UNITED STATES
DEPARTMENT OF TRANSPORTATION

Road Weather Management and the Connected Vehicle

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

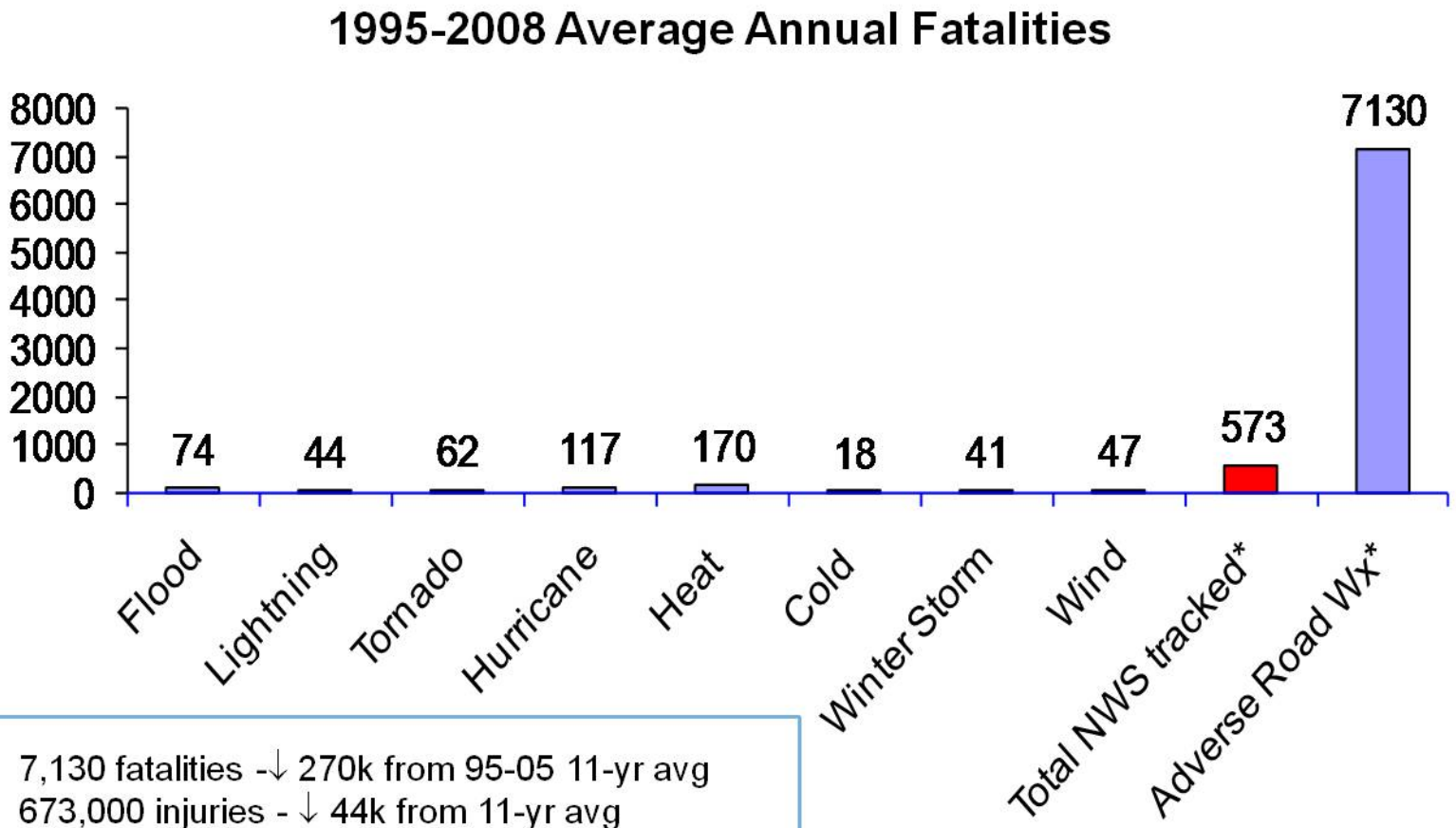
July 27, 2011

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



- 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

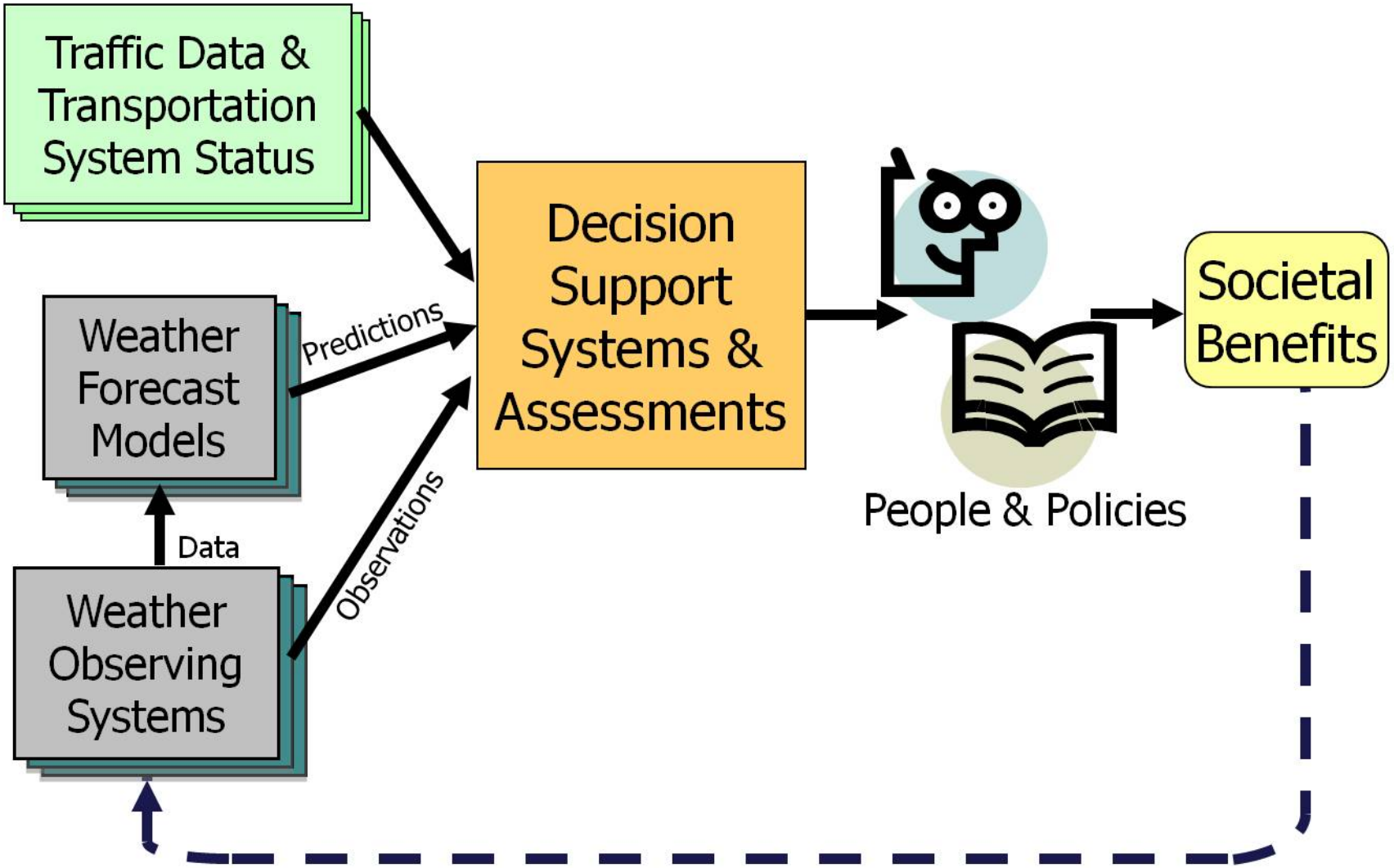
- Trucking delays due to weather = $3.1billion/yr for the 50 largest cities
- Lost commerce due to snow closures = $10billion/day
- More than $2billion/yr is spent on snow and ice control by State DOTs
- Weather accounts for 25% of non-recurring congestion
- Chemicals affect watersheds, air quality and infrastructure

Road Weather Management

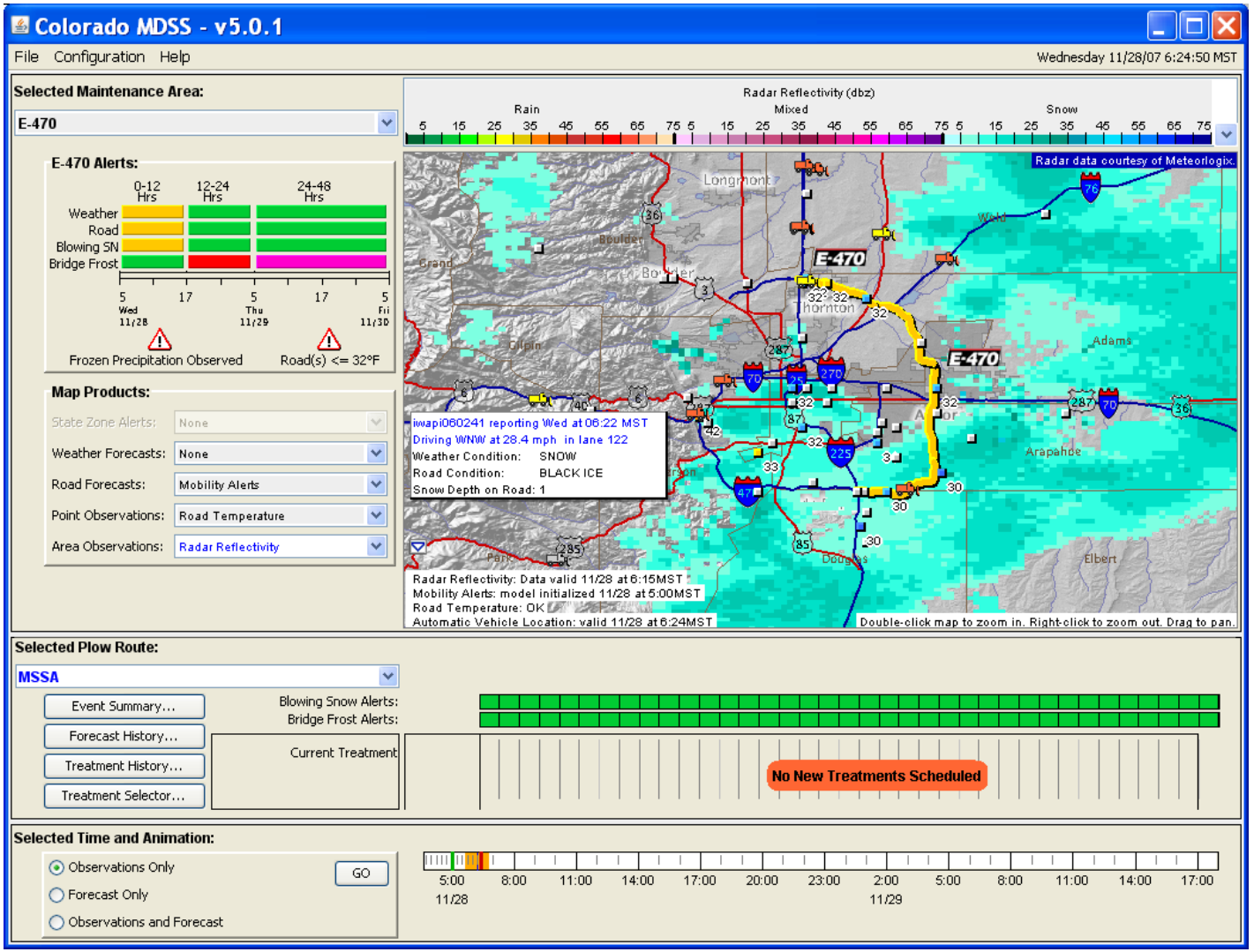
Goal – Improve mobility and safety by alleviating the impacts of weather on the surface transportation system

