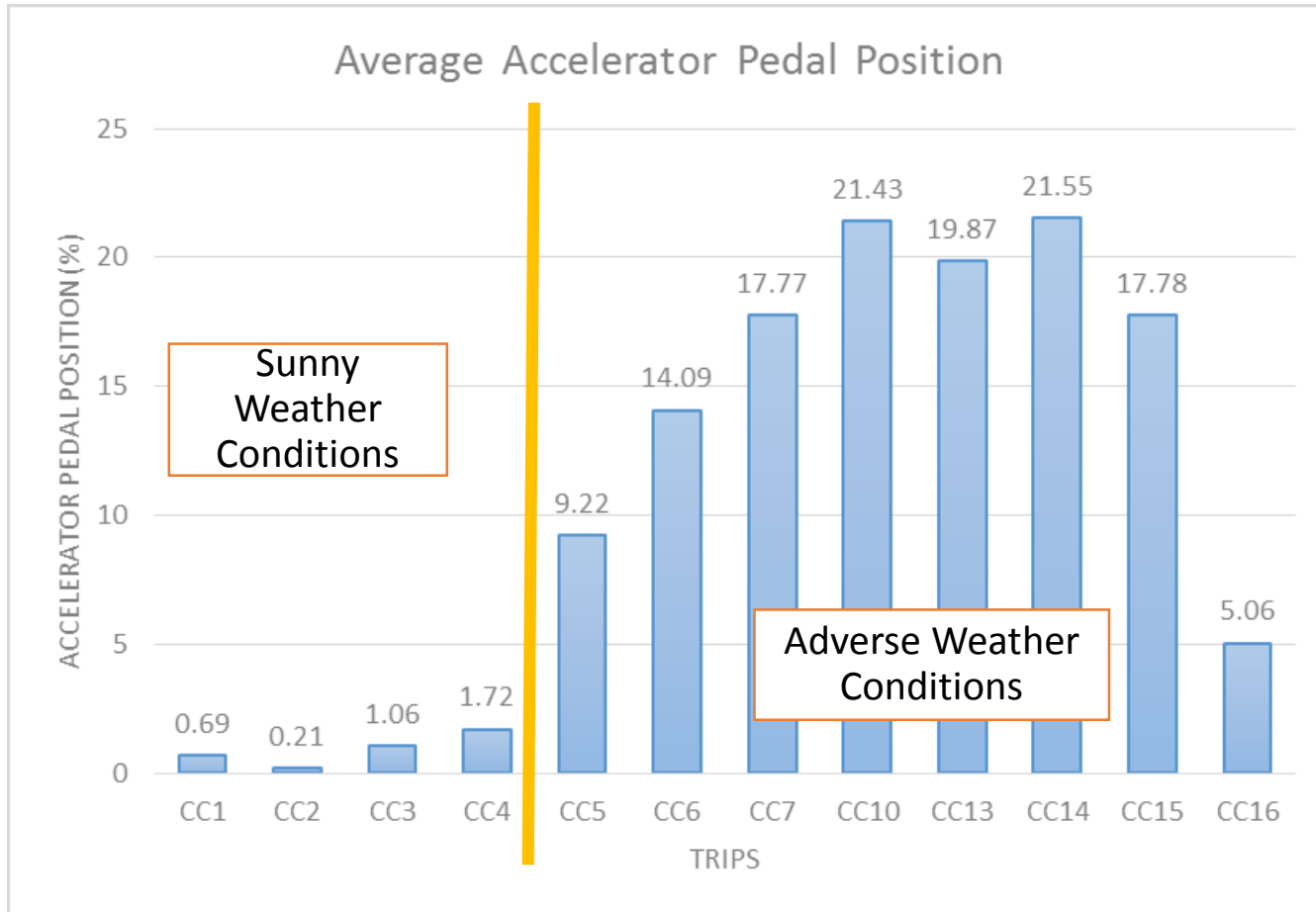


Vehicle Data Summary: Vehicle and Engine Speed



CV Road Weather Condition System

