Road Weather Management and the Connected Vehicle

Paul Pisano, FHWA
Gabe Guevara, FHWA
Mike Chapman, National Center for Atmospheric Research

July 27, 2011
Overview of Webinar

- **Purpose**
  - Provide an update on USDOT efforts to build the link between the Connected Vehicle and Road Weather Management

- **Agenda**
  - Introduction to Road Weather Management and how it relates to connected vehicles
    - *Paul Pisano, FHWA*
  
  - "Integrating Mobile Observations" project overview
    - *Gabriel Guevara, FHWA*
  
  - The Vehicle Data Translator and related applications
    - *Michael Chapman, National Center for Atmospheric Research*
  
  - Discussion
Weather & Roads – Safety

1995-2008 Average Annual Fatalities

- 7,130 fatalities ↓ 270k from 95-05 11-yr avg
- 673,000 injuries ↓ 44k from 11-yr avg
- 1.5 million crashes ↓ 100k from 11-year avg

Bottom Line: 24% of all crashes occur under adverse wx
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
Road Weather Management

**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
- This includes current and predicted information about weather’s affect on roads…
- … and the decision support tools to aid road users and operators to make effective decisions, e.g.,
  - When to pre-treat roads for snow & ice control
  - When to post traveler advisories (fog, floods, rain, snow, etc.)
Achieving the Program’s Goal

Traffic Data & Transportation System Status

Weather Forecast Models

Weather Observing Systems

Decision Support Systems & Assessments

Societal Benefits

People & Policies
Weather Tailored for Winter Maintenance
The **Clarus System** – fixed sensors

Over 75% of State DOTs (c.95% of the Nation’s sensors)
The **Clarus System** – fixed sensors

Over 75% of State DOTs (c.95% of the Nation’s sensors)
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Program Vision

To research and facilitate a national, **multimodal surface transportation system** that features a connected transportation environment around **vehicles of all types**, the infrastructure, and portable devices to serve the public good by leveraging technology to maximize safety, mobility, and environmental performance.

Plan developed with full participation by all surface transportation modal administrations as well as with significant interaction with multi-modal stakeholders.
Connected Vehicles & Road Weather

Real-time Data Capture and Management

- Vehicle Status Data
  - ...65 mph...
  - ...brakes on...
  - ...two passengers...
- Weather Data
- Truck Data
- Transit Data
- Infrastructure Status Data

Data Environment

Dynamic Mobility Applications

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

- Identify and explore a range of mobile platforms as a source of robust data
- Develop algorithms and processing capabilities to translate the mobile data into useable weather and road condition observations
  - Is the probe data of sufficient quality?
  - What are the minimum # of samples and minimum sampling period per road segment to get valid obs?
  - What QC algorithms are needed?
  - What are the best ways to package/disseminate the obs?
- Incorporate these observations into effective mgmt. systems and decision support tools (e.g., MDSS, weather-responsive traffic management strategies)
  - What is gained by utilizing mobile observations?
  - What are the resultant data and communications requirements?
Weather-related Observations

- Barometric Pressure
- Windshield Wiper Setting
- Headlights Status
- Ambient Air Temperature
- Speed and Heading
- Adaptive Cruise Control (ACC)
- Location and Elevation
- Hours of Operation
- Anti-lock Braking System (ABS)
- Brake Status
- Stability Control
- Traction Control
- Yaw/Pitch/Roll
- Accelerometer
- Steering Angle
- Differential Wheel Speed
Work Completed to Date

- Noblis conducted two analyses along the Dulles Toll Road (2006)
  - Exploratory look at mobile observing

- National Center for Atmospheric Research (NCAR) was tasked to develop the Vehicle Data Translator (VDT)
  - Feasibility study (2007)
  - VDT Ver1.0 completed in July, 2009
  - VDT Ver2.0 completed in July, 2010
  - VDT Ver3.0 development underway

- Development Test Environment in Detroit
  - Source of most of the probe data for the VDT development
  - New work will use data from State DOTs, NCAR
Stakeholder Coordination

- Next Road Weather Management Stakeholder Coordination Meeting:
  - September 7-9
  - Albuquerque, NM
- Let me know if you want to be added to our contact list
FHWA Road Weather Mgmt. Team

Paul Pisano, Team Leader
FHWA Office of Operations
202-366-1301

Roemer Alfelor
FHWA Office of Operations
202-366-9242

Gabriel Guevara
FHWA Office of Operations
202-366-0754

Dale Thompson
USDOT RITA, JPO
202-366-4876

C.Y. David Yang
FHWA Off. of Operations R&D
202-493-3284

Ray Murphy
FHWA Resource Center (IL)
708-283-3517
IMO Project Overview – Gabe Guevara

- Background on the Integrating Mobile Observations (IMO) Project
- Partnering States
- Current Status
Vehicle-based Probe Data

- Speed and Heading
- Adaptive Cruise Control
- Location & Elevation
- Hours of Operation
- Sun/Rain Sensor
- Windshield Wiper Setting
- Headlight Status
- Ambient Air Temperature
- Anti-lock Braking System (ABS)
- Brake Status
- Stability Control
- Traction Control
VDT Data Processing - Overview

Stage I:
- Mobile data ingesters
- QC Module
- Output data handler

Parsed mobile data

Stage II:
- Ancillary data ingesters
- QC Module
- Output data handler
- Segment module

Basic road segment data

Stage III:
- Inference Module
- QC Module
- Output data handler

Advanced road segment data

Apps and Other Data Environments

Ancillary: Radar, Satellite, RWIS, Etc.
Invitation for Partnership with States

- NCAR requested expressions of interest last fall (2010)
  - Scope of Work
  - Funding assistance / Grant
- Pooled Funds and Consortia were targeted: Aurora, Connected Vehicles, Clear Roads, MDSS
- A handful of states expressed interest:
  - Idaho
  - Minnesota
  - Nevada
  - South Dakota
Partnership with States…

- Selection based on:
  - Fleet
  - Maturity of the maintenance ITS program
  - Integration of mobile obs into state’s application – MMS, MDSS, MODSS, TIS,…
  - Other factors/synergies (multi-state, corridor, etc.)
  - Willingness to make data and lessons learned widely available /open source
Selected States

- Minnesota
- Nevada
Minnesota...

- Why
  - Mature AVL/MDSS program
  - Relatively new fleet
  - Strong upper management support
  - Strong workplan
    - Significant # of vehicles fitted for the test
    - Proposed integration with MDSS, MMS, TIS
    - Ability to collect desired data parameters (from CAN-Bus and add-on sensors)
Minnesota....

Project Team:

Champion: Steve Lund
Project Manager: Curt Pape
Consultant: Ameritrak, LLC
NCAR: Dr. Sheldon Drobot & Mike Chapman, Brice Lambi
FHWA: Paul Pisano & Gabe Guevara
Project Status / Details

- Ameritrak is the AVL provider; has already developed and tested the prototype system:
  - Mounting brackets
  - Wiring harnesses
  - Mobile Computing Device
    - AVL/GPS
    - CAN-Bus Interface
    - Interface with external sensors, etc…
  - MN uses Cellular as its communication platform
- By October, 2011: 140-160 Snowplow vehicles collecting and sending data to:
  - NCAR
  - Clarus
  - Prototype Data Environment - DCM
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<td>Adaptive cruise control</td>
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<td>Blue =&gt; External Sensor</td>
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The AT500 in-vehicle transponder hardware and software has been modified to accept data from many different in-vehicle sources.
AT500 Transponder

Front view

10-1/4” x 7-1/2” x 2”
Prototype mechanical packages being worked on for the new MaxxForce trucks.
The AT500 prototype mount for the 2010 International MaxxForce trucks. Our project will include these 40 new MaxxForce vehicles.
The Mobile Data Terminal (MDT) will feature a custom dash mount for the new MaxxForce trucks.
AT500 MDT
Main Screen

Road N/A
Air N/A

Maps & Forecast
Skype

Connection GPS Time
5:19 PM

Road Conditions
Weather Conditions
Lane Position

Compacted Snow
Drizzle
CenterLine
AT500 MDT
Road Conditions Input

Road Conditions:
- Dry
- Wet
- Slush
- Frost
- Snow
- Blowing Snow
- Compacted Snow
- Ice

5:19 PM
Connection GPS Time
Road 70
Air 70
Maps & Forecast

Done
### AT500 MDT

**Maps: Meridian Forecast**

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Nevada

- Why
  - Actively pursuing an AVL/MDSS program
  - Fleet adds variety to the study (different manufacturer)
  - Strong upper management support
  - Strong proposal
    - Potential corridor-wide participation (I-80 corridor)
    - Strong partnership with academia (Univ. Nevada-Reno)
    - Proposed integration with MDSS, MMS, TIS
    - Ability to collect desired data parameters (from CAN-Bus and add-on sensors)
Nevada

- **Project Team**
  - Champion: Rick Nelson
  - Project Manager: Denise Inda
  - Consultant: University of Nevada Reno
    - Dr. Jeff LaCombe
    - Dr. Eric Wang
  - NCAR: Dr. Sheldon Drobot & Mike Chapman, Brice Lambi
  - FHWA: Paul Pisano & Gabe Guevara
Data Being Gathered
NV IMO Project (UNR/NDOT)

- General Data
  - GPS Date, time, location, bearing, speed, altitude, accuracy
- Road Conditions
  - Road surface temperature
  - Vehicle accelerations (surface friction)
  - Road condition images (camera)
- Atmospheric Conditions
  - Pressure, temperature, relative humidity, dew point
  - Wind speed and direction
- Vehicle & Equipment Data
  - Speed, brake status, engine intake air temperature & pressure
  - Spreader and plow status
  - Steering, traction control, ABS, yaw, accelerations, emissions data, engine data, headlight and wiper status

Blue denotes parameter being implemented
Gray denotes parameter “under study”
Two Vehicle Types
Based in NV Districts 2 & 3 Along I-80 Corridor

- Vehicles with winter assignments along I-80 were selected.
- Makes & models are presently limited to vehicles with compatible CANBus or OBDII vehicle data formats.
Various Weather & MDSS Data Parameters

• Numerous sensors and devices are controlled or monitored by a vehicle-mounted computer.

• Data is logged in-vehicle as well as sent via radio to UNR in near-real-time using the NDOT EDACS radio network.

• All instrument and equipment installations are being done by UNR & NDOT teams who are familiar with the vehicles (NDOT) and instrumentation (UNR).
What is next...

- This project will be completed April 2012
  Interim update will be given at the Road Weather Management Stakeholder Meeting in September

- Further refinements to the VDT

- Follow-on work with these or other states

- Refinement of Standards and communication protocols

- Work with the OEM’s to be able to access the metadata for the parameter ID’s

- Continue to cooperate with the Connected-Vehicle efforts, i.e., feed data into Clarus, the Research Development Environment, and collaborate with appropriate Dynamic Mobility efforts.
Weather Observations from Connected Vehicles

Michael Chapman
National Center for Atmospheric Research
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Boulder, Colorado
Weather Observations from Connected Vehicles
Weather Observations from Connected Vehicles

Barometric Pressure
Windshield Wiper Setting
Headlights Status
Ambient Air Temperature

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

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

Yaw/Pitch/Roll
Accelerometer
Steering Angle
Differential Wheel Speed
Objectives

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

- Better Characterization of current weather and road-weather conditions

- Accurate Quality Checking and/or Quality Control of vehicle data

- Development of inferred road segment specific weather and road-weather information for end-user applications
Vehicle Data Translator (VDT) - Version 3.0

Ancillary: Radar, Satellite, RWIS, Etc.

Stage I
- Mobile data ingesters
- QC Module
- Output data handler

Stage II
- Ancillary data ingesters
- QC Module
- Output data handler
- Segment module

Stage III
- Inference Module
- QC Module
- Output data handler

Parsed mobile data
Basic road segment data
Advanced road segment data

Apps and Other Data Environments
Vehicle Data Translator (VDT) - Version 3.0

Ancillary: Radar, Satellite, RWIS, Etc.

Stage I
- Mobile data ingesters
- QC Module
- Output data handler

Stage II
- Ancillary data ingesters
- QC Module
- Output data handler

Stage III
- Inference Module
- QC Module
- Output data handler

Parsed mobile data
Basic road segment data
Advanced road segment data

Apps and Other Data Environments
Vehicle Data Translator (VDT) - Version 3.0

- Ingest vehicle data from CANBus & aftermarket sensors
- Data parsed, sorted/binned
- Sorted by time, road segment and grid cell
  - Segments & grids user defined
- All processed data available for other applications
Vehicle Data Translator (VDT) - Version 3.0

Ancillary: Radar, Satellite, RWIS, Etc.

Stage I
- Mobile data ingesters
- QC Module
- Output data handler

Stage II
- Ancillary data ingesters
- QC Module
- Output data handler

Stage III
- Inference Module
- QC Module
- Output data handler

Parsed mobile data
Basic road segment data
Advanced road segment data

Apps and Other Data Environments
Vehicle Data Translator (VDT) - Version 3.0

- Ingest ancillary data for QC and Stage III
- Quality Checks
  - From Clarus: Sensor Range, Spatial, Climate Range
  - New Mobile Data Tests: Data Filtering (tunnel, slow speeds), Model Analysis, Neighboring Vehicle, Combined Algorithm
- Combines point data into basic road segment products
  - Temp range, speed, etc
Vehicle Data Translator (VDT) - Version 3.0

Ancillary: Radar, Satellite, RWIS, Etc.

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Stage II
- Ancillary data ingesters
- QC Module
- Output data handler

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Parsed mobile data
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Apps and Other Data Environments
Vehicle Data Translator (VDT) - Version 3.0

- **Precipitation Type and Intensity**: combines basic vehicle (e.g. wiper, temp), weather radar and satellite data
- **Visibility**: combines basic vehicle (e.g. headlight, wiper, temp), satellite and fixed weather station data
- **Pavement Condition**: combines more vehicle (e.g. ABS, traction, etc), weather radar and satellite data
Applications - IMO Project

End of Shift Reports – MnDOT
- Material Management
- Efficiency

Observation assimilation
- Accurate pavement temperature modeling
- Fill in the gaps between fixed stations

MDSS
- Where are the roads slick?
- Real-time pavement temperatures

VDT 3.0 Development
- Algorithm tuning and development
- Quality Checking refinement
APPLICATIONS

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

Not just for the everyday driver!
Winter Maintenance – Where are we losing the road?
APPLICATIONS

Winter Maintenance – Where are we losing the road?

Route Specific Warnings for…
APPLICATIONS

Winter Maintenance – Where are we losing the road?

Route Specific Impact Warnings for…

School Buses
APPLICATIONS

Winter Maintenance – Where are we losing the road?

Route Specific Impact Warnings for...

School Buses

Truckers
APPLICATIONS

Winter Maintenance – Where are we losing the road?

Route Specific Impact Warnings for...

- School Buses
- Truckers
- EMS
More APPLICATIONS

Numerical Weather Modeling
More APPLICATIONS

Numerical Weather Modeling

Traffic Modeling and Alerting
More APPLICATIONS

Numerical Weather Modeling

Traffic Modeling and Alerting

Weather Modeling – complex terrain
More APPLICATIONS

Numerical Weather Modeling

Traffic Modeling and Alerting

Weather Modeling – complex terrain

Other surface transportation users