- *"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

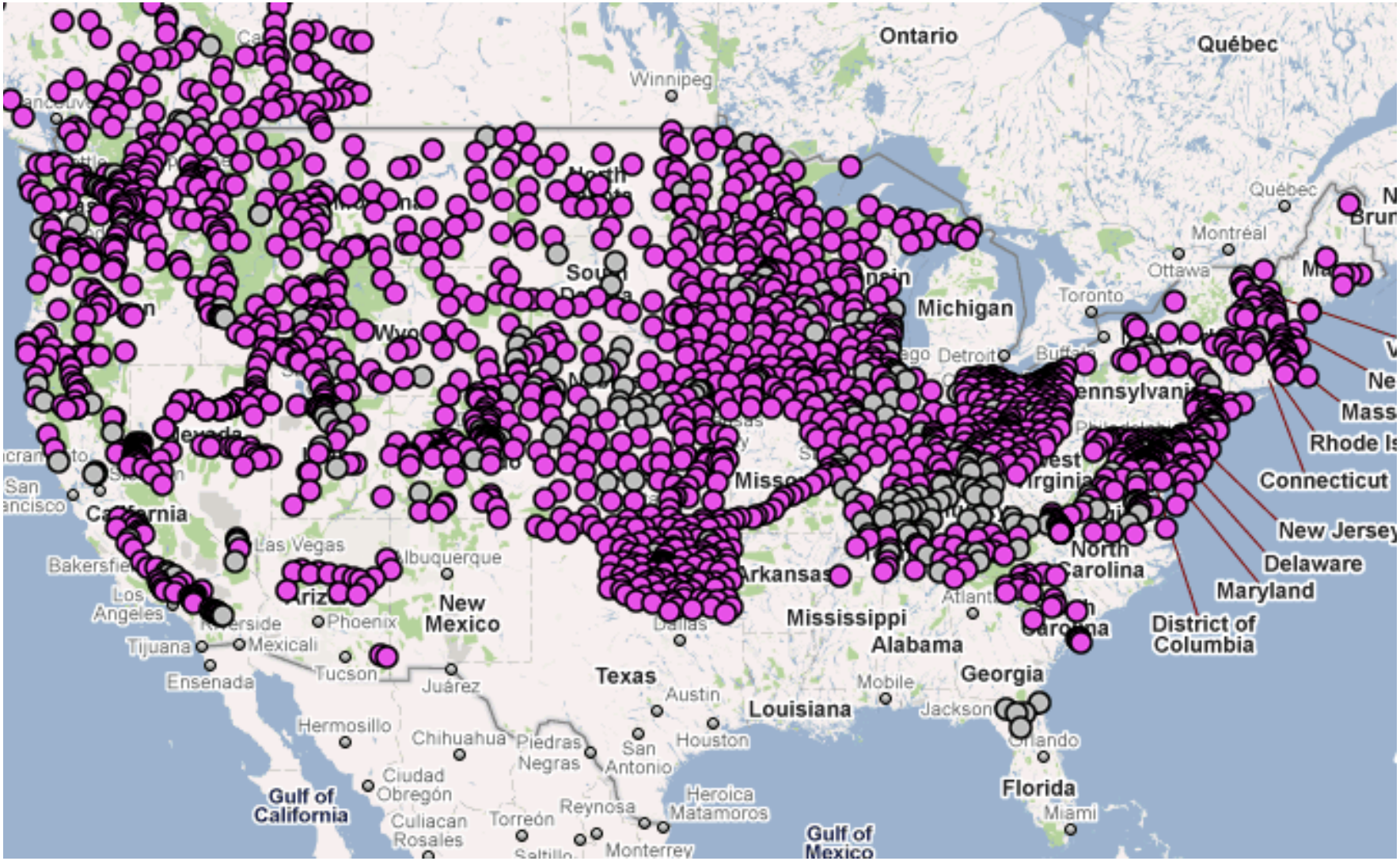


Weather Tailored for Winter Maintenance



The *Clarus* System – fixed sensors

Over 75% of State DOTs (c.95% of the Nation's sensors)



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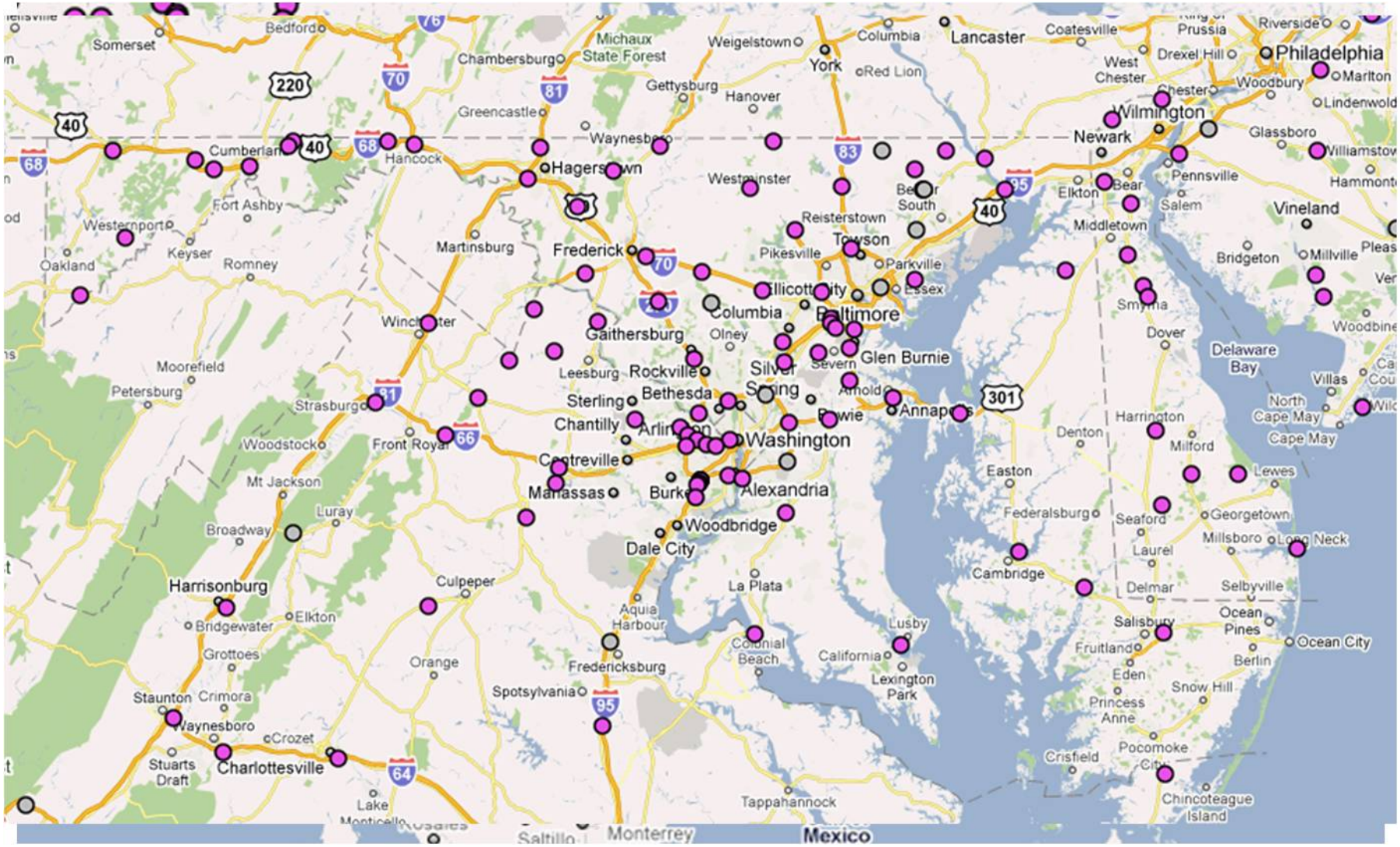
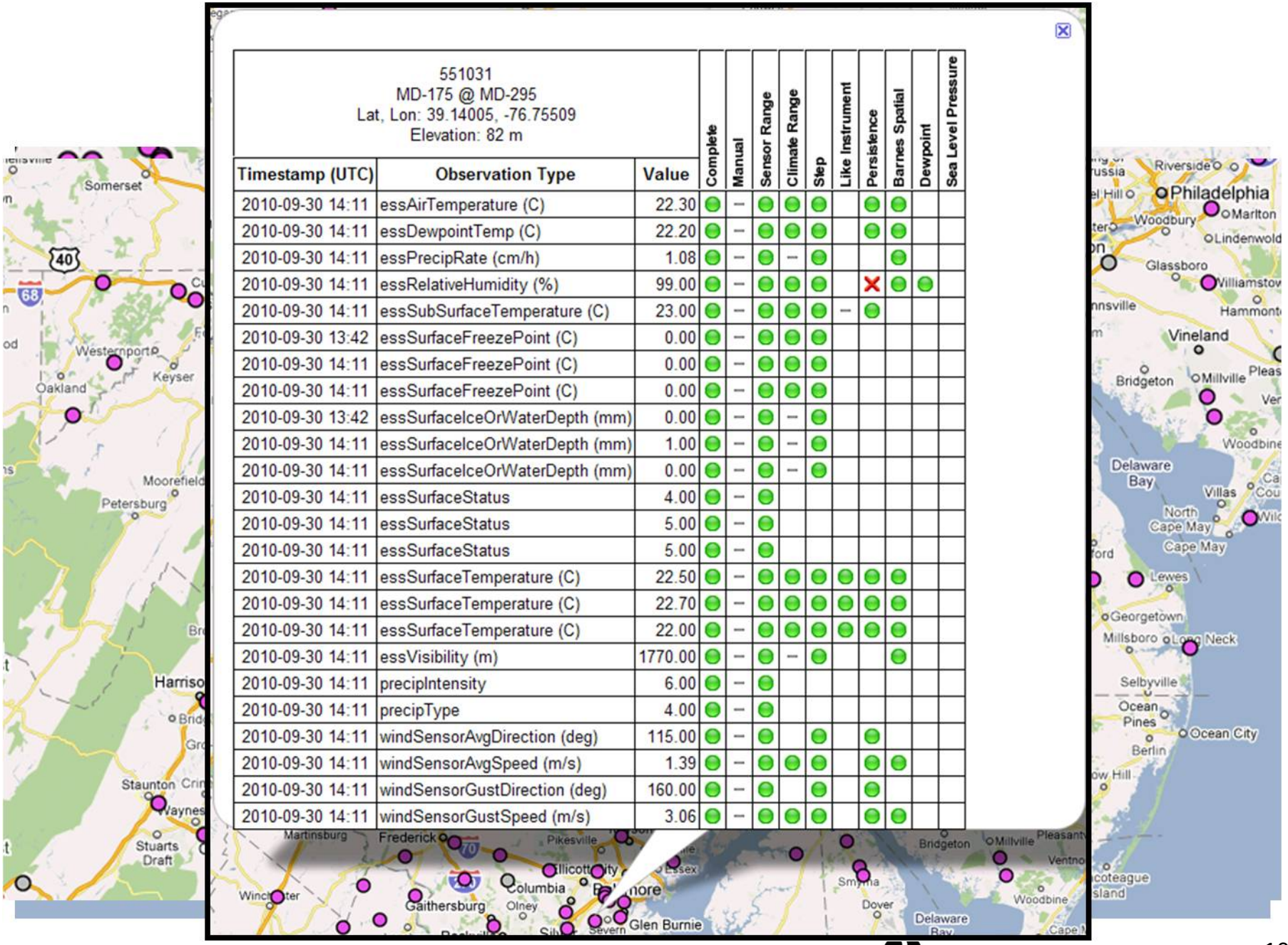




