Weather, Clarus & Connected Vehicles

…the Transport of Hazardous Materials





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

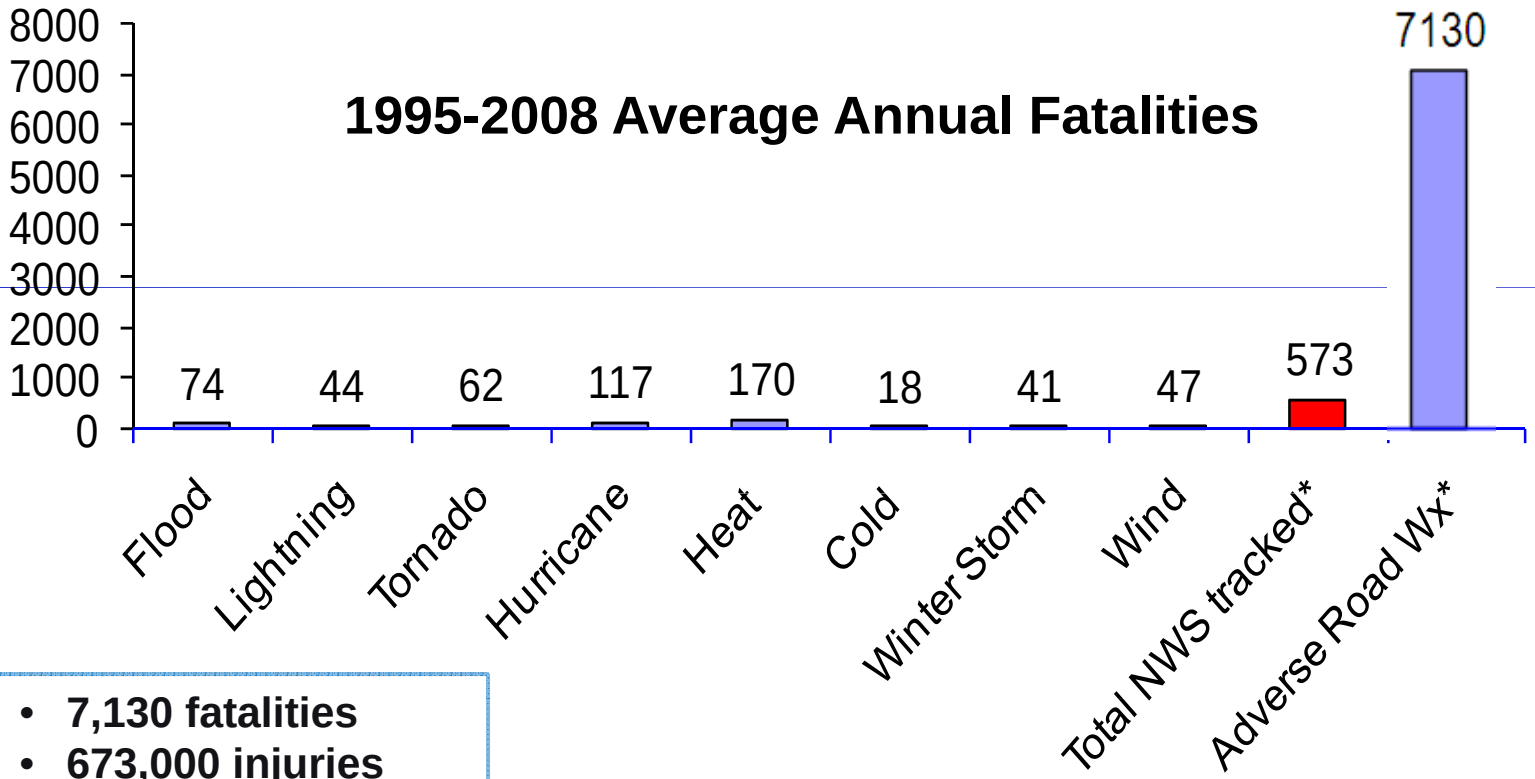
Southern States Energy Board
Joint Meeting of the Radioactive Materials Transportation Committee and the Transuranic Waste Transportation Working Group

Presentation Overview

- Context of Weather
- *Clarus*
- Connected Vehicles

Weather & Roads – Safety

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



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

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 = $3.1billion/yr for the 50 largest cities

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

More than $2billion/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

FHWA Road Weather Management Program

Goal – Improve mobility and safety by alleviating the impacts of weather on the surface transportation system

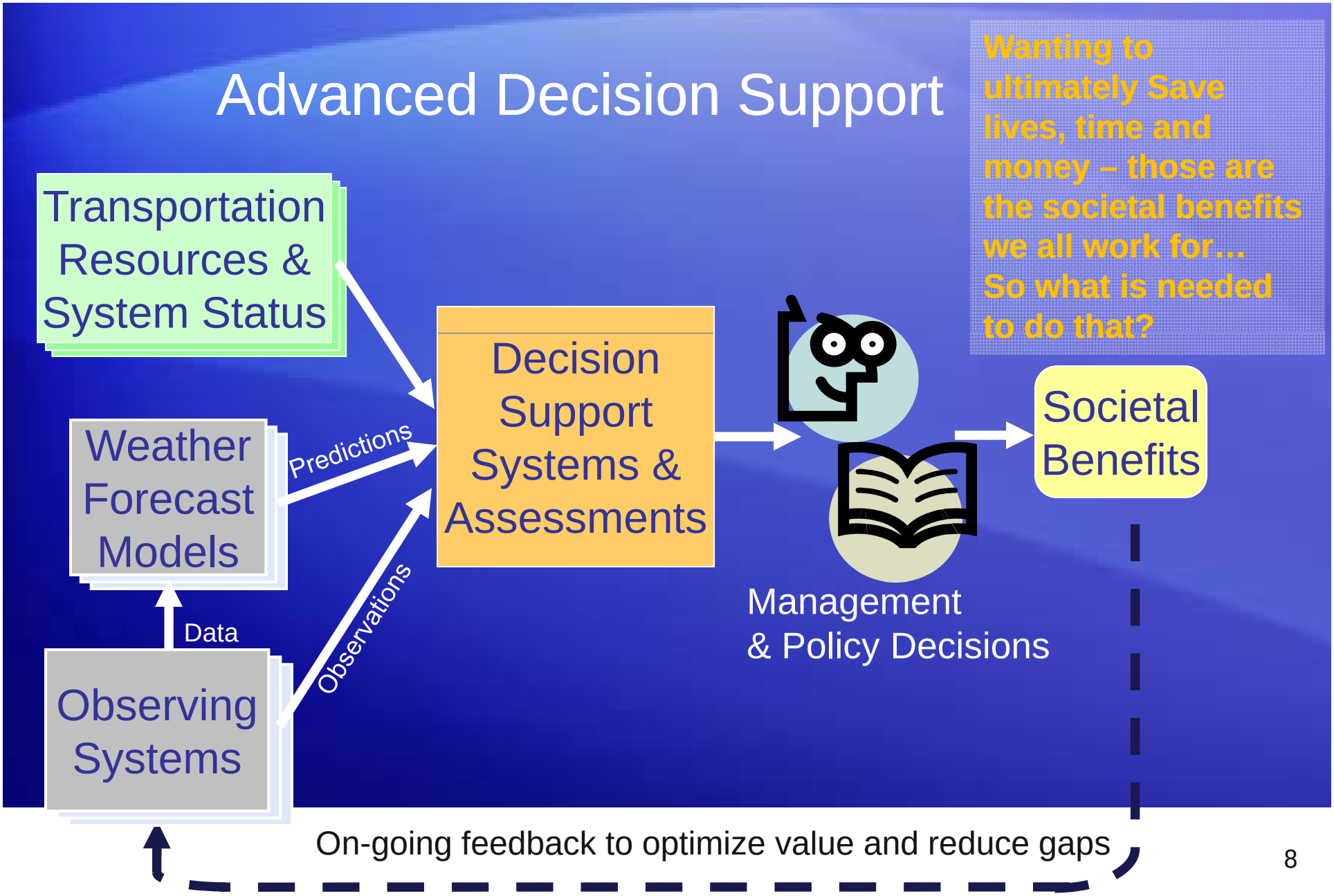
"Anytime, Anywhere Road Weather Information" is the program's mission