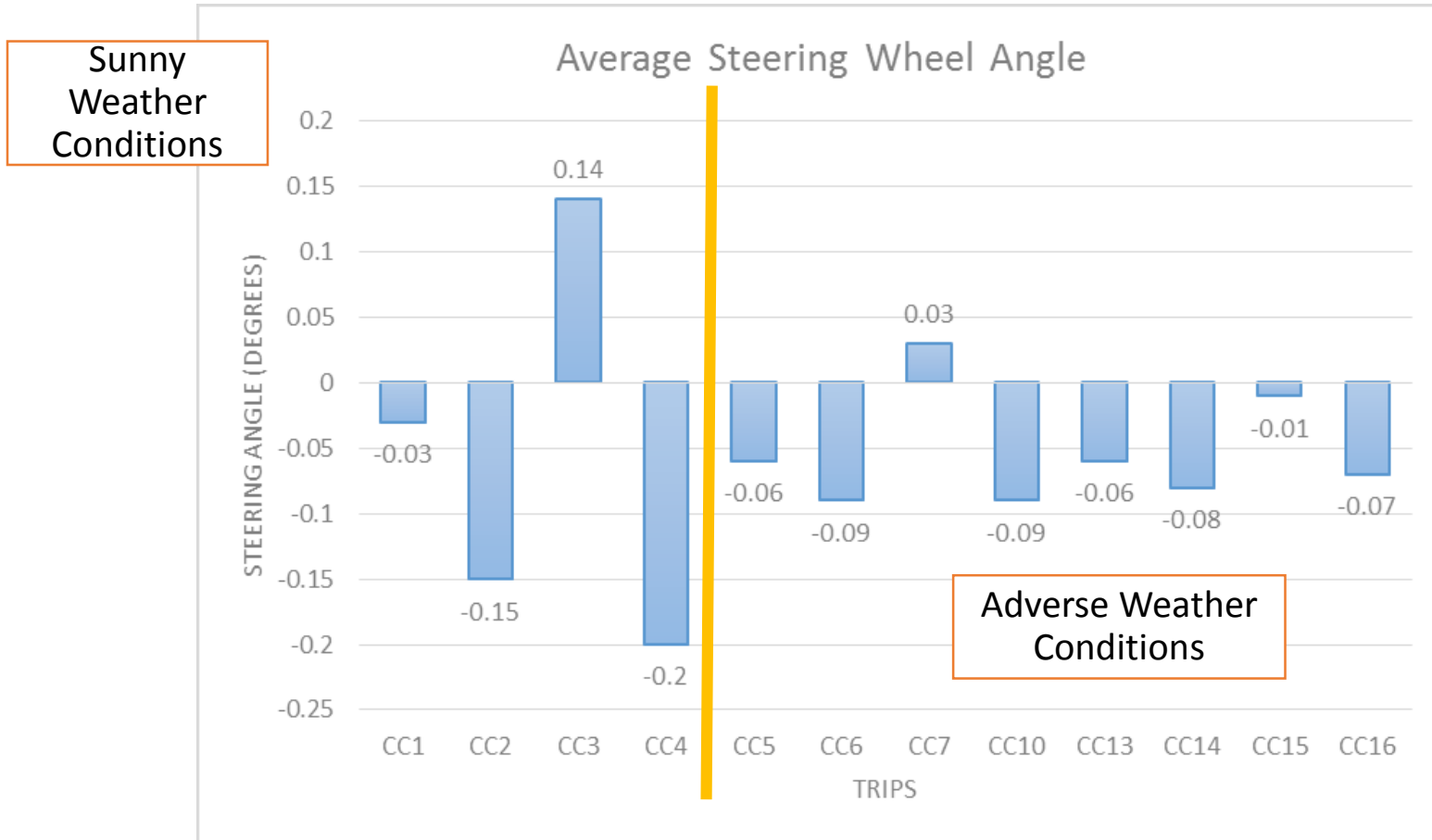
Vehicle Data Summary: Average Accelerator Pedal Position