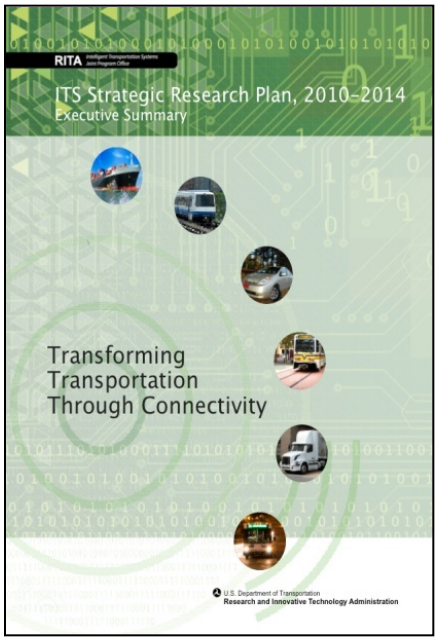
Timestamp (UTC)	Observation Type	Value	Complete	Manual	Sensor Range	Climate Range	Step	Like Instrument	Persistence	Barnes Spatial	Dewpoint	Sea Level Pressure
2010-09-30 14:11	essAirTemperature (C)	22.30	●	–	●	●	●		●	●		
2010-09-30 14:11	essDewpointTemp (C)	22.20	●	–	●	●	●		●	●		
2010-09-30 14:11	essPrecipRate (cm/h)	1.08	●	–	●	–	●			●		
2010-09-30 14:11	essRelativeHumidity (%)	99.00	●	–	●	●	●		✗	●	●	
2010-09-30 14:11	essSubSurfaceTemperature (C)	23.00	●	–	●	●	●	–	●			
2010-09-30 13:42	essSurfaceFreezePoint (C)	0.00	●	–	●	●	●					
2010-09-30 14:11	essSurfaceFreezePoint (C)	0.00	●	–	●	●	●					
2010-09-30 14:11	essSurfaceFreezePoint (C)	0.00	●	–	●	●	●					
2010-09-30 13:42	essSurfaceIceOrWaterDepth (mm)	0.00	●	–	●	–	●					
2010-09-30 14:11	essSurfaceIceOrWaterDepth (mm)	1.00	●	–	●	–	●					
2010-09-30 14:11	essSurfaceIceOrWaterDepth (mm)	0.00	●	–	●	–	●					
2010-09-30 14:11	essSurfaceStatus	4.00	●	–	●							
2010-09-30 14:11	essSurfaceStatus	5.00	●	–	●							
2010-09-30 14:11	essSurfaceStatus	5.00	●	–	●							
2010-09-30 14:11	essSurfaceTemperature (C)	22.50	●	–	●	●	●	●	●	●		
2010-09-30 14:11	essSurfaceTemperature (C)	22.70	●	–	●	●	●	●	●	●		
2010-09-30 14:11	essSurfaceTemperature (C)	22.00	●	–	●	●	●	●	●	●		
2010-09-30 14:11	essVisibility (m)	1770.00	●	–	●	–	●			●		
2010-09-30 14:11	precipIntensity	6.00	●	–	●							
2010-09-30 14:11	precipType	4.00	●	–	●							
2010-09-30 14:11	windSensorAvgDirection (deg)	115.00	●	–	●		●		●			
2010-09-30 14:11	windSensorAvgSpeed (m/s)	1.39	●	–	●	●	●		●	●		
2010-09-30 14:11	windSensorGustDirection (deg)	160.00	●	–	●		●		●			
2010-09-30 14:11	windSensorGustSpeed (m/s)	3.06	●	–	●	●	●		●	●		

ITS Strategic Research Plan 2010-2014
A Truly Multimodal and Connected Effort

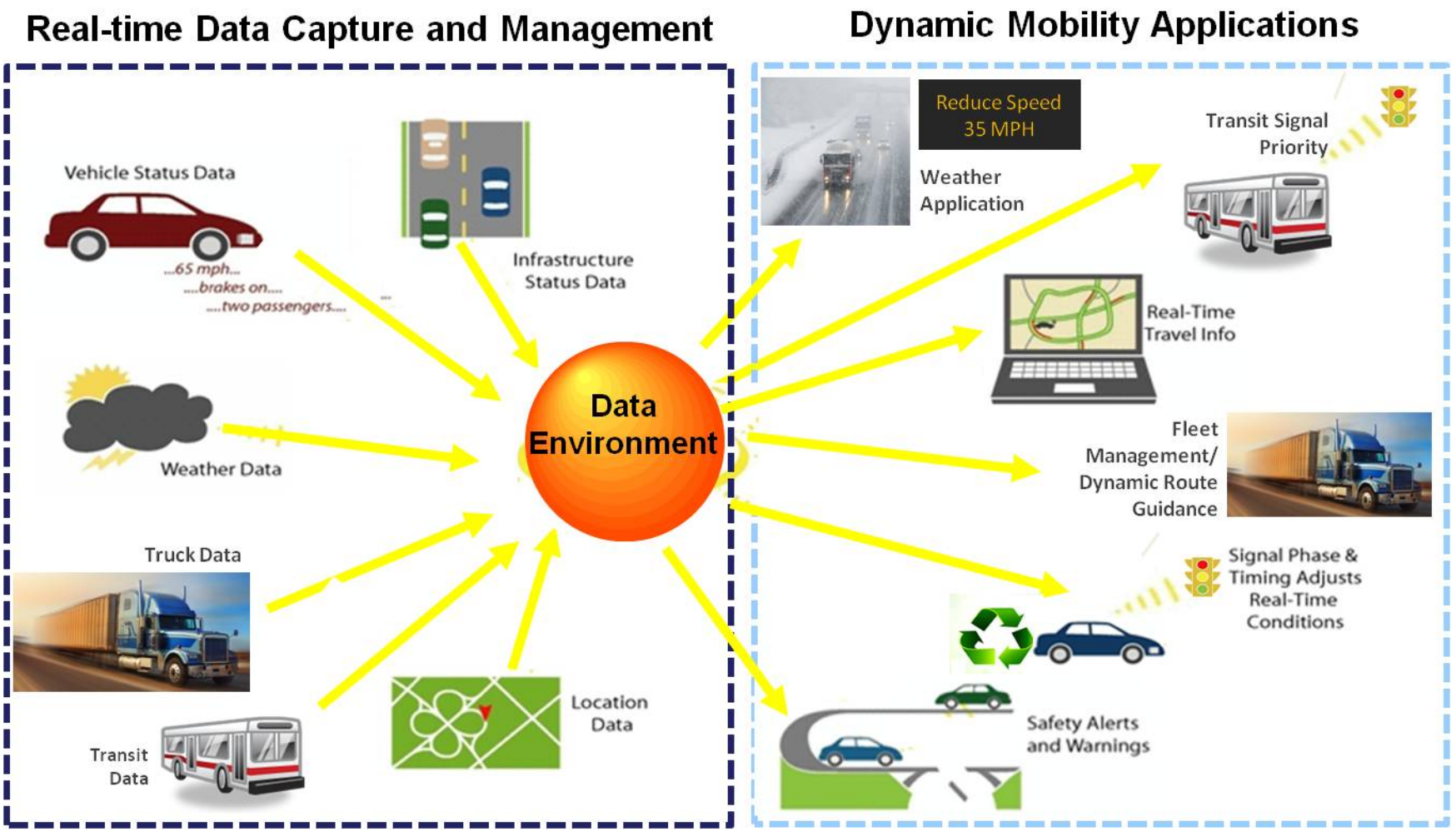
Program Vision

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.