FHWA Road Weather Management Program

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

Getting From Problems to Solutions



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

www.*clarus*-system.com

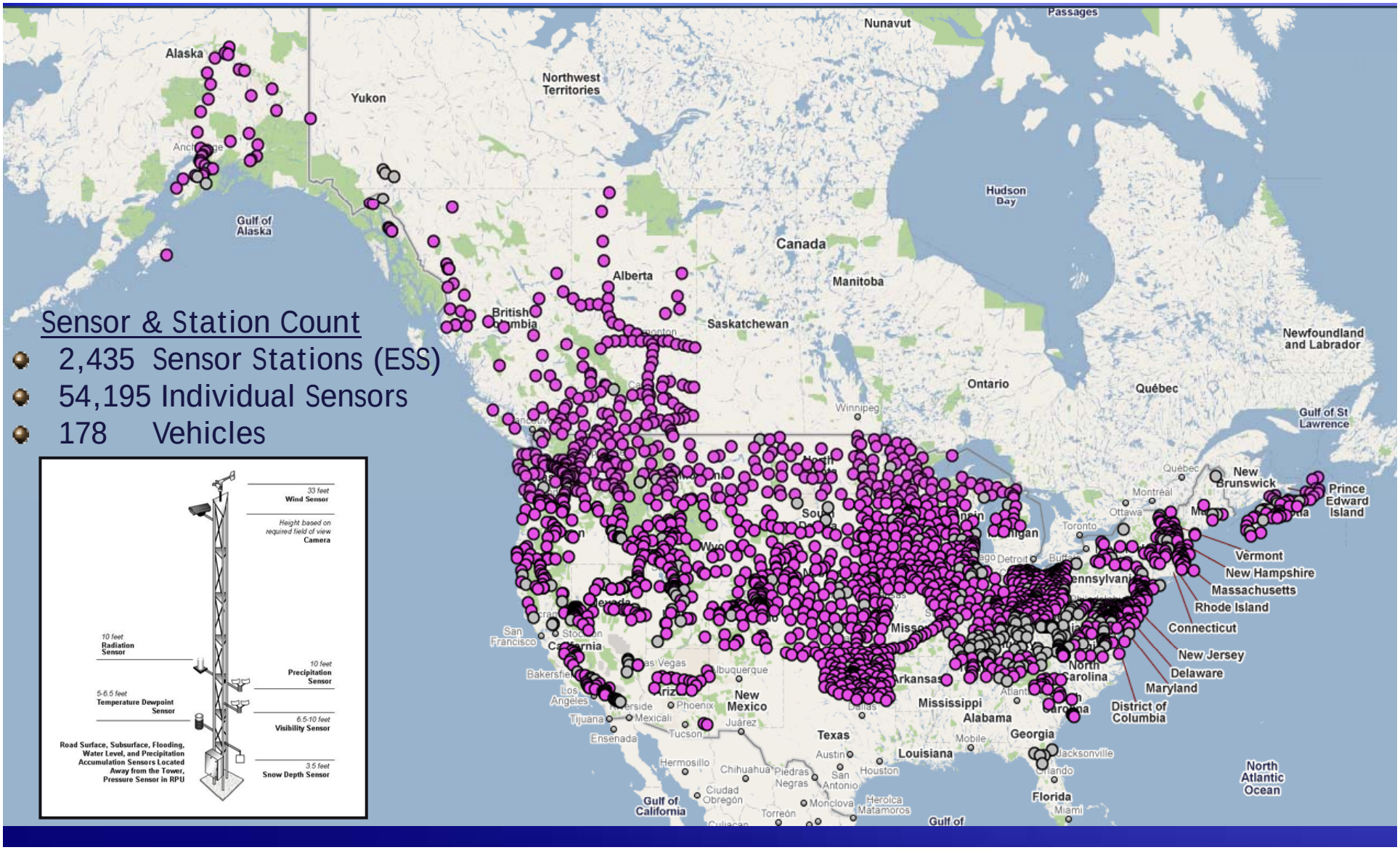
- ✓ A database management system for all surface transportation weather observations in North America
- ✓ One database removes borders
- ✓ Provides advanced quality checking for both surface & subsurface data
- ✓ Includes extensive metadata, permanent, transportable, and mobile stations
- ✓ Easy access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

