Weather, Clarus & Connected Vehicles

…the Transport of Hazardous Materials

Ray Murphy, Office of Technical Services
U.S. DOT – Federal Highway Administration

Southern States Energy Board
Joint Meeting of the Radioactive Materials Transportation Committee and the Transuranic Waste Transportation Working Group
Presentation Overview

- Context of Weather
- **Clarus**
- Connected Vehicles
Weather & Roads – Safety

Bottom Line: 24% of all crashes occur under adverse weather

1995-2008 Average Annual Fatalities

- 7,130 fatalities
- 673,000 injuries
- 1.5 million crashes

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Weather’s Wrath

**Safety**
1.57± million weather-related crashes/year
- 7,400 fatalities; 690,000 injuries
- 24% of all crashes occurred on slick pavement or under adverse weather

**Mobility:** Cost of congestion is $9.45 billion/yr for the 85 major urban areas (weather causes ~25% of non-recurrent delay on freeways)

**Productivity:** Weather-related delay adds $3.4 billion to freight costs annually
Weather & Roads – Economy & Environment

Trucking delays due to weather = $3.1 billion/yr for the 50 largest cities

Lost commerce due to snow closures = $10 billion/day

More than $2 billion/yr is spent on snow and ice control by State DOTs

Weather accounts for 25% of non-recurring congestion

Chemicals affect watersheds, air quality and infrastructure
Goal – Improve mobility and safety by alleviating the impacts of weather on the surface transportation system

“Anytime, Anywhere Road Weather Information” is the program’s mission
1. Stakeholder Coordination
2. Applied Research
   - Weather-related connected vehicle observing & forecasting
   - Weather-related connected vehicle applications
   - Weather-responsive Traffic Management
3. Technology Transfer, Training & Education
4. Performance Management & Evaluation

Anytime, Anywhere Road Weather Information
Wanting to ultimately save lives, time, and money – those are the societal benefits we all work for... So what is needed to do that?

Advanced Decision Support

Transportation Resources & System Status

Weather Forecast Models

Observing Systems

Decision Support Systems & Assessments

Management & Policy Decisions

Societal Benefits

On-going feedback to optimize value and reduce gaps
The *Clarus* Initiative

- *Clarus* is an R&D initiative to demonstrate and evaluate the value of “Anytime, Anywhere Road Weather Information” that is provided by both **public agencies and the private weather enterprise** to transportation users and operators.

- To do so, FHWA created a robust
  - data assimilation,
  - quality checking, and
  - data dissemination system

that provides near real-time atmospheric and pavement observations from the collective states’ investments in Environmental Sensor Stations (ESS).
The *Clarus* Initiative: 4 Objectives

1. Provide a North American resource to **collect**, **quality check**, and **disseminate** weather and road condition **observations**

2. Demonstrate that these observations will support **general purpose weather forecasting**

3. Demonstrate that the observations will support **real-time operational responses** to weather

4. Support the enhancement and creation of models to **improve forecasts at and near the earth’s surface**
The **Clarus System**

- A database management system for all surface transportation weather observations in North America
- One database removes borders
- Provides advanced quality checking for both surface & subsurface data
- Includes extensive metadata, permanent, transportable, and mobile stations
- Easy access via web portal & subscription

**Clarus**

A Clear Solution For Road Weather Information

Once development is completed, FHWA will transfer to NOAA for operations
Over 75% of State DOTs Participate in Clarus

Sensor & Station Count
2,435 Sensor Stations (ESS)
54,195 Individual Sensors
178 Vehicles

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Participation Status for Clarus as of April 25, 2012

Canadian Participation

Local Participation
- City of Indianapolis, IN
- McHenry County, IL
- City of Oklahoma City, OK
- Kansas Turnpike Authority
- Parks Canada

Clarus Connection Status
- Sensor & Station Count
  - 2,435 Sensor Stations (ESS)
  - 54,195 Individual Sensors
  - 178 Vehicles (mobile data)

- Connected (36 States, 5 Locals, 4 Provinces)
- Connected plus vehicles (2 states: MN, NV)
- Pending (5 States, 3 Locals, 1 Province)
- Considering (3 States, 1 Local)
## Clarus System Observations

![Map of observation points](image)