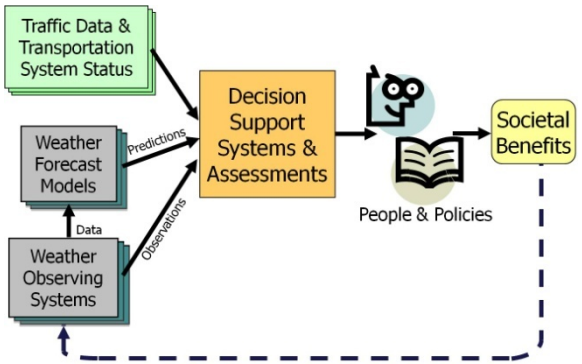


Connected Vehicles & Road Weather



Connected Vehicles & Weather – Vision

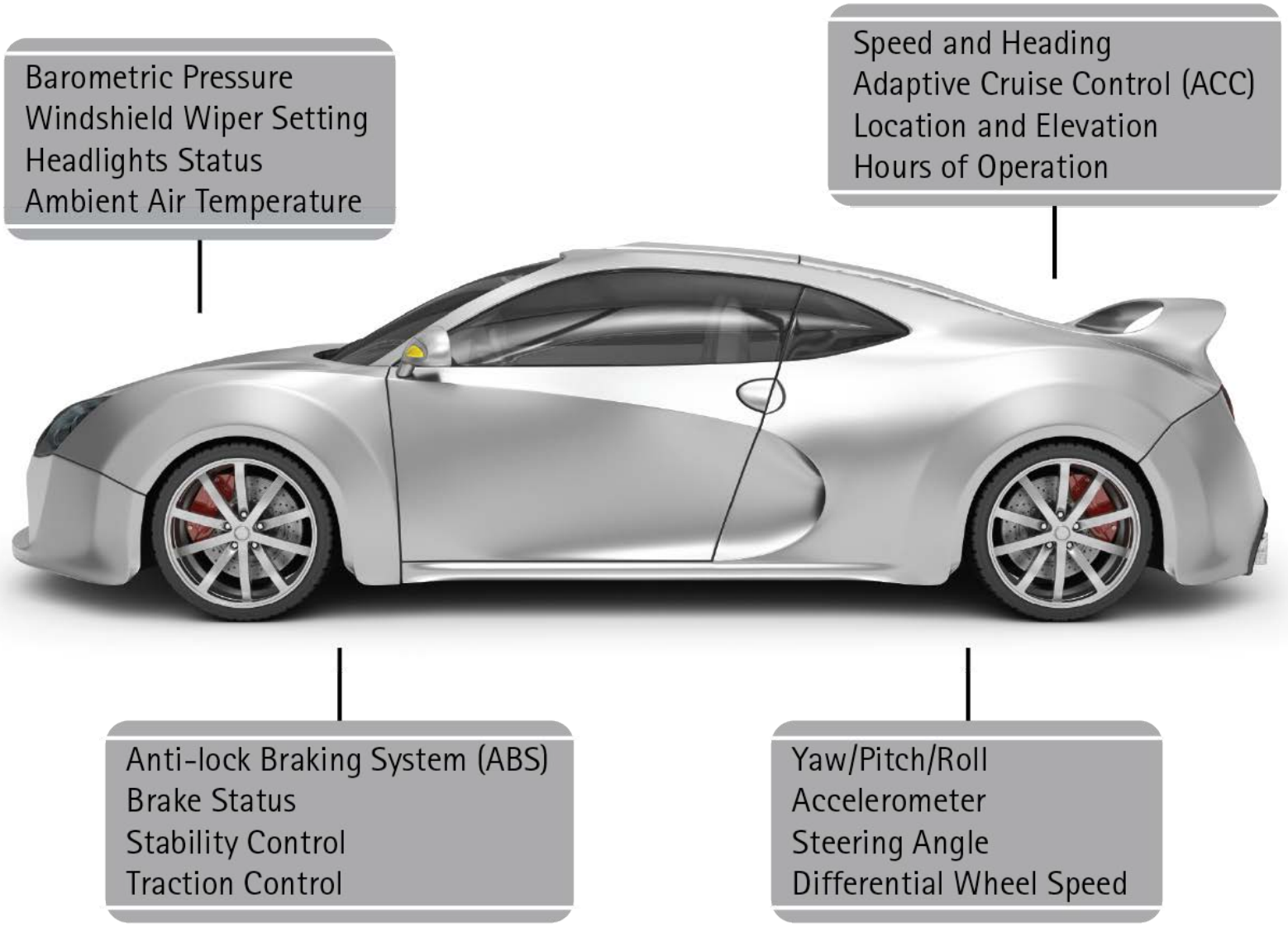
- Obtain a thorough picture of current weather and road conditions by including mobile sources
  - Higher resolution observations that spatially augment fixed sensors
  - Take advantage of existing standards and on-board sensors
- Improve weather-related decision support tools to mitigate safety and 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



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

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Roemer Alfelor
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Gabriel Guevara
FHWA Office of Operations
202-366-0754

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

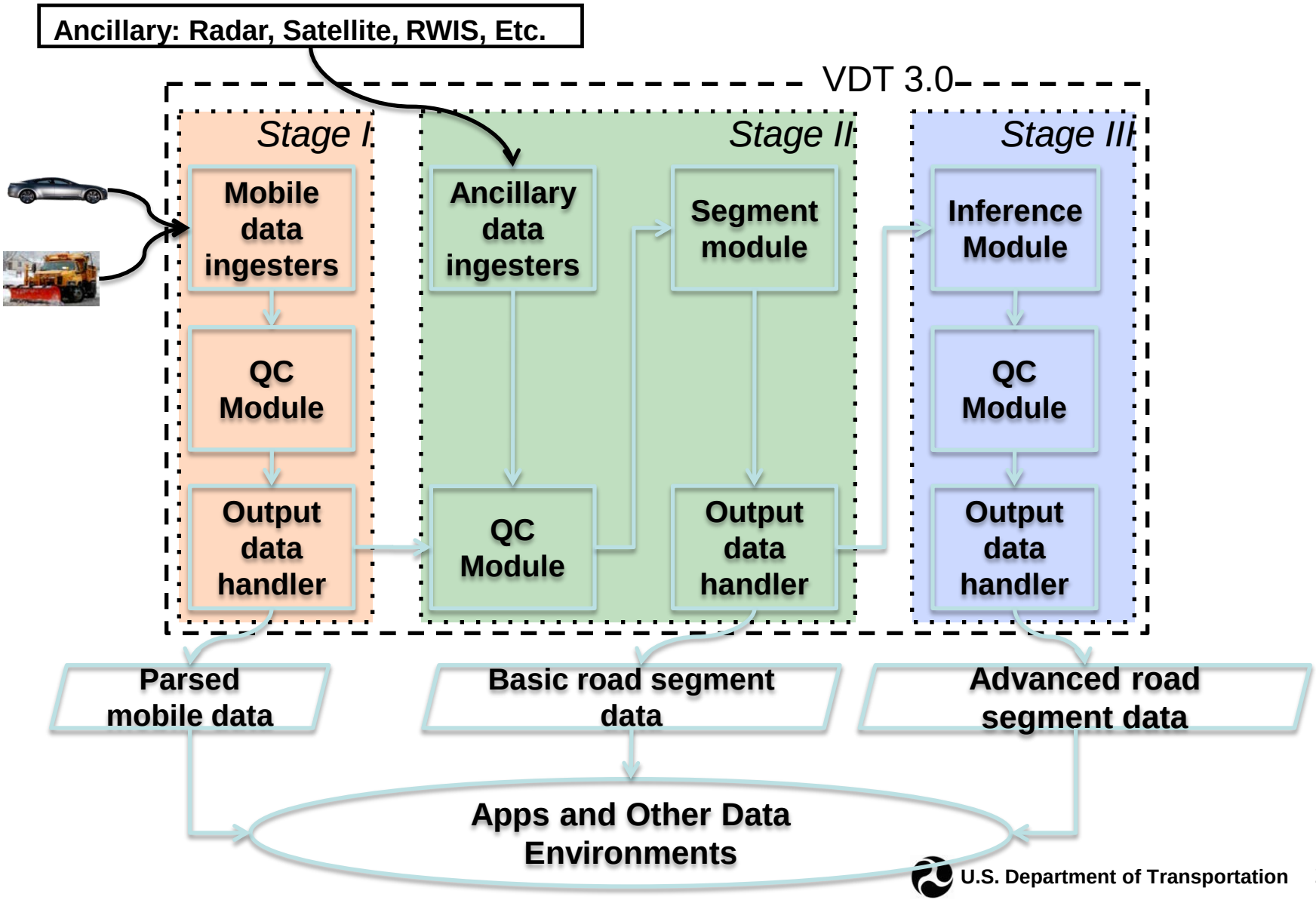
Vehicle-based Probe Data

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



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*

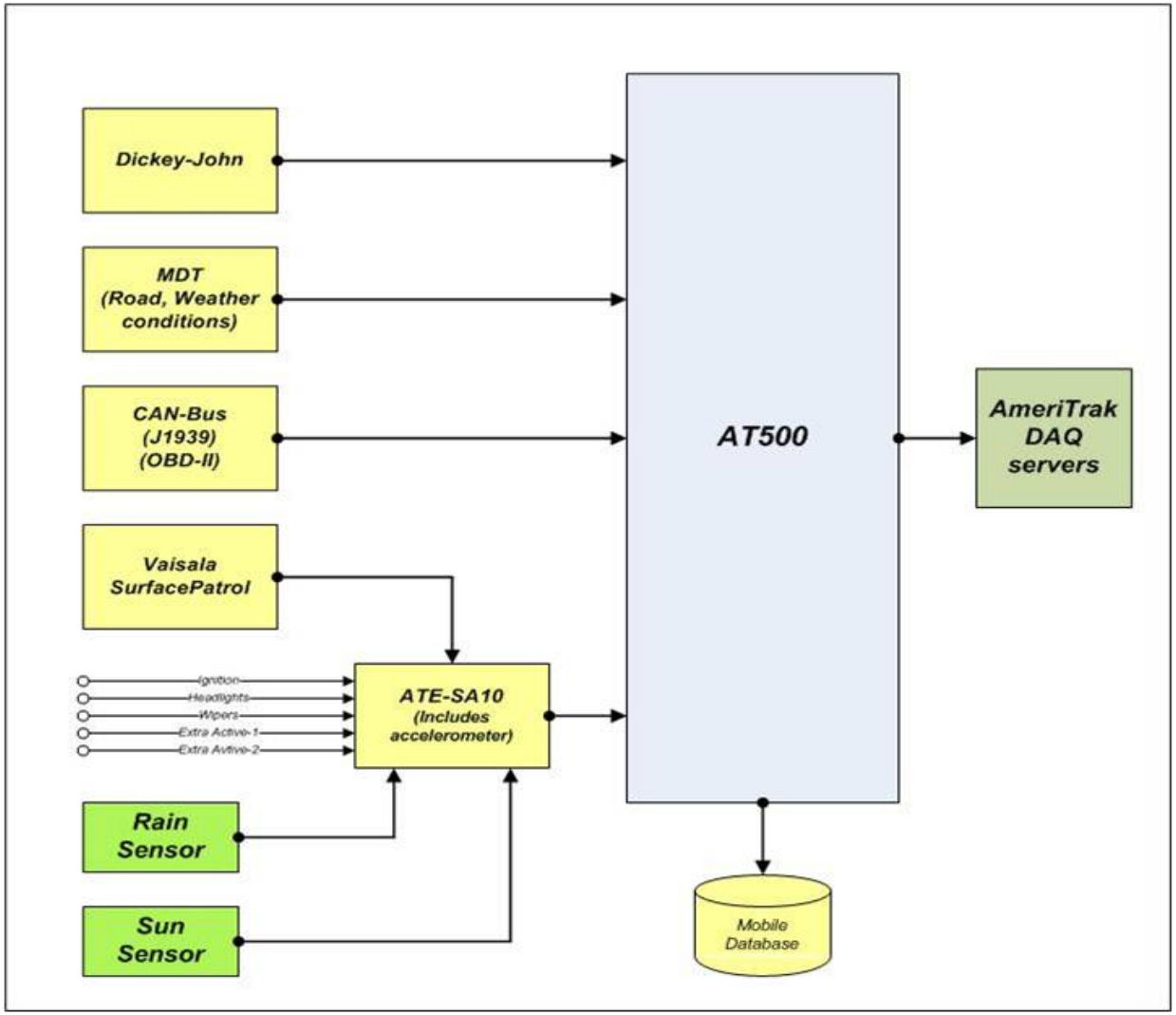
FHWA / NCAR / MnDOT
Parameter List

External air temperature	Accelerometer
Pavement temperature	Impact sensor
Atmospheric pressure	Steering angle
Rain (rain sensor)	Yaw rate
Relative humidity	Anti-lock braking system
Wiper status	Brake boost status
Headlight status	Brake status
Pavement wetness	Stability control system
Sun (sun sensor)	Traction control status