CV Road Weather Condition System



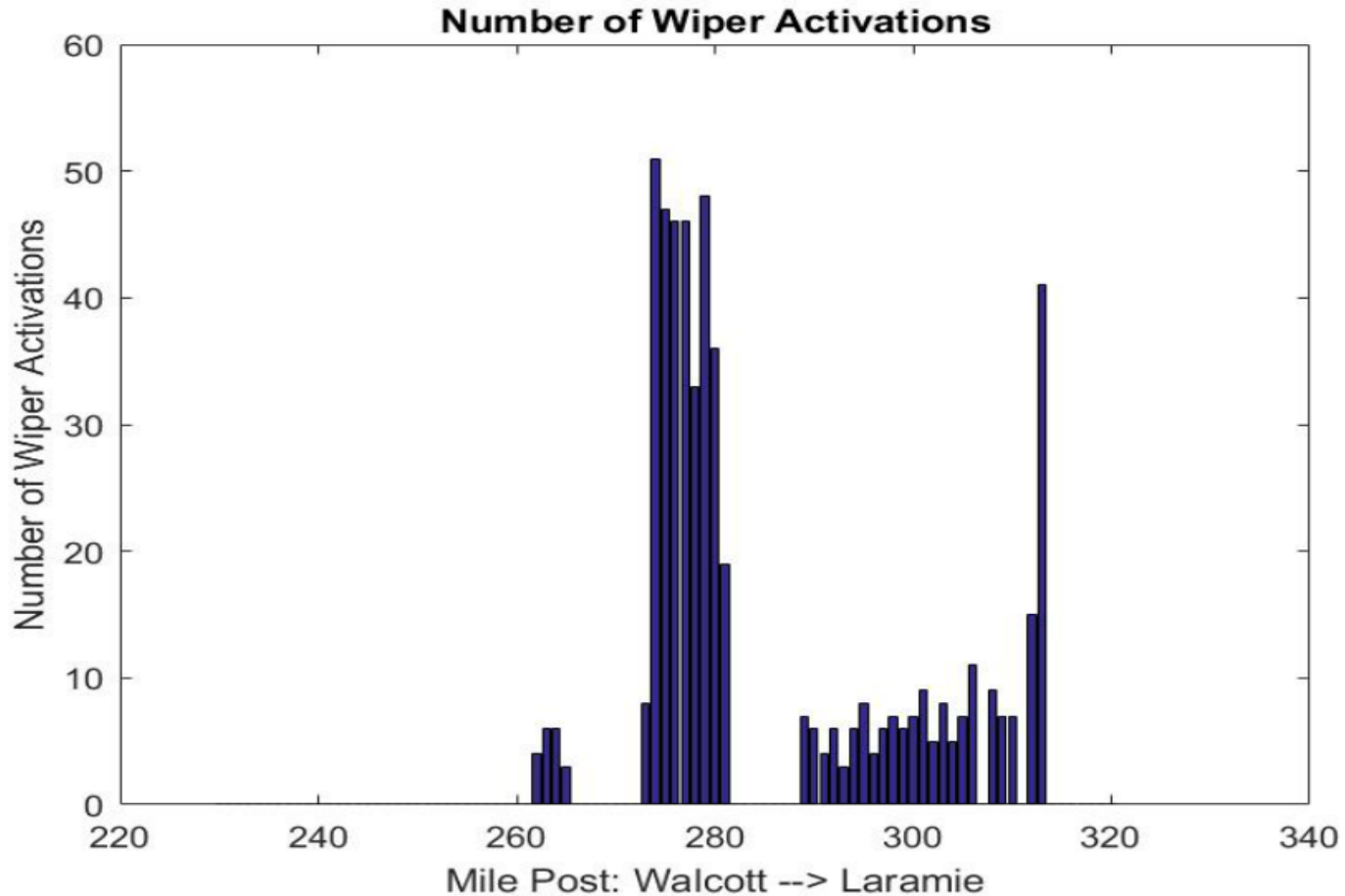
Vehicle Data Summary



CV Road Weather Condition System