Clarus

A Clear Solution For Road Weather Information

Once development is completed, FHWA will transfer to NOAA for operations

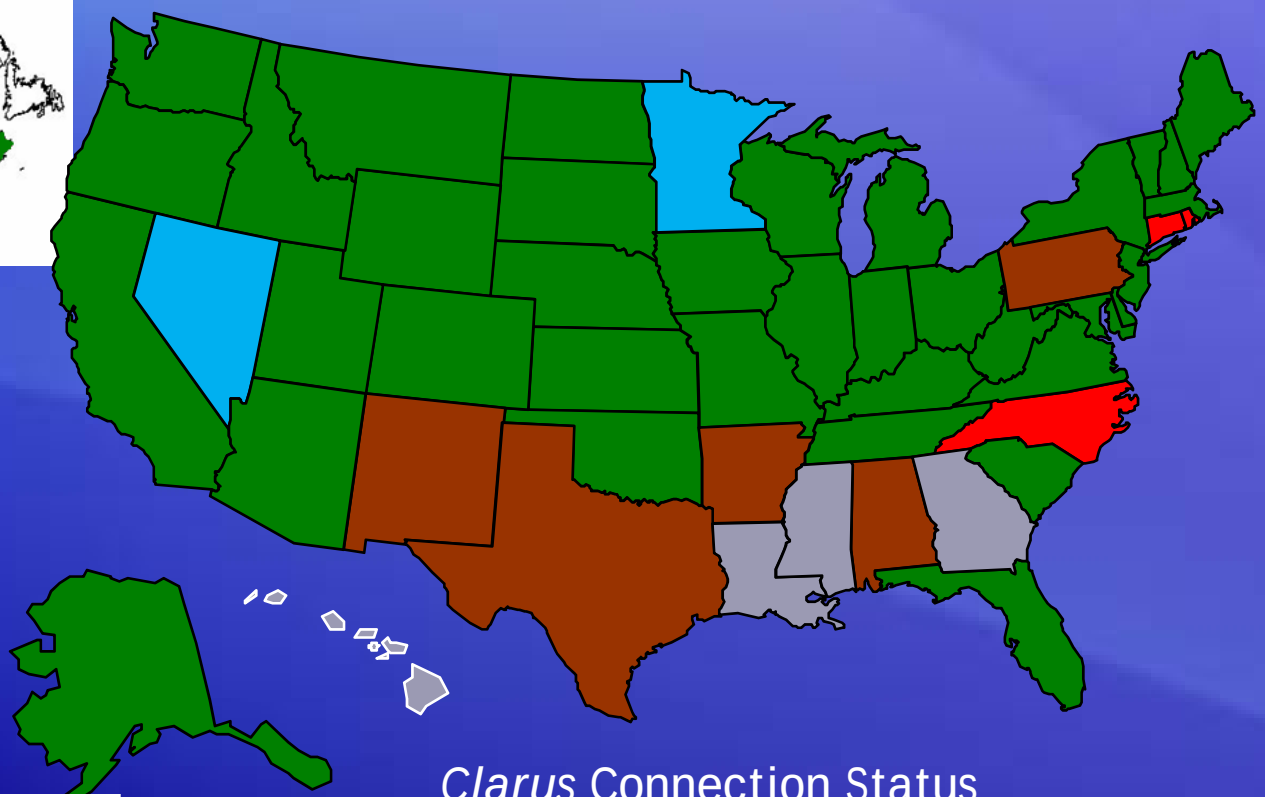
Over 75% of State DOTs Participate in *Clarus*







Participation Status for *Clarus* as of April 25, 2012



Local Participation

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

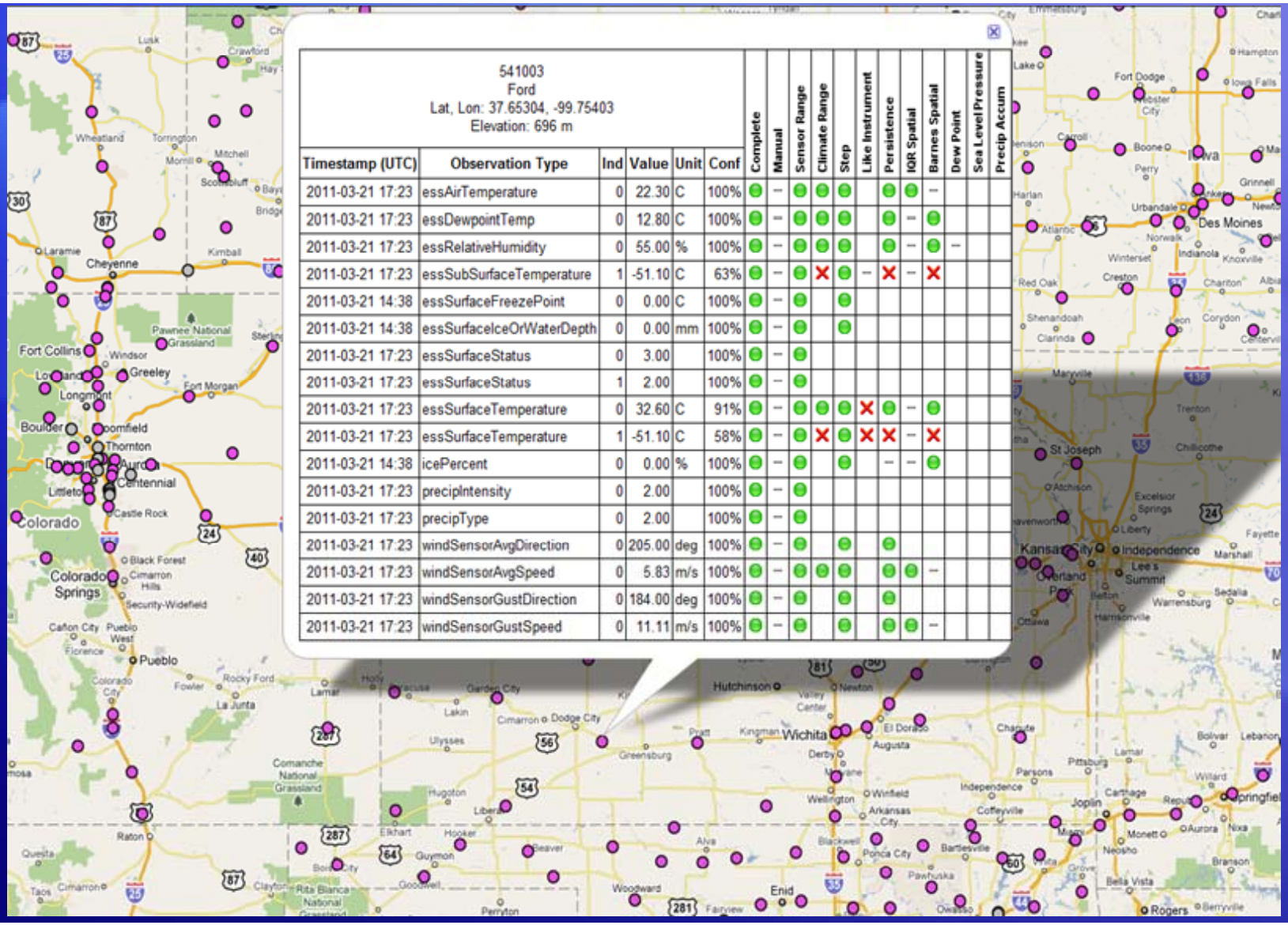
Sensor & Station Count

- 2,435 Sensor Stations (ESS)
- 54,195 Individual Sensors
- 178 Vehicles (mobile data)