FHWA / NCAR / MnDOT
Parameter List *(continued)*

Differential wheel speed	Emission data (NOx, HC, CO, CO2, particulate matter, etc)
Short-range wide beam radar	Date and time
Adaptive cruise control	Vehicle location, heading
Camera imagery	Vehicle velocity
	Elevation
Gray => CAN-Bus	Blue => External Sensor

AT500 Transponder Data Acquisition (DAQ)



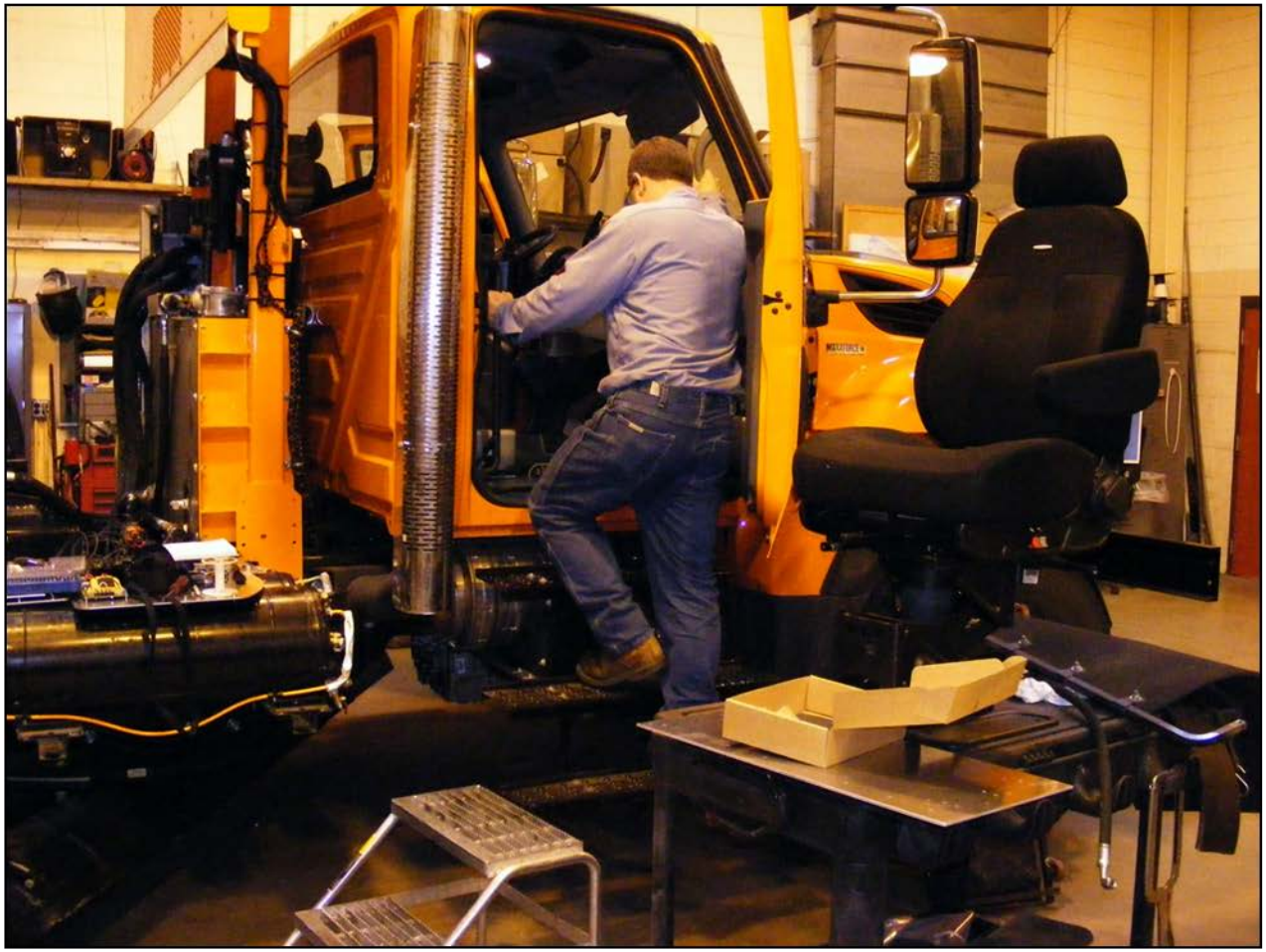
The AT500 in-vehicle transponder hardware and software has been modified to accept data from many different in-vehicle sources.

AT500 Transponder

Front view

10-1/4” x 7-1/2” x 2”

2010 International MaxxForce Truck Fleet

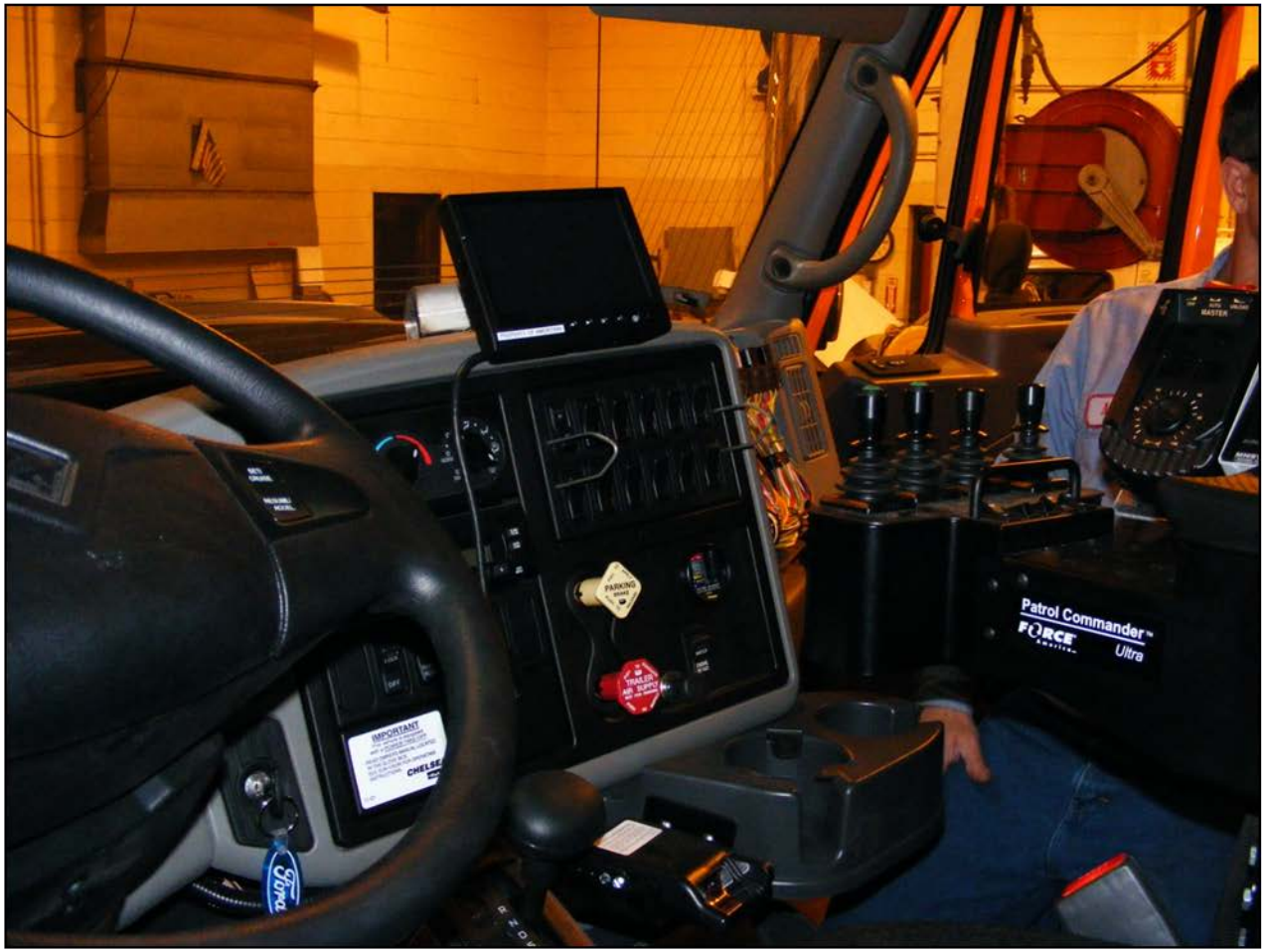


Prototype mechanical packages being worked on for the new MaxxForce trucks.