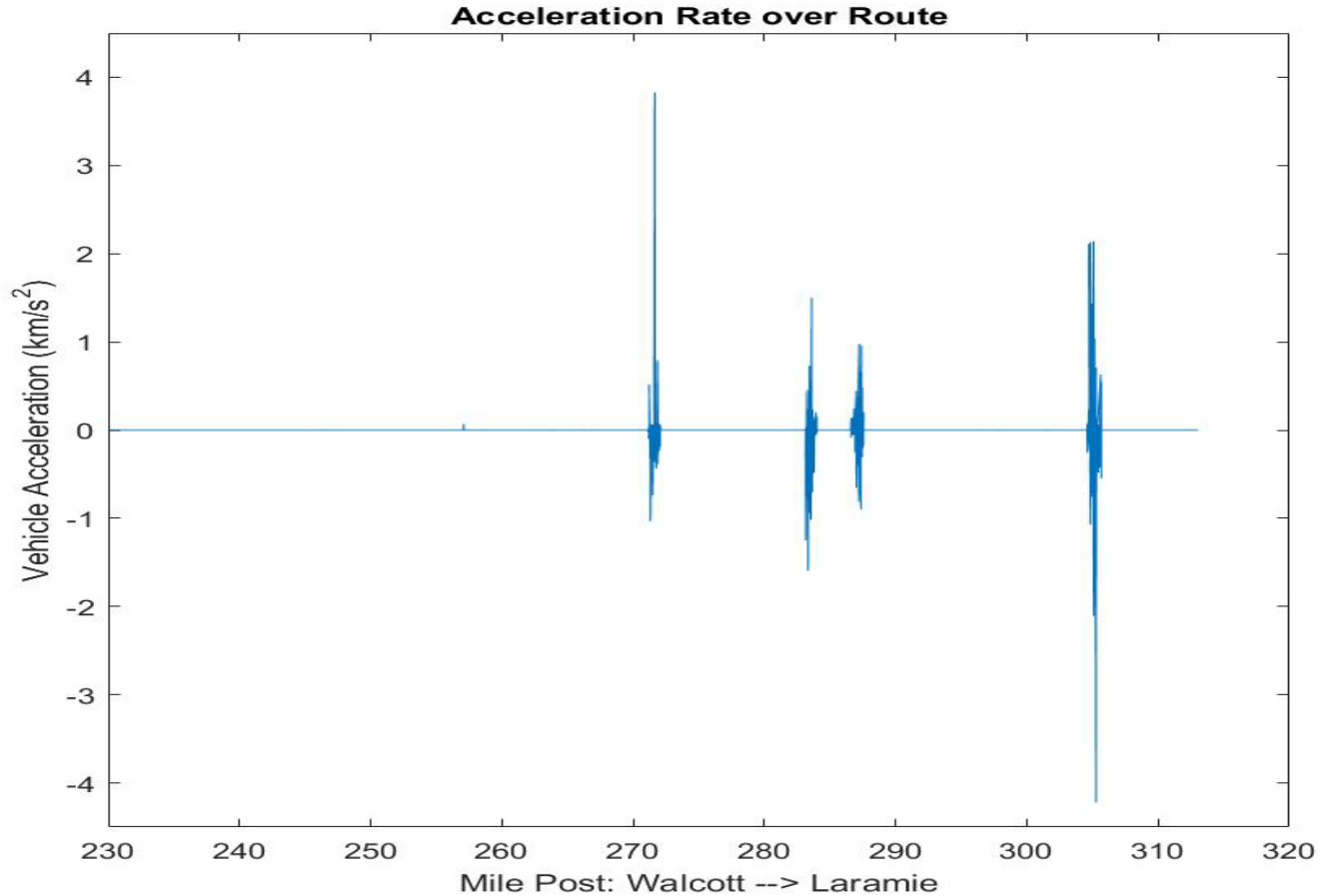
Vehicle Data Summary: Windshield Wiper Activations



CV Road Weather Condition System