Clarus Connection Status

- 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



541003
Ford
Lat, Lon: 37.65304, -99.75403
Elevation: 696 m

Timestamp (UTC)	Observation Type	Ind	Value	Unit	Conf	Complete	Manual	Sensor Range	Climate Range	Step	Like Instrument	Persistence	IQR Spatial	Barnes Spatial	Dew Point	Sea Level Pressure	Precip Accum
2011-03-21 17:23	essAirTemperature	0	22.30	C	100%	●	–	●	●	●		●	●	–			
2011-03-21 17:23	essDewpointTemp	0	12.80	C	100%	●	–	●	●	●		●	–	●			
2011-03-21 17:23	essRelativeHumidity	0	55.00	%	100%	●	–	●	●	●		●	–	●	–		
2011-03-21 17:23	essSubSurfaceTemperature	1	-51.10	C	63%	●	–	●	✕	●	–	✕	–	✕			
2011-03-21 14:38	essSurfaceFreezePoint	0	0.00	C	100%	●	–	●		●							
2011-03-21 14:38	essSurfaceIceOrWaterDepth	0	0.00	mm	100%	●	–	●		●							
2011-03-21 17:23	essSurfaceStatus	0	3.00		100%	●	–	●									
2011-03-21 17:23	essSurfaceStatus	1	2.00		100%	●	–	●									
2011-03-21 17:23	essSurfaceTemperature	0	32.60	C	91%	●	–	●	●	●	✕	●	–	●			
2011-03-21 17:23	essSurfaceTemperature	1	-51.10	C	58%	●	–	●	✕	●	✕	✕	–	✕			
2011-03-21 14:38	icePercent	0	0.00	%	100%	●	–	●		●		–	–	●			
2011-03-21 17:23	precipIntensity	0	2.00		100%	●	–	●									
2011-03-21 17:23	precipType	0	2.00		100%	●	–	●									
2011-03-21 17:23	windSensorAvgDirection	0	205.00	deg	100%	●	–	●		●		●					
2011-03-21 17:23	windSensorAvgSpeed	0	5.83	m/s	100%	●	–	●	●	●		●	●	–			
2011-03-21 17:23	windSensorGustDirection	0	184.00	deg	100%	●	–	●		●		●					
2011-03-21 17:23	windSensorGustSpeed	0	11.11	m/s	100%	●	–	●		●		●	●	–			

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

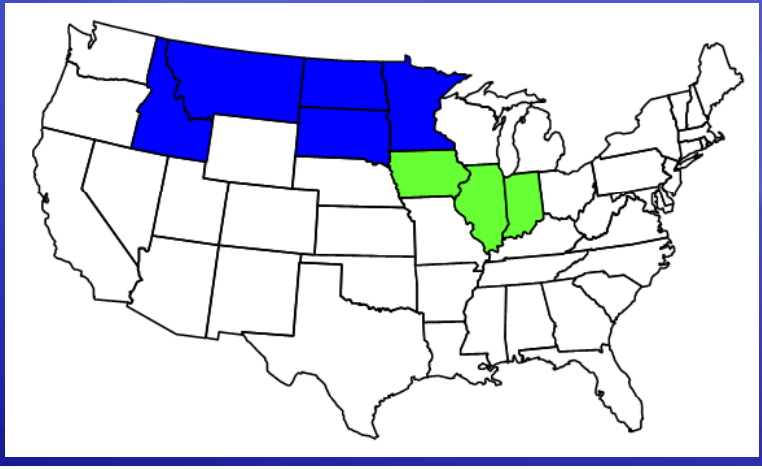
5 Use Case Scenarios

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

Meridian Team
Scenarios 1, 2, 5

Mixon Hill Team
Scenarios 1, 3, 4

State Transportation Agency Partners



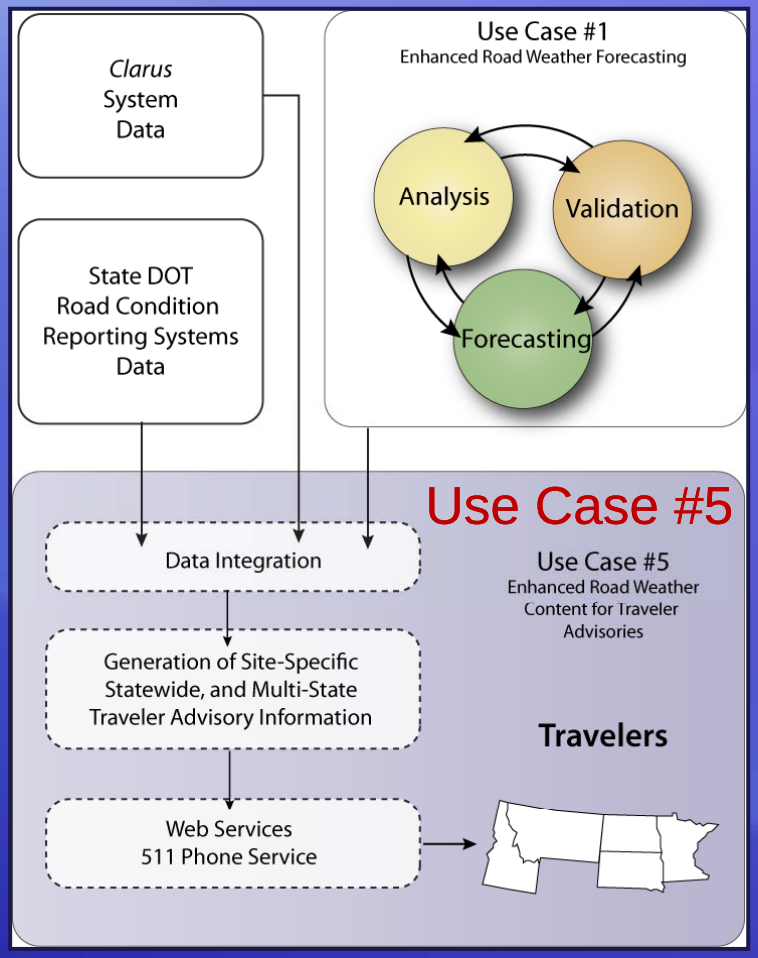
Enhanced Road Weather Content for Traveler Advisories

Goal:

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

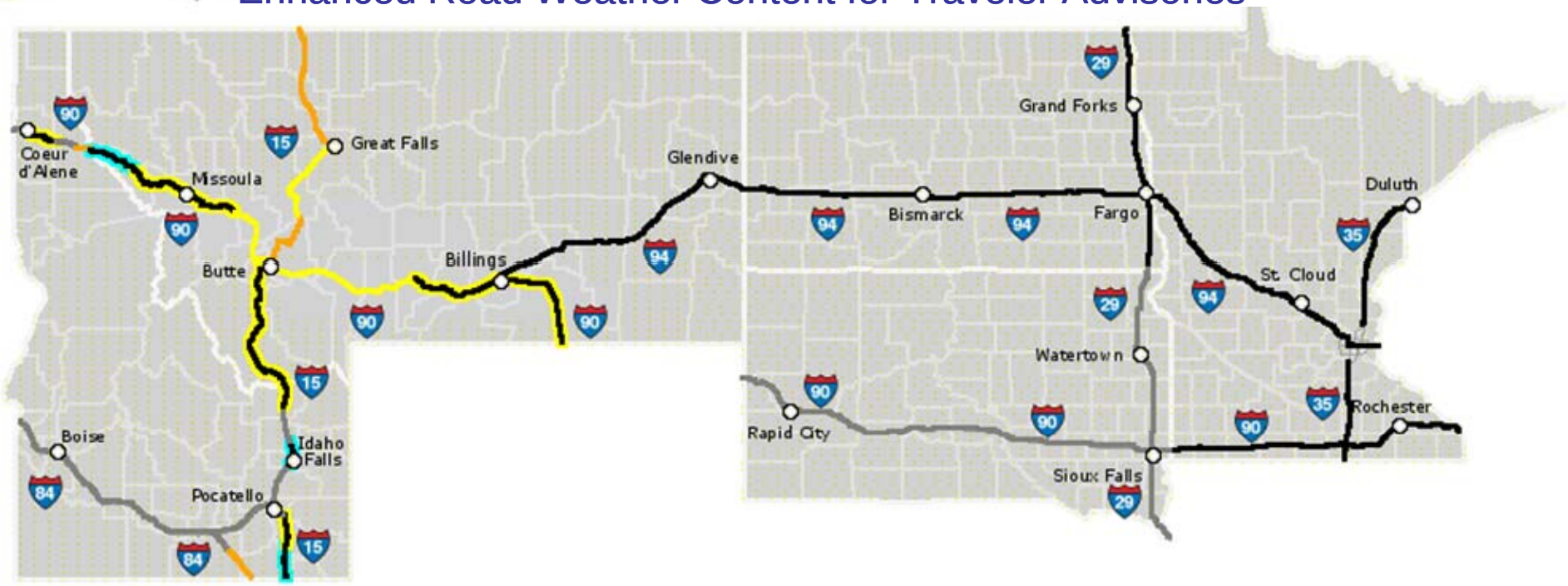
Methods:

- 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



Observed Road Conditions

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

Analysis Suggests Road Conditions

- 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

Clarus & Transportation Decision Support

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

Clarus

A Clear Solution For Road Weather Information

TRB TRANSPORTATION RESEARCH BOARD OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

HMCRP HM-16 [Active] http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3140

Model Post-Secondary Education Curricula for the Transportation of Hazardous Materials

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

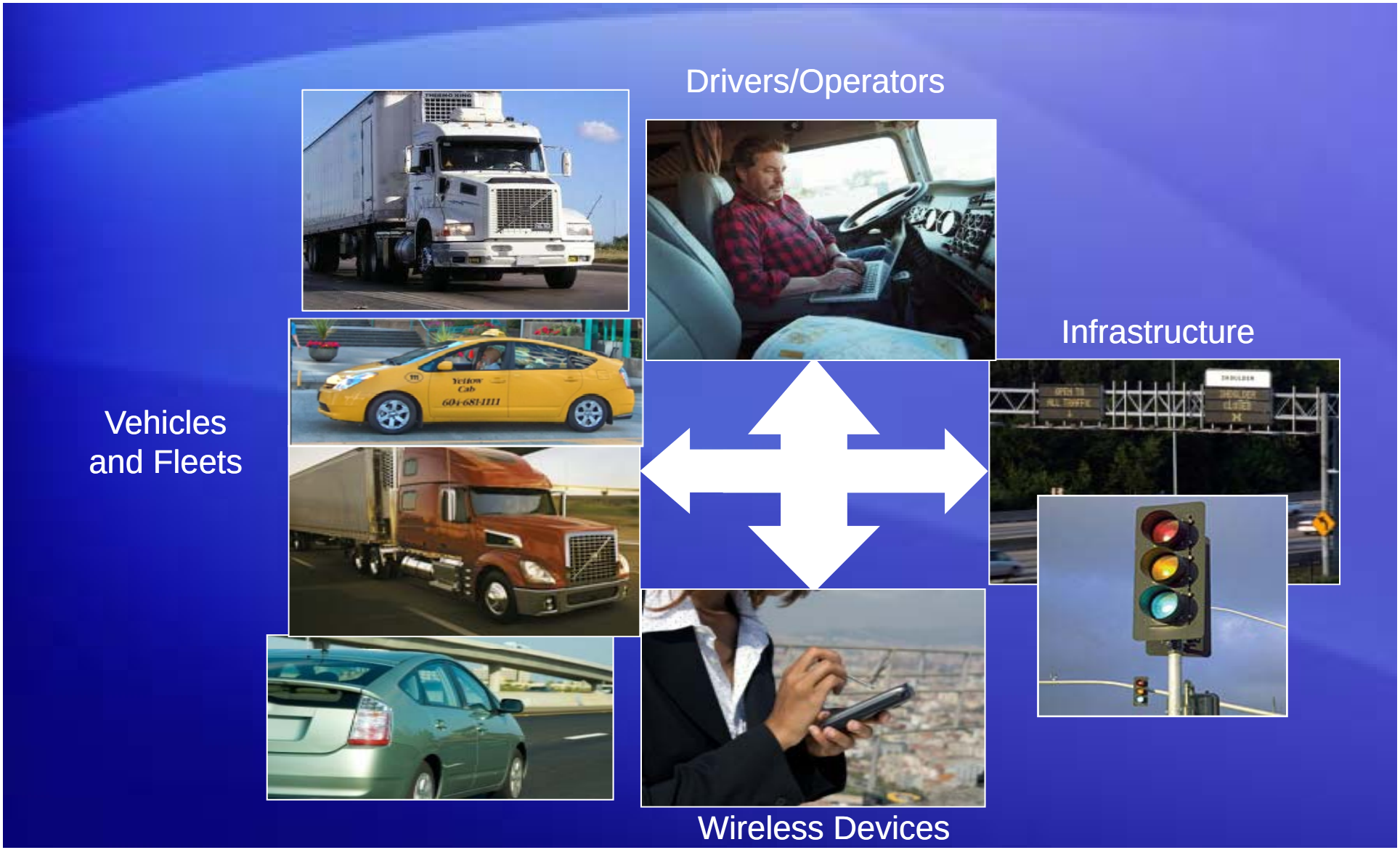
Obtain a thorough picture of current weather and road conditions by including mobile sources