2010 International MaxxForce Truck Fleet

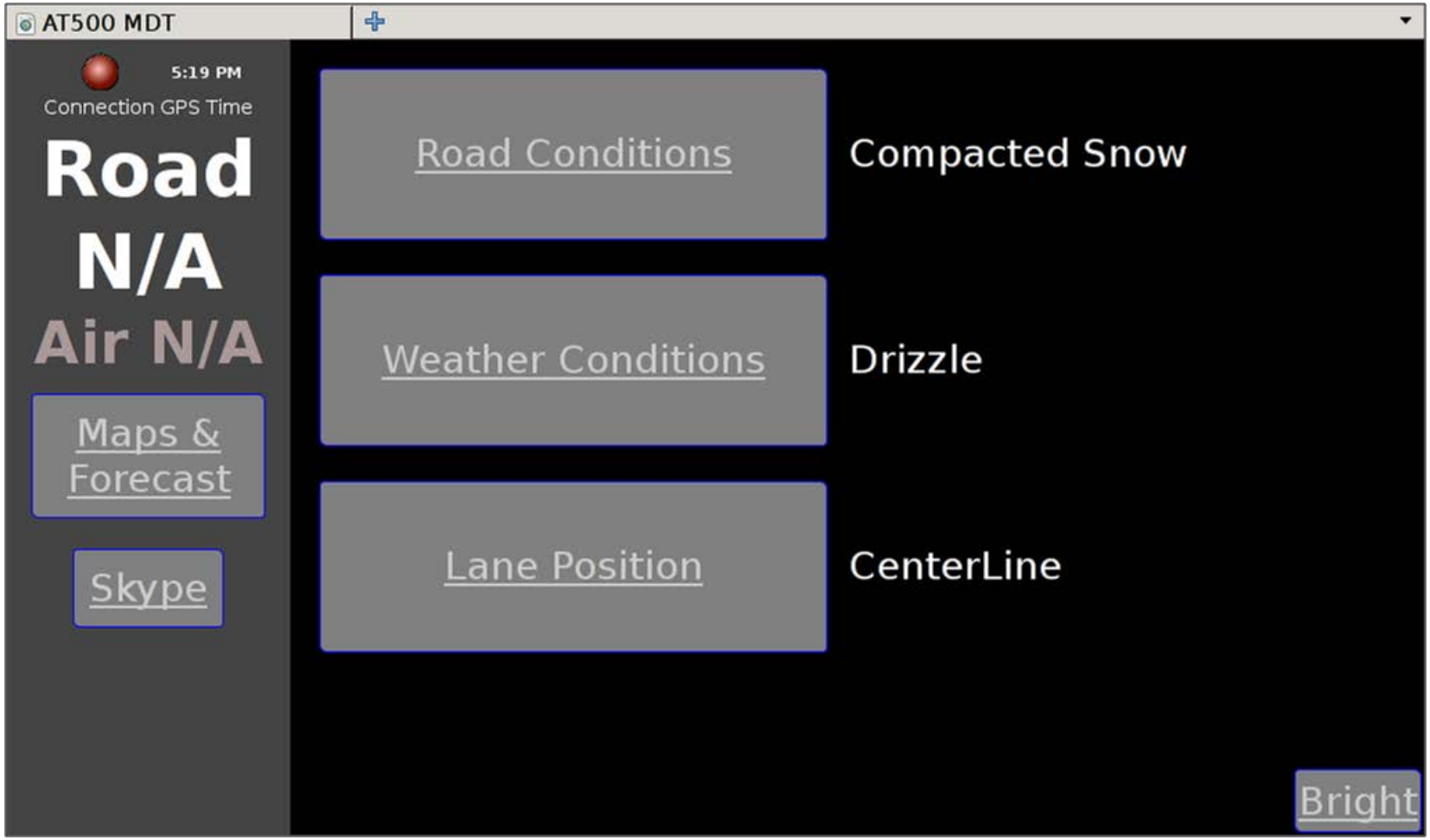
The AT500 prototype mount for the 2010 International MaxxForce trucks. Our project will include these 40 new MaxxForce vehicles.

2010 International MaxxForce Truck Fleet

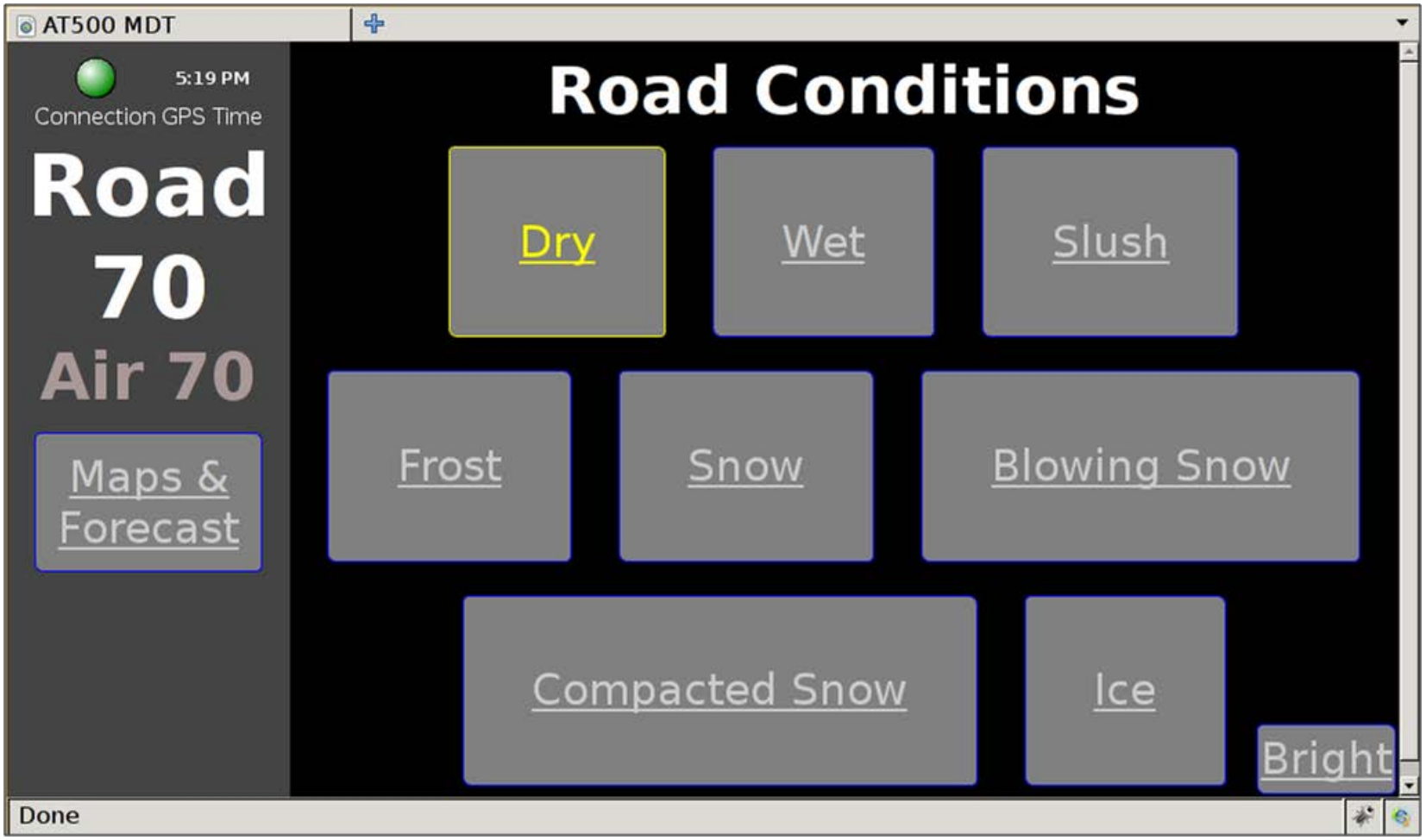


The Mobile Data Terminal (MDT) will feature a custom dash mount for the new MaxxForce trucks.

AT500 MDT
Main Screen

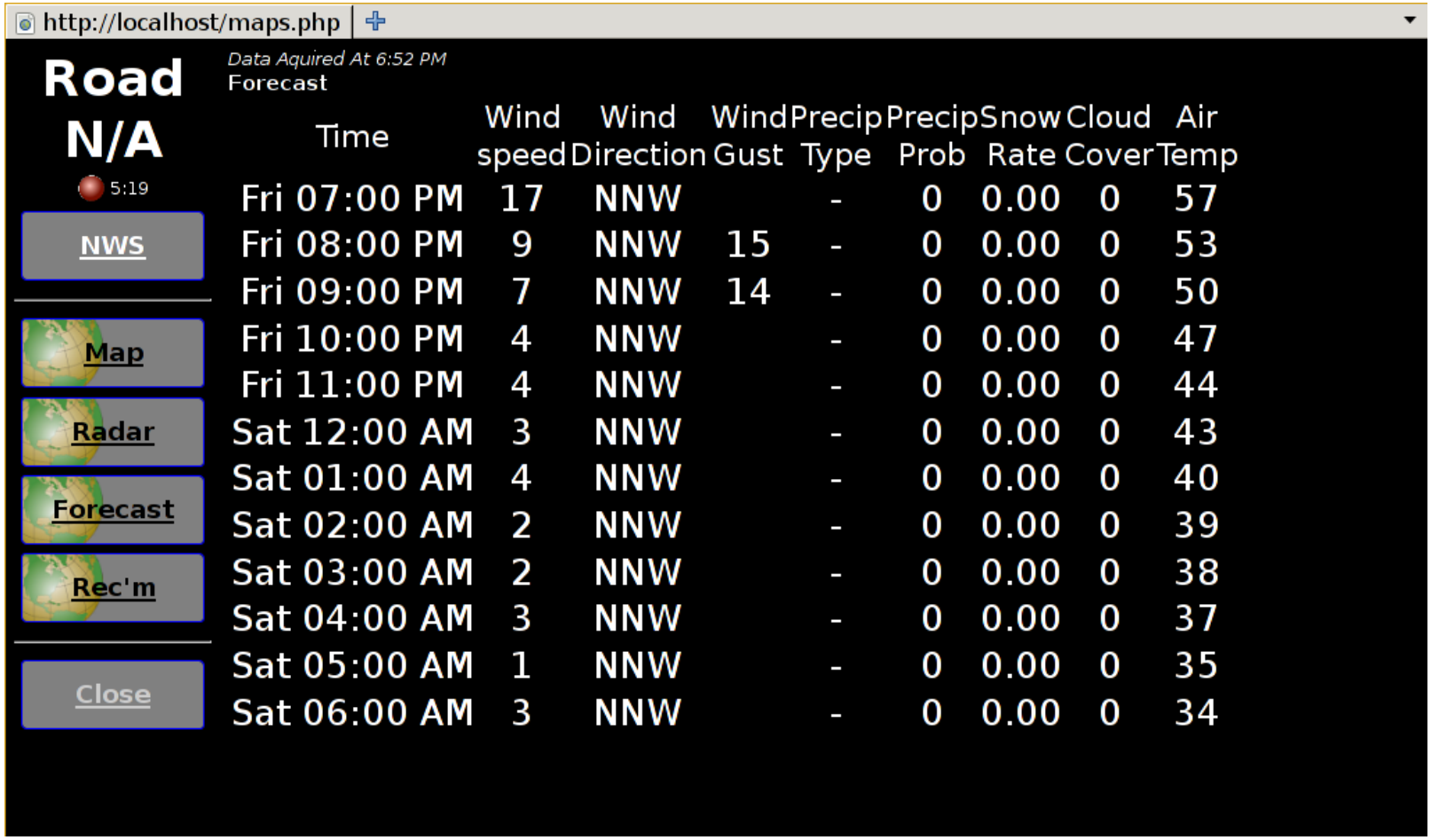


AT500 MDT
Road Conditions Input



AT500 MDT

Maps: Meridian Forecast



Time	Wind speed	Wind Direction	Wind Gust	Precip Type	Precip Prob	Snow Rate	Cloud Cover	Air Temp
Fri 07:00 PM	17	NNW		-	0	0.00	0	57
Fri 08:00 PM	9	NNW	15	-	0	0.00	0	53
Fri 09:00 PM	7	NNW	14	-	0	0.00	0	50
Fri 10:00 PM	4	NNW		-	0	0.00	0	47
Fri 11:00 PM	4	NNW		-	0	0.00	0	44
Sat 12:00 AM	3	NNW		-	0	0.00	0	43
Sat 01:00 AM	4	NNW		-	0	0.00	0	40
Sat 02:00 AM	2	NNW		-	0	0.00	0	39
Sat 03:00 AM	2	NNW		-	0	0.00	0	38
Sat 04:00 AM	3	NNW		-	0	0.00	0	37
Sat 05:00 AM	1	NNW		-	0	0.00	0	35
Sat 06:00 AM	3	NNW		-	0	0.00	0	34