Vehicle Data Summary: Acceleration Rate

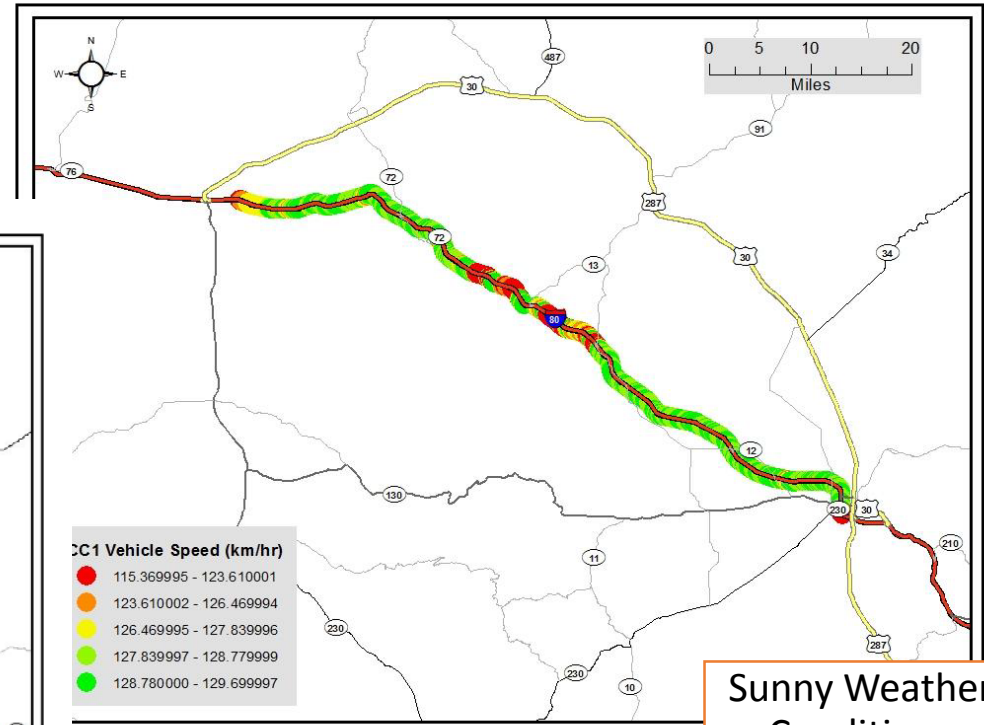
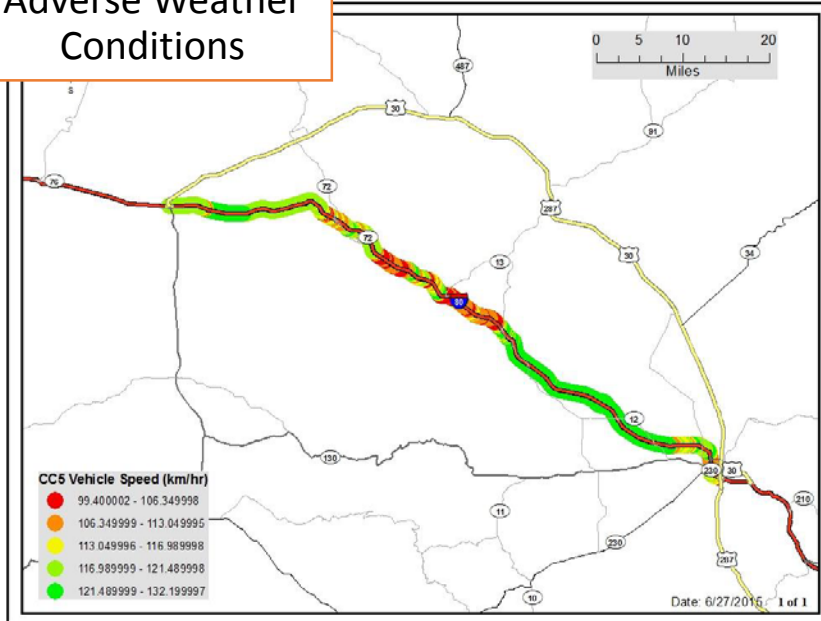


CV Road Weather Condition System



Vehicle Data Summary: Vehicle Speed

Adverse Weather Conditions

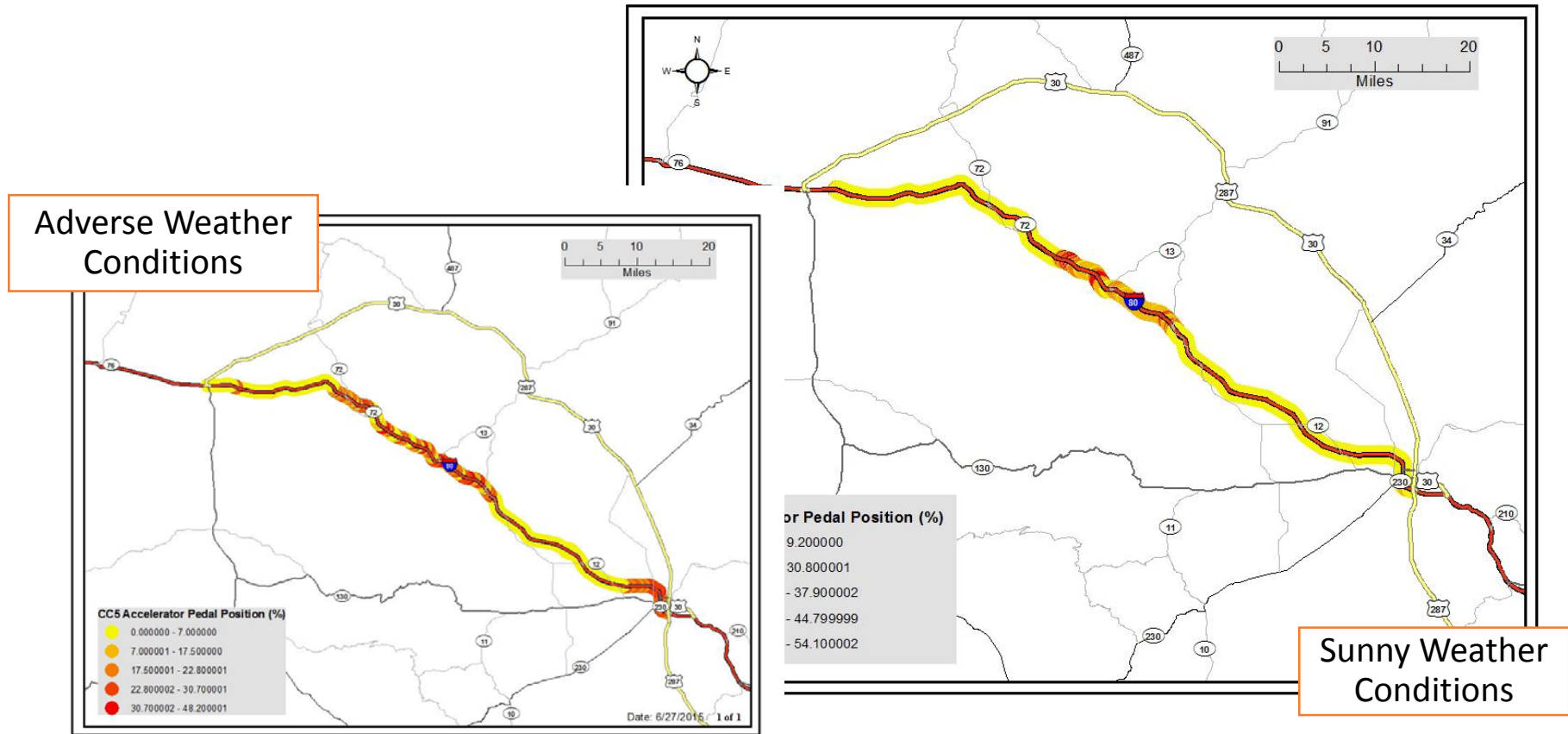


Sunny Weather Conditions

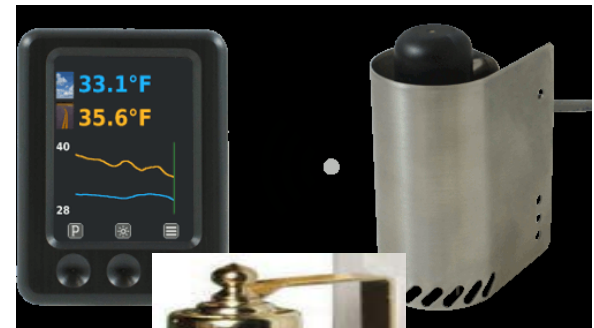
CV Road Weather Condition System



Vehicle Data Summary: Accelerator Pedal Position

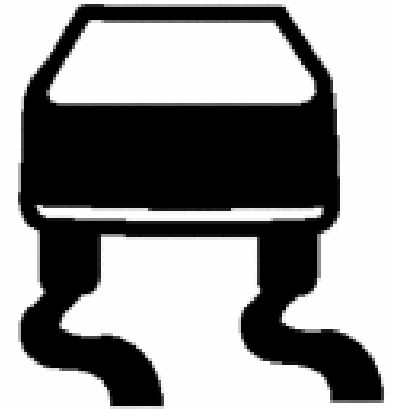


- Difficulty setting up standalone Pikalert System
- Contact with NCAR
 - Crucial vehicle data missing from data sets
 - Traction and Stability Control & ABS Activation
 - Ambient Air Temperature
 - Road Surface Temperature



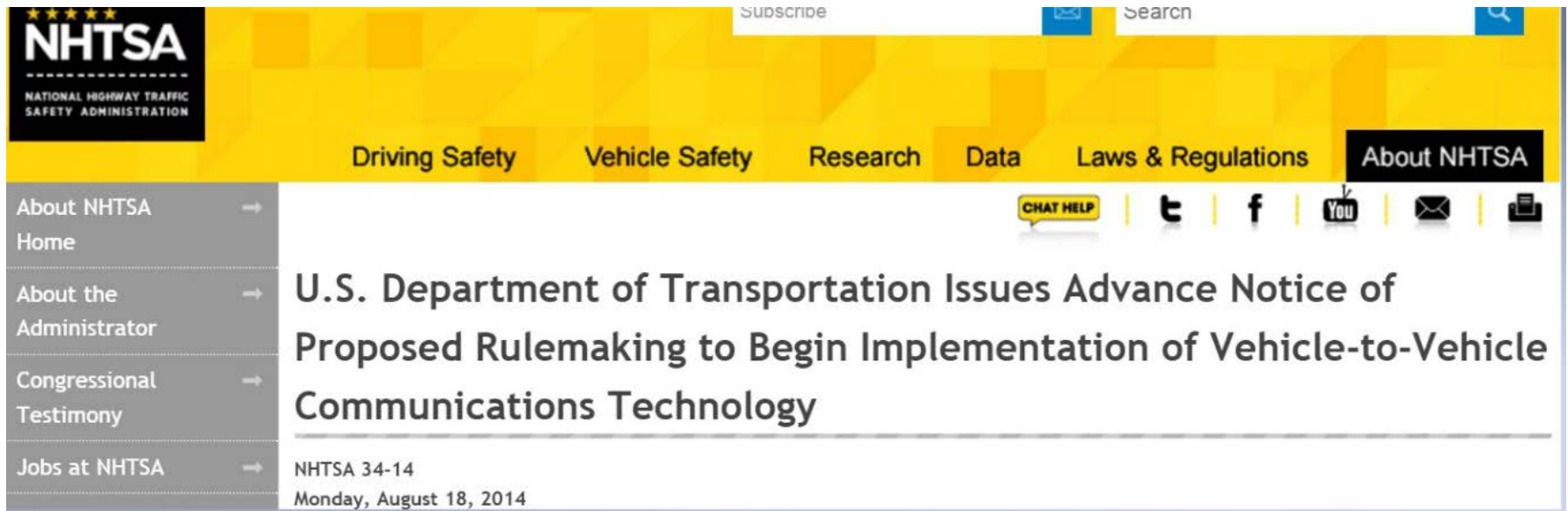
Lessons Learned

- Lack of Standardization
- Proprietary Vehicle Data Collection
 - ABS Brake and Traction Stability Control Activation



Lessons Learned

- Lack of Standardization
- Proprietary Vehicle Data Collection
 - ABS Brake and Traction Stability Control Activation



The screenshot shows the NHTSA website header with the logo and navigation menu. The main content area features a news article titled "U.S. Department of Transportation Issues Advance Notice of Proposed Rulemaking to Begin Implementation of Vehicle-to-Vehicle Communications Technology" dated Monday, August 18, 2014. The article is preceded by a "CHAT HELP" button and social media icons for Twitter, Facebook, YouTube, Email, and Print.

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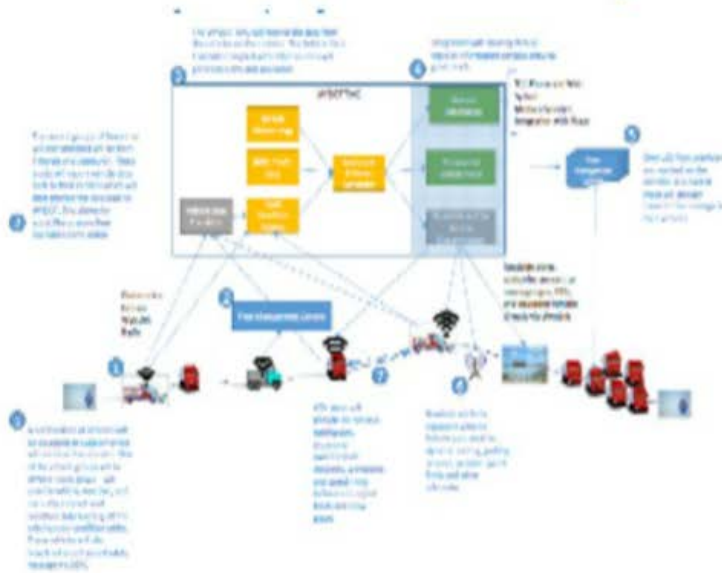
Congressional Testimony →

Jobs at NHTSA →

U.S. Department of Transportation Issues Advance Notice of Proposed Rulemaking to Begin Implementation of Vehicle-to-Vehicle Communications Technology

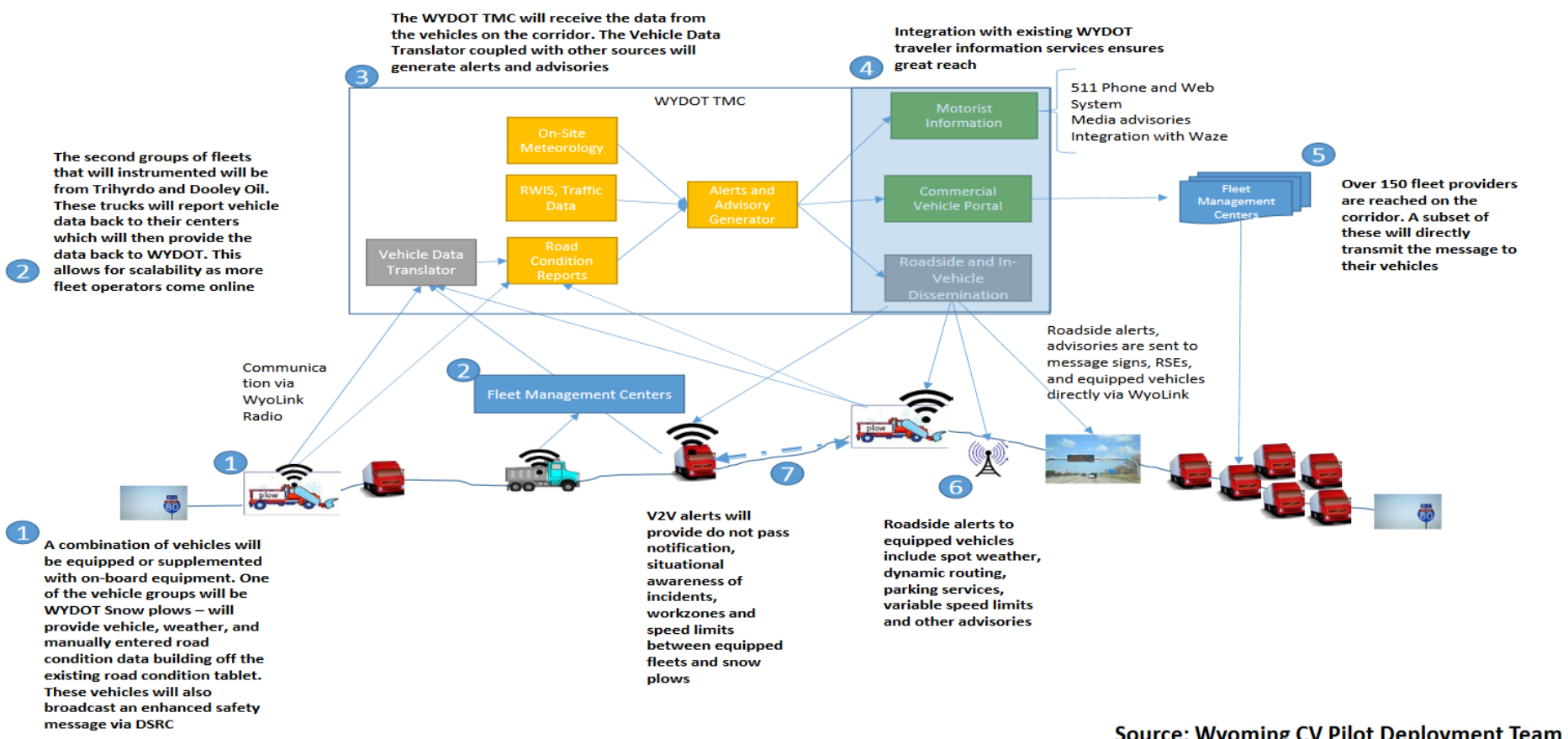
NHTSA 34-14
Monday, August 18, 2014

Wyoming DOT Connected Vehicle Pilot Deployment Program



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

Wyoming CV Pilot Deployment Program



Source: Wyoming CV Pilot Deployment Team

Wyoming CV Pilot Deployment Program



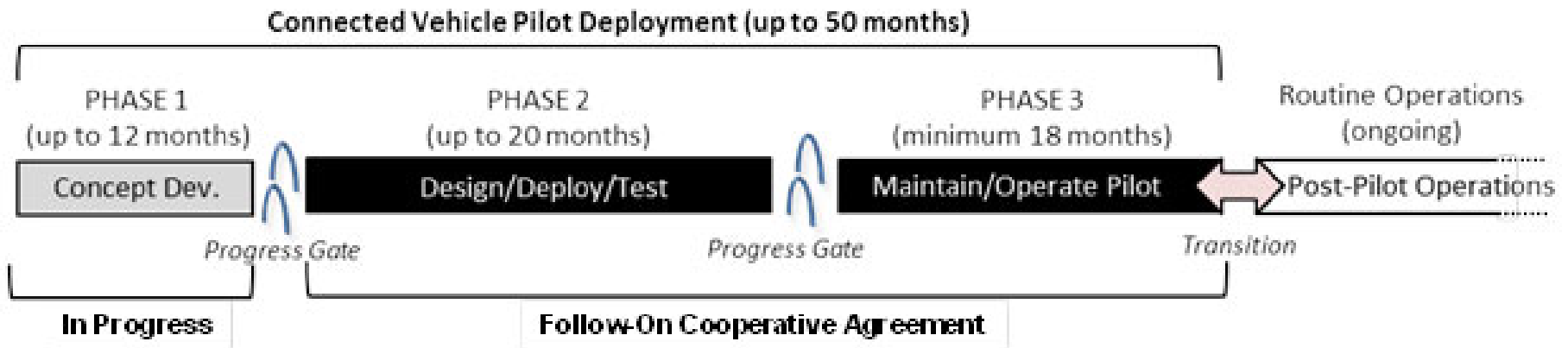
Phase I Timeline

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. Measurement									◆			
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								

Wyoming CV Pilot Deployment Program



Phase II and III



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

Future of CV and Road Weather Condition Systems

- 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 Crash on I-80 (WY)

April 20, 2015

- 59 Vehicle Crash on I-80 (WY)