- 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

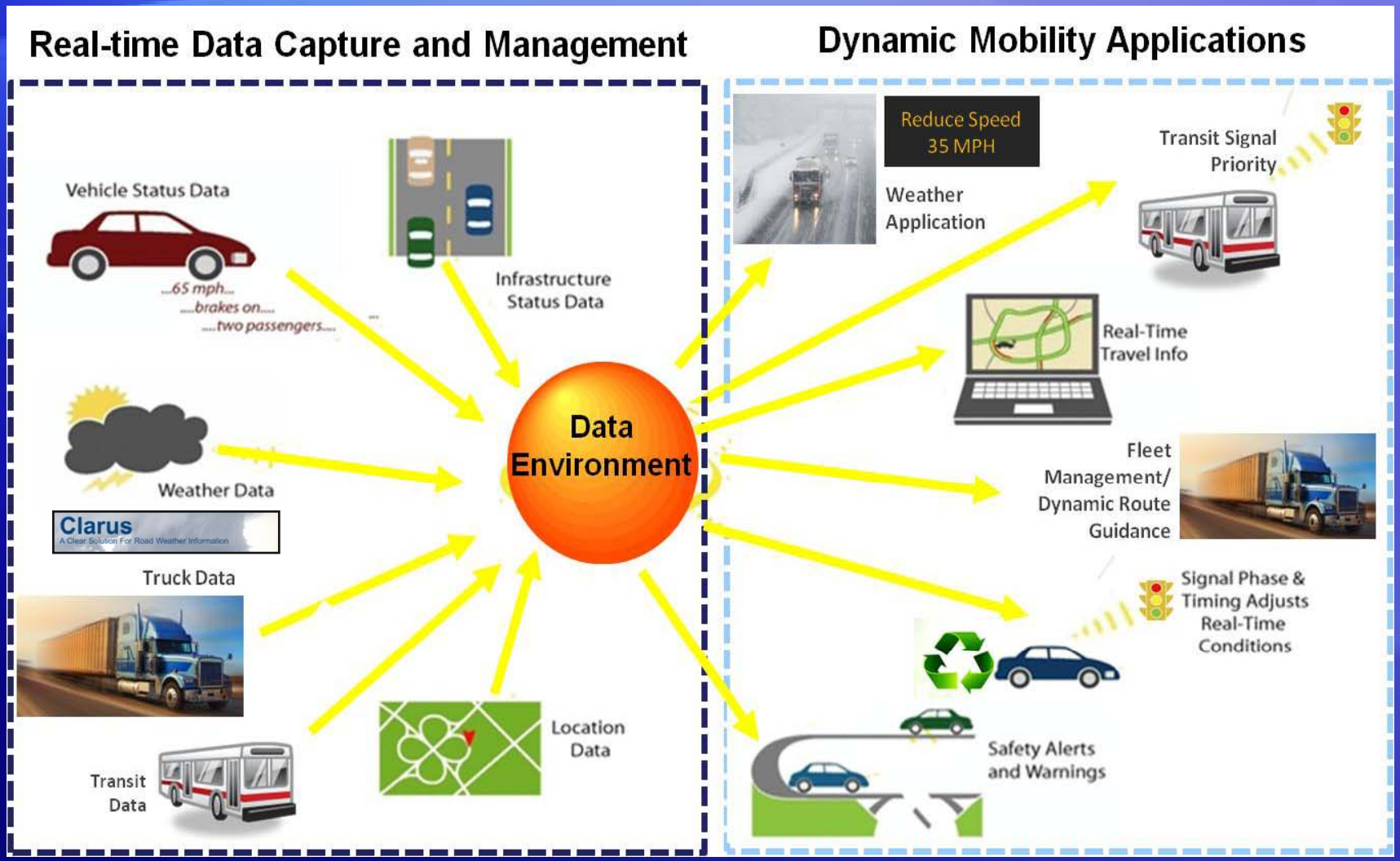
Weather + Connected Vehicles… & Fleets



Southern States Energy Board

The Connected Vehicle

Improving Road Weather Awareness



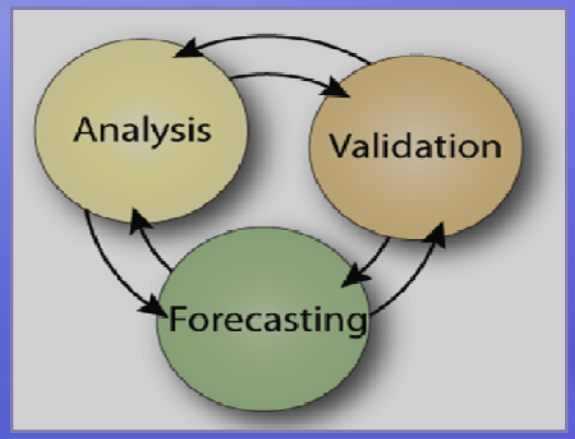
Connected Vehicle Scenarios

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

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



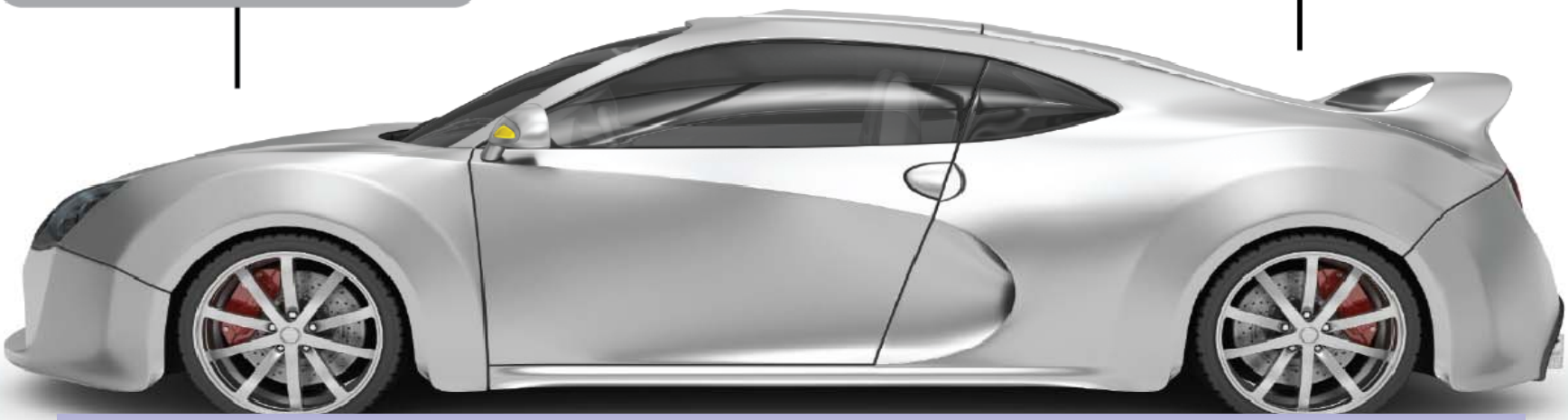
Improve weather-related decision support tools to mitigate safety and mobility impacts of weather

- 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



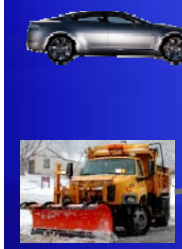
OEM sensors (e.g., air temp, wiper status, braking status)