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Clarus Regional Demonstrations - Objectives

- Ensure the Clarus System works as designed
  - Demonstrate the ability of the Clarus System to process and provide data from large numbers of ESS
  - Promote/educate on metadata collection

- Foster proactive transportation system management

- Encourage improved private sector services for road weather information enabled with data from the Clarus System
Clarus Regional Demonstration

5 Use Case Scenarios

1. Enhanced Road Weather Forecasting Enabled by Clarus
2. Seasonal Weight Restriction Decision Support Tool
3. Non-winter Maintenance & Operations Decision Support Tool
4. Multi-state Control Strategy Tool
5. Enhanced Road Weather Content for Traveler Advisories

State Transportation Agency Partners

Meridian Team
Scenarios 1, 2, 5

Mixon Hill Team
Scenarios 1, 3, 4
Enhanced Road Weather Content for Traveler Advisories

Goal:

Use Clarus’ data to develop enhanced road weather information for travelers.

Methods:

• by leveraging the multi-state nature of Clarus to create a multi-state traveler information platform
• by applying Clarus’ data to develop enhanced road / weather forecasts that can alert drivers of conditions before they occur
Use Case #5
Web Portal

Enhanced Road Weather Content for Traveler Advisories

Good Driving Conditions
Fair Driving Conditions
Difficult Driving Conditions
Road Closed/Blocked
Unknown

May Change from Good to Fair Driving Conditions
May Change from Good to Difficult Driving Conditions
Sensors indicate Conditions May Vary From Observed Road Conditions

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Integrated **traveler information** - *Clarus*
System data provides decision support to track approaching weather systems.

**Data delivery** to trucking dispatch centers and transportation agency centers

**Integration** of vehicle detectors and radio frequency identification with ESS to provide value-added services to CVO services
BACKGROUND

Despite the critical role of hazardous materials in the nation’s industry and commerce and the need to ensure that hazmat transportation occurs safely and efficiently, there is very little coverage of this topic in post-secondary education curricula in the United States. What little formal instruction that does exist is focused on training shipper and transportation company operations personnel in how to conduct hazmat transport within the current regulations, and training emergency responders for incident management. Those involved in the total supply chain; transportation officials in the public sector; and other officials involved in planning, enforcement, and economic development have little or no formal education in hazmat transportation. As a result, new employees with responsibility for ensuring the safe transportation of hazmat must learn the requirements through on-the-job training. Few programs address proactive and sound management principles and strategies. And, as the current cadre in industry and government involved with hazardous materials transportation expertise reaches retirement age, there will be a knowledge gap in the workforce that must be addressed.
Hazmat transport & weather decision support...

*Clarus Data*

**pavement temperatures**, which when combined with radar could provide an indication of potentially slippery or hazardous winter conditions for transporting HAZMAT. *This could result in decisions to either reduce speed, deviation of course or to delay departure, pending better weather conditions;*

**precipitation amount**, which could provide an indication of excessive precipitation and the potential of flash flooding; *this could result in decisions to a deviation of course or to delay departure, pending better weather conditions;*

**wind direction**, which could provide an estimate of the trajectory for toxic plumes in the event of a release. If the winds are blowing toward a populated area, *this could result in decisions to change the route* so that the vehicle travels on the downwind side of a populated area;

**wind speed**, which could be used to determine if there will be excessive buffeting (high profile vehicles) which might lead to loss of control.
Next Steps… Weather & Connected Vehicles/Fleets

Obtain a thorough picture of current weather and road conditions by including mobile sources

- Higher resolution observations that spatially augment fixed sensors
- Take advantage of existing standards and on-board sensors

Improve weather-related decision support tools to mitigate safety and mobility impacts of weather

- Based on ability to better detect and forecast road weather and pavement conditions
Weather + Connected Vehicles... & Fleets

Drivers/Operators

Infrastructure

Vehicles and Fleets

Wireless Devices
The Connected Vehicle
Improving Road Weather Awareness

Real-time Data Capture and Management

- Vehicle Status Data
- Weather Data
- Truck Data
- Transit Data
- Infrastructure Status Data