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

Light Duty Vehicles (Crew, general purpose)

- 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).

In-vehicle computer

Road and weather sensors

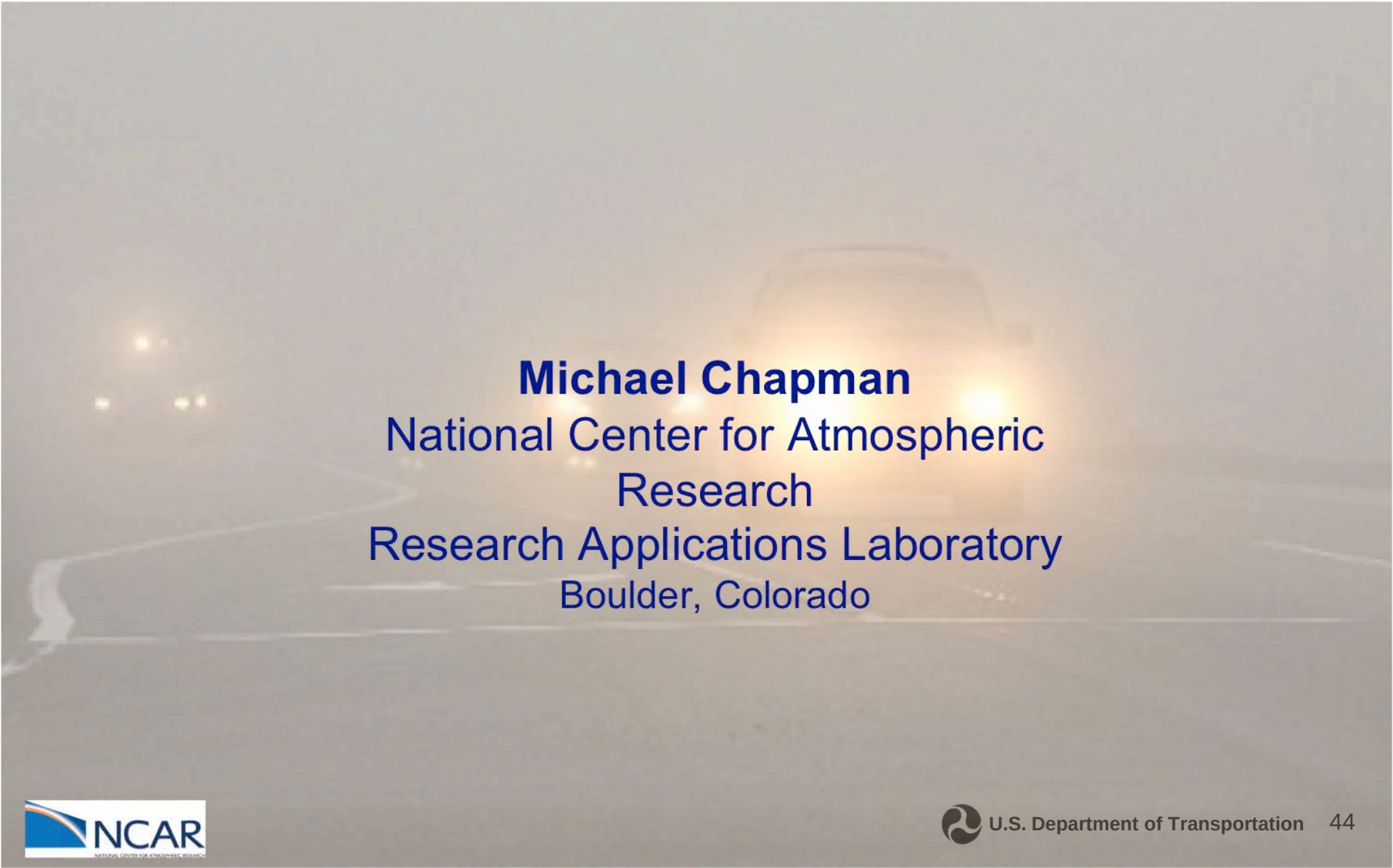
What is next…

- This project will be completed April 2012

  Interim update will be given at the Road Weather Management Stakeholder Meeting in September

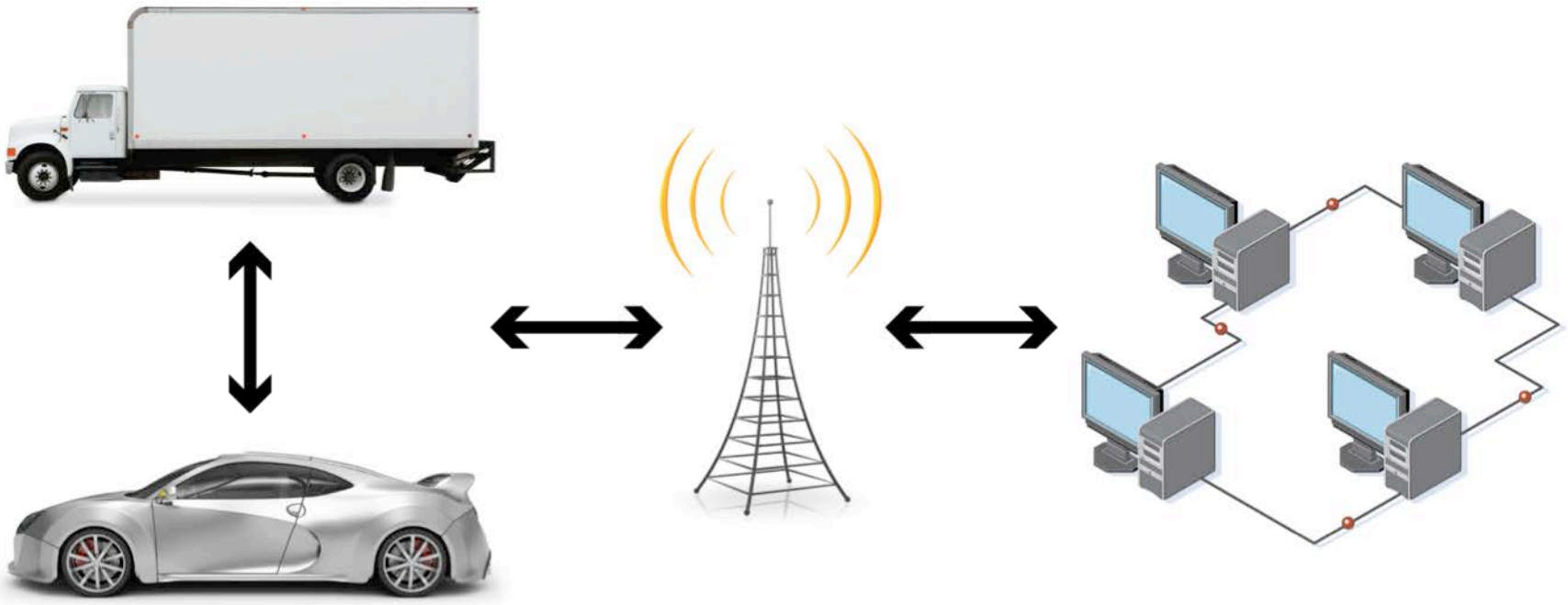
- Further refinements to the VDT
- Follow-on work with these or other states
- Refinement of Standards and communication protocols
- Work with the OEM's to be able to access the metadata for the parameter ID's
- Continue to cooperate with the Connected-Vehicle efforts, i.e., feed data into Clarus, the Research Development Environment, and collaborate with appropriate Dynamic Mobility efforts.