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



Stage I

Mobile data ingesters

Output data handler

Stage II

Ancillary data ingesters

QCh Module

Statistics module

Output data handler

Stage III

Inference Module

Output data handler

VDT 3.0

Parsed mobile data

Qched data, Basic road segment data

Advanced road segment data

Apps

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

Vehicle Data Translator (VDT) - Objectives

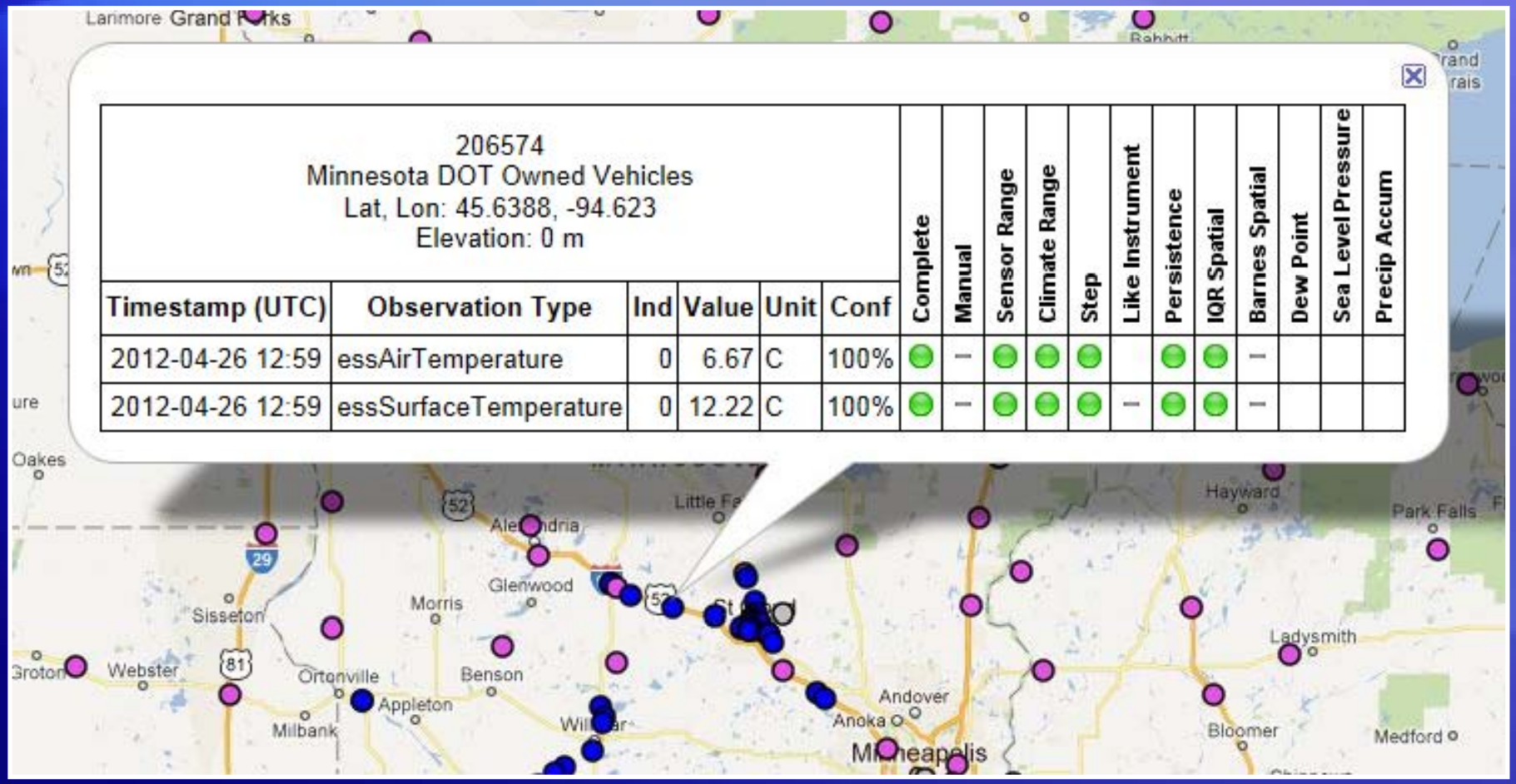
- ✓ Develop the Connected Vehicles' role in "Anytime, Anywhere Road Weather Information"
- ✓ Exploit any and all vehicle-based data
  - ✓ OEM sensors (e.g., air temp, wiper status, braking status)
  - ✓ After market sensors (e.g., pavement temp, plow status)
- ✓ Combine data from vehicles & fleets with fixed sources (*Clarus*)
- ✓ Development of inferred road segment specific weather and road-weather information for end-user applications

Composite image simulates the road warning system being tested by NCAR.