Dynamic Mobility Applications

- Reduce Speed 35 MPH
- Transit Signal Priority
- Weather Application
- Real-Time Travel Info
- Fleet Management/Dynamic Route Guidance
- Signal Phase & Timing Adjusts Real-Time Conditions
- Safety Alerts and Warnings

Data Environment
## Connected Vehicle Scenarios

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<th>Scenario</th>
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<td><strong>Daily operations</strong></td>
<td>- Recurring congestion and peak ridership conditions (i.e., the baseline for activities)</td>
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<tr>
<td><strong>Major traffic incident</strong></td>
<td>Extended closures/fatalities/ major structural damage occurring on either freeway or arterials with impacts for freeway, arterial, transit, and parking management</td>
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<tr>
<td><strong>Major Evacuation</strong></td>
<td>Major evacuation of large numbers of people caused by unpredictable events (e.g., wild fire, terrorist attack)</td>
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<tr>
<td><strong>Major Weather Event</strong></td>
<td>Major weather event such as ice, snow, fog, etc. with a regional impact</td>
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<tr>
<td><strong>Special Events</strong></td>
<td>Planned major event impacting corridors and downtown area</td>
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Weather & the Connected Vehicle

Obtain a thorough picture of current weather and road conditions by including mobile sources

- Higher resolution observations that spatially augment fixed sensors
- Take advantage of existing standards and on-board sensors

Improve weather-related decision support tools to mitigate safety and mobility impacts of weather

- Based on ability to better detect, forecast and validate surface (pavement) conditions
Connected Vehicle data "Anytime, Anywhere Road Weather Data"

Barometric Pressure  
Windshield Wiper Setting  
Headlights Status  
Ambient Air Temperature

Speed and Heading  
Adaptive Cruise Control (ACC)  
Location and Elevation  
Hours of Operation

OEM sensors (e.g., air temp, wiper status, braking status)

Anti-lock Braking System (ABS)  
Brake Status  
Stability Control  
Traction Control

Yaw/Pitch/Roll  
Accelerometer  
Steering Angle  
Differential Wheel Speed
Vehicle Data Translator (VDT) Data Processing

Ancillary Data: Radar, Satellite, RWIS, etc.  *Clarus* is one of the “ancillary” data source feeding into Stage II of the process; *Clarus* and other data are used to perform quality checks on the mobile data used to make the inferences/roadway hazard assessments in Stage III.

The National Center for Atmospheric Research is sponsored by the National Science Foundation.

 parsed mobile data

 Qched data, Basic road segment data

 Advanced road segment data

 Apps
Vehicle Data Translator (VDT) - Objectives

- Develop the Connected Vehicles’ role in “Anytime, Anywhere Road Weather Information”

- Exploit any and all vehicle-based data
  - OEM sensors (e.g., air temp, wiper status, braking status)
  - After market sensors (e.g., pavement temp, plow status)

- Combine data from vehicles & fleets with fixed sources (*Clarus*)

- Development of inferred road segment specific weather and road-weather information for end-user applications
Minnesota mobile data displayed in the Clarus System

![Map with data](image)

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Integrated Mobile Observing & Dynamic Decision Support

- State DOT & Private Vehicle Data
- VDT (NCAR)
- Connected Vehicle Data Capture
- Clarus

Other Connected Vehicle Applications
What Can You Do With VDT-based Data?

There are any number of road weather dynamic applications that could use vehicle-based observations:

- **Transportation-specific applications**
- **Broad Weather & Transportation applications**
Transportation-specific Applications

VDT-based weather alerts:
- Impending weather hazards
- Alerts from other vehicles
- Re-routing

* Simulated screen, designed to not distract the driver
Broad Transportation Applications

VDT-based data

Route Specific Impact Warnings for...

School Buses

Truckers

EMS
Weather-related Applications

Numerical Weather Modeling

Traffic Modeling and Alerting

Weather Modeling – complex terrain

Other surface transportation users
Solutions to help save lives, time & money

Road Weather Decision Support

- Transportation Resources & System Status
- Weather Forecast Models
- Observing Systems
- Decision Support Systems & Assessments
- Societal Benefits

On-going feedback to optimize value and reduce gaps
Thank you!

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Office of Technical Services
ray.murphy@dot.gov, 708-283-3517

FHWA Road Weather Management Program
www.ops.fhwa.dot.gov/weather