Weather Observations from Connected Vehicles

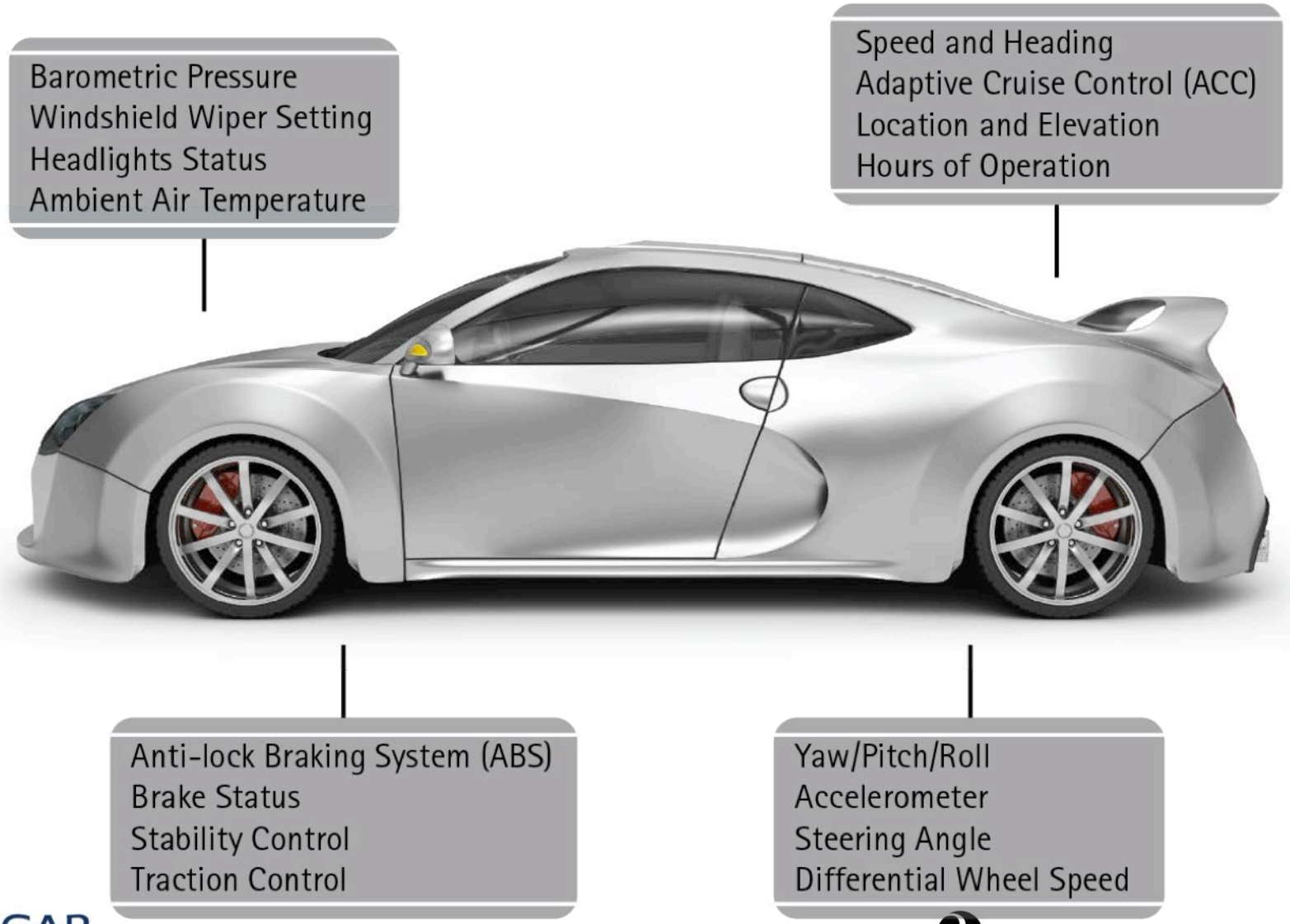


Michael Chapman
National Center for Atmospheric Research
Research Applications Laboratory
Boulder, Colorado

Weather Observations from Connected Vehicles



Weather Observations from Connected Vehicles

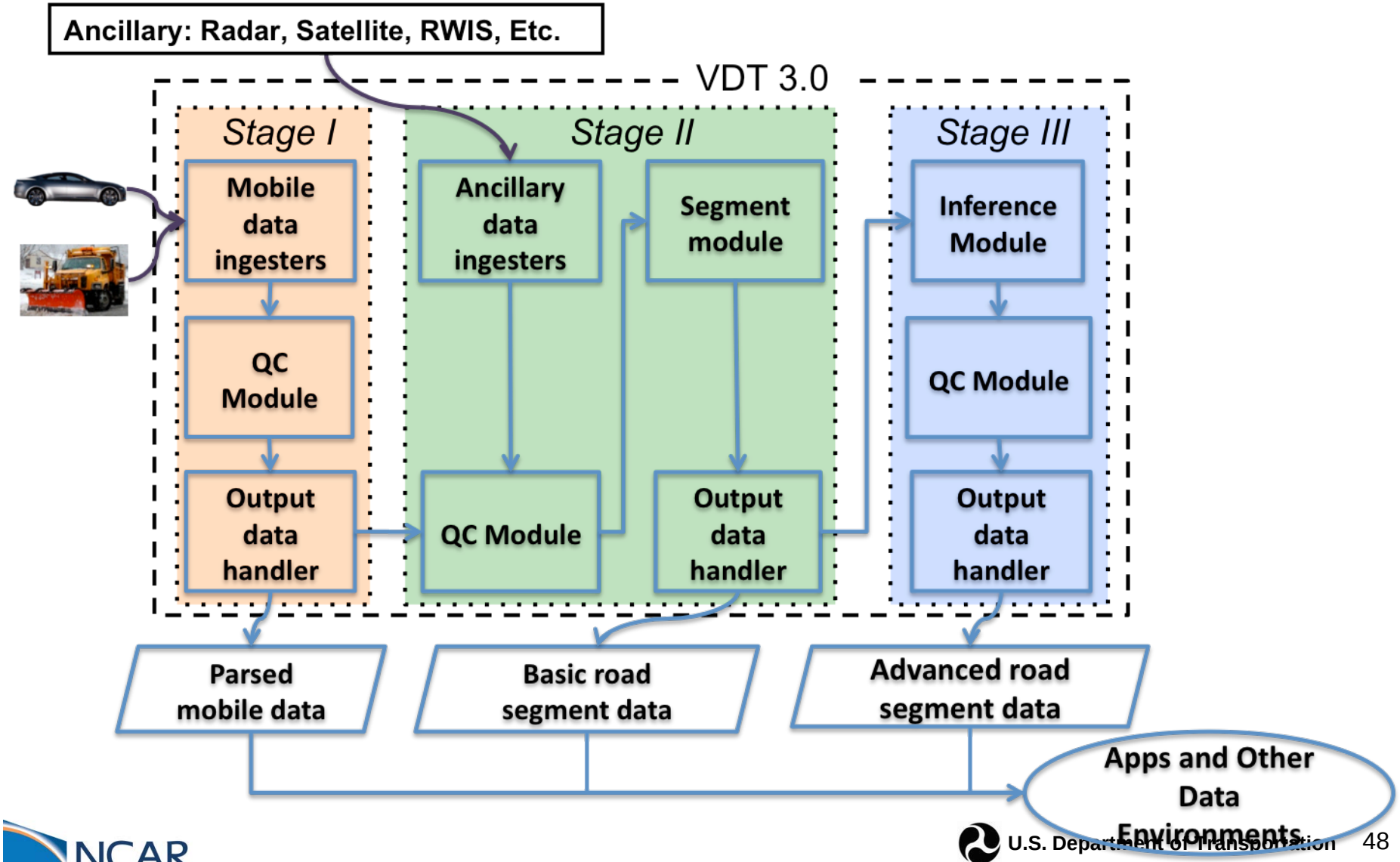


Vehicle Data Translator (VDT) – Version 3.0

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



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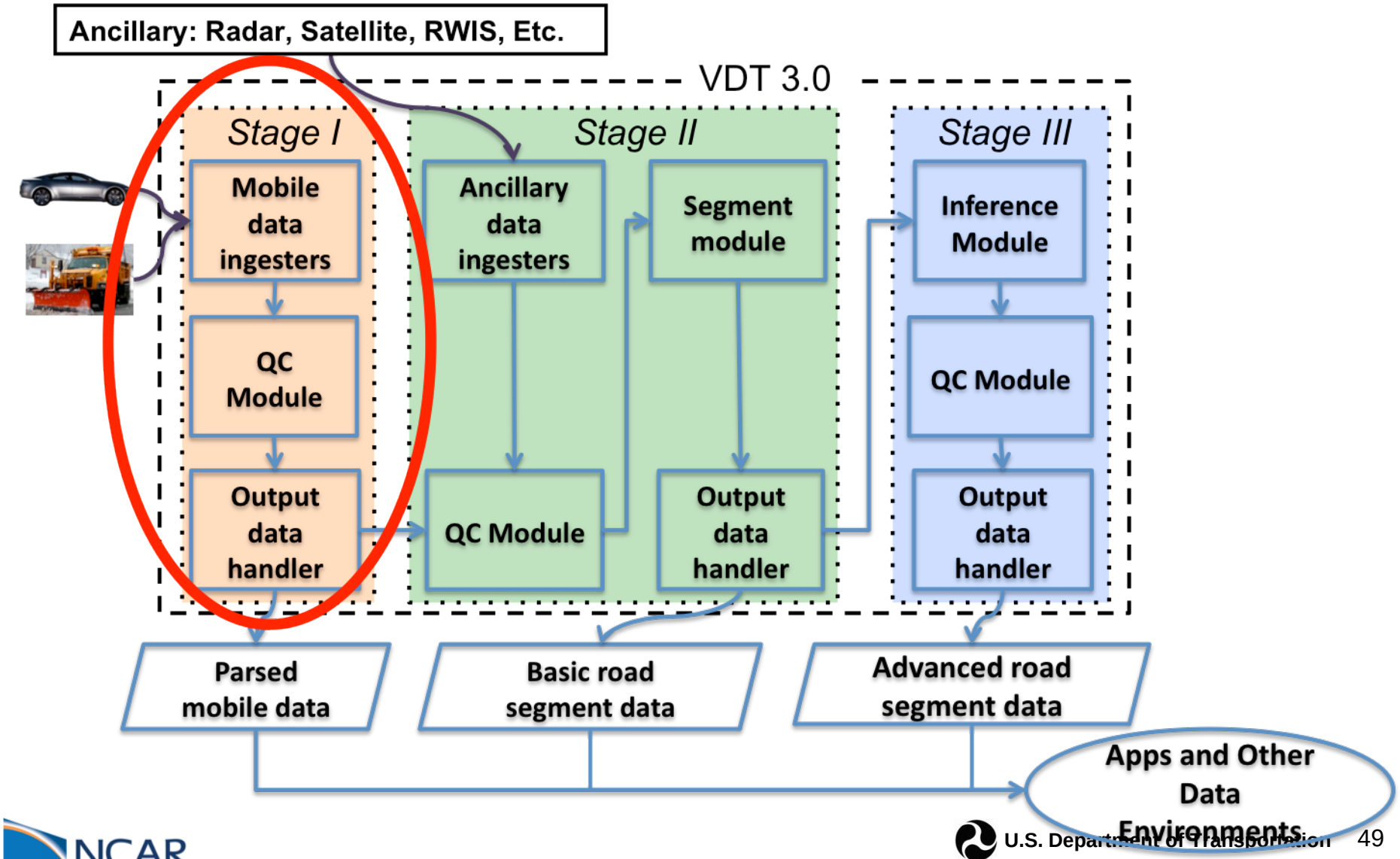

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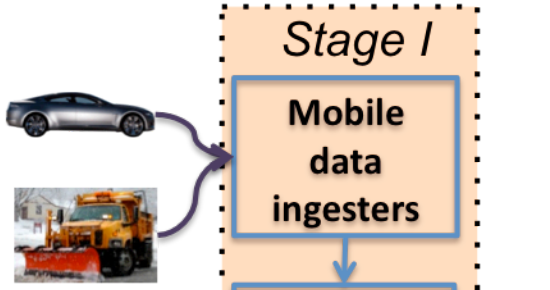