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

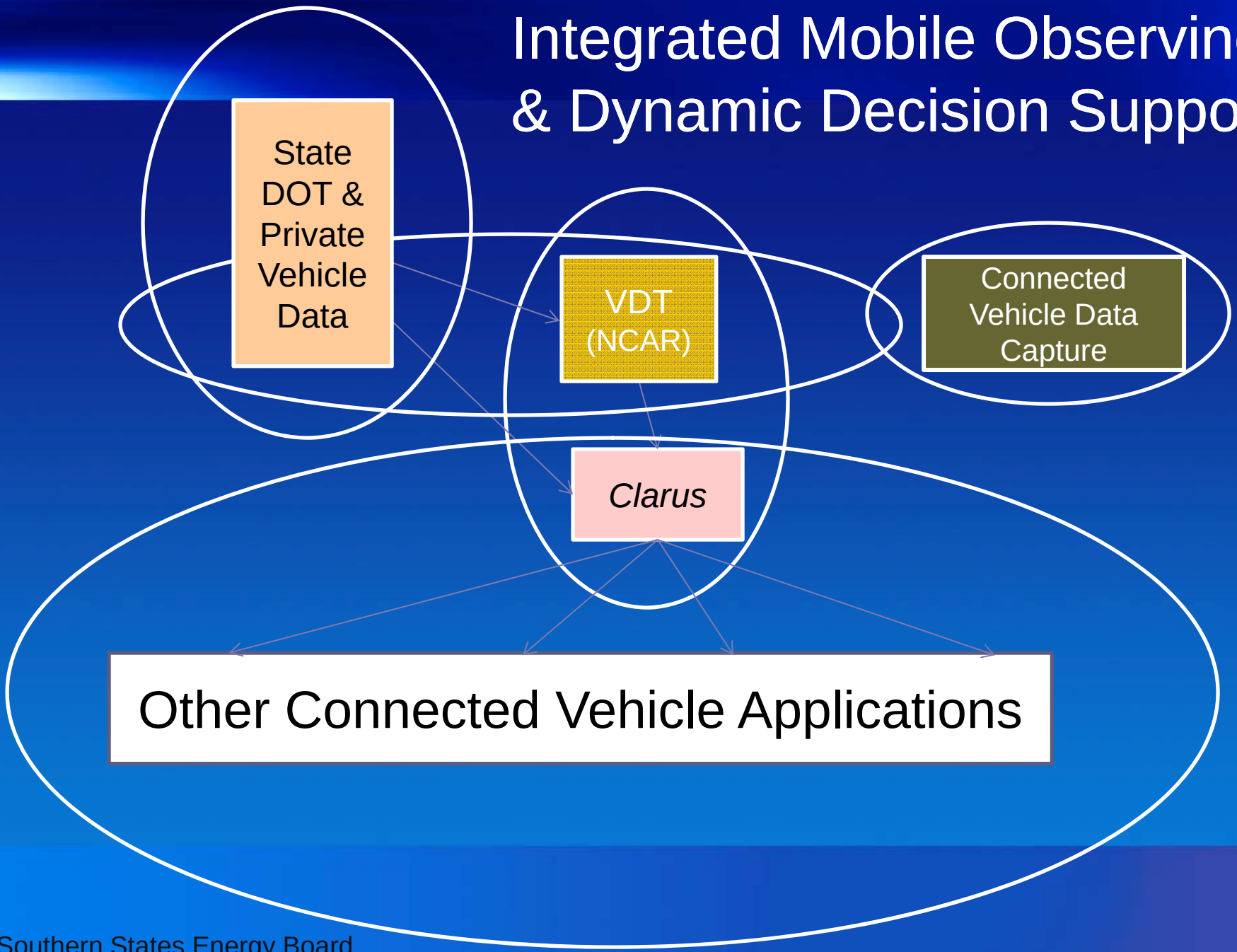
Clarus – Mobile Data

Minnesota mobile data displayed in the *Clarus* System



Timestamp (UTC)	Observation Type	Ind	Value	Unit	Conf	Complete	Manual	Sensor Range	Climate Range	Step	Like Instrument	Persistence	IQR Spatial	Barnes Spatial	Dew Point	Sea Level Pressure	Precip Accum
2012-04-26 12:59	essAirTemperature	0	6.67	C	100%	●	–	●	●	●		●	●	–			
2012-04-26 12:59	essSurfaceTemperature	0	12.22	C	100%	●	–	●	●	●	–	●	●	–			

Integrated Mobile Observing & Dynamic Decision Support



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

*Simulated screen, designed to not distract the driver

VDT-based weather alerts:

- Impending weather hazards
- Alerts from other vehicles
- Re-routing

Broad Transportation Applications

VDT-based data

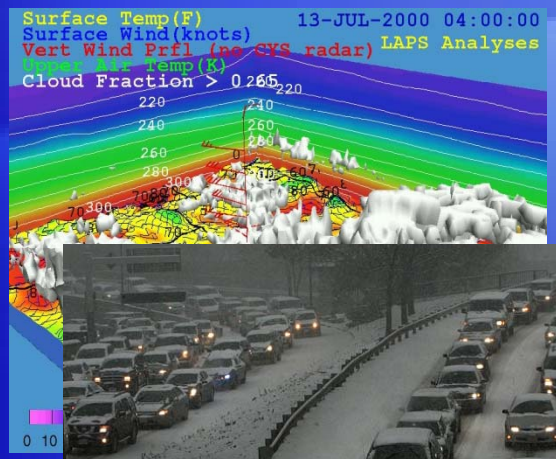
Route Specific Impact Warnings for…

School Buses

Truckers

EMS

Weather-related Applications



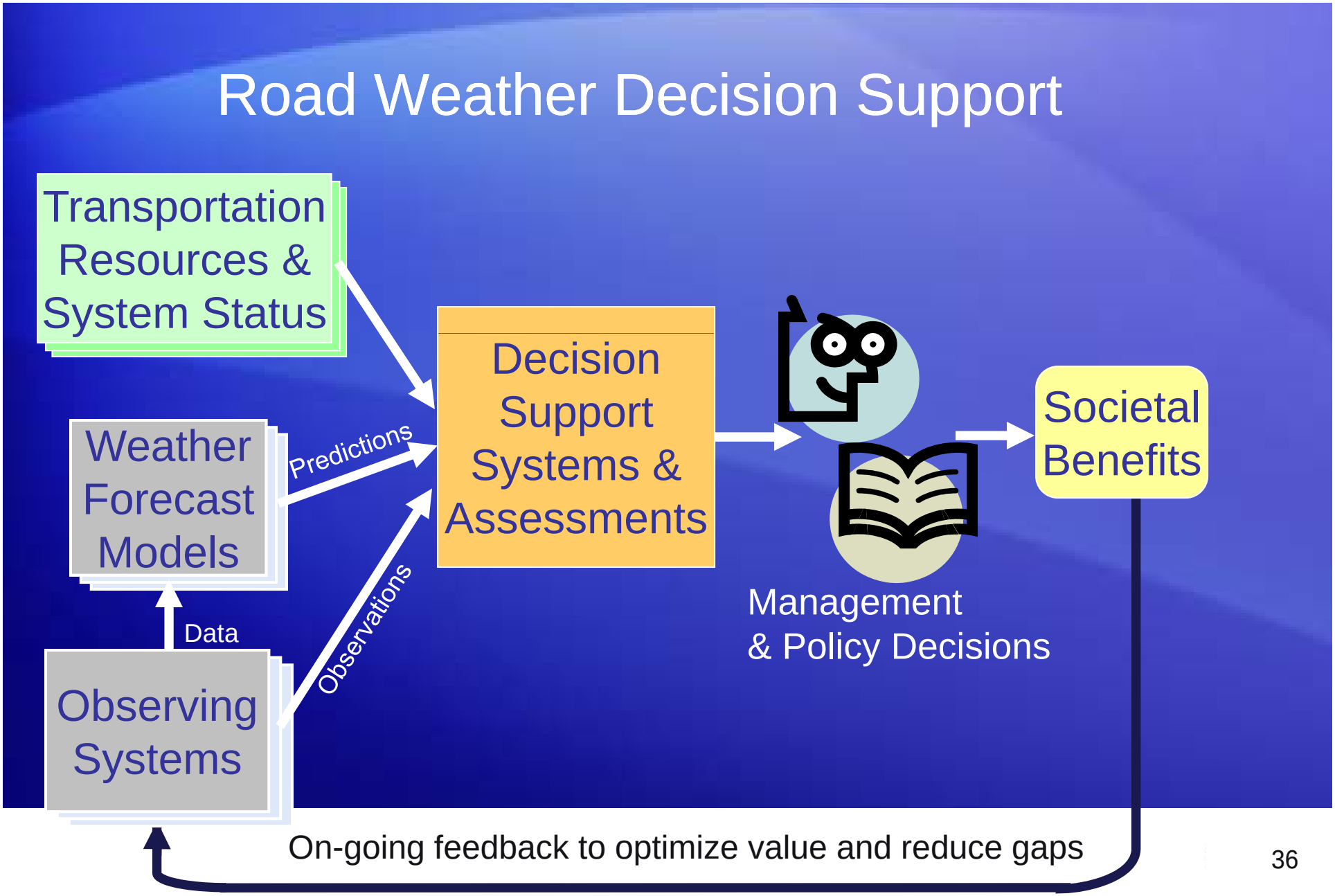
Numerical Weather Modeling

Traffic Modeling and Alerting

Weather Modeling – complex terrain

Other surface transportation users

Solutions to help save lives, time & money



Thank you!

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ray.murphy@dot.gov, 708-283-3517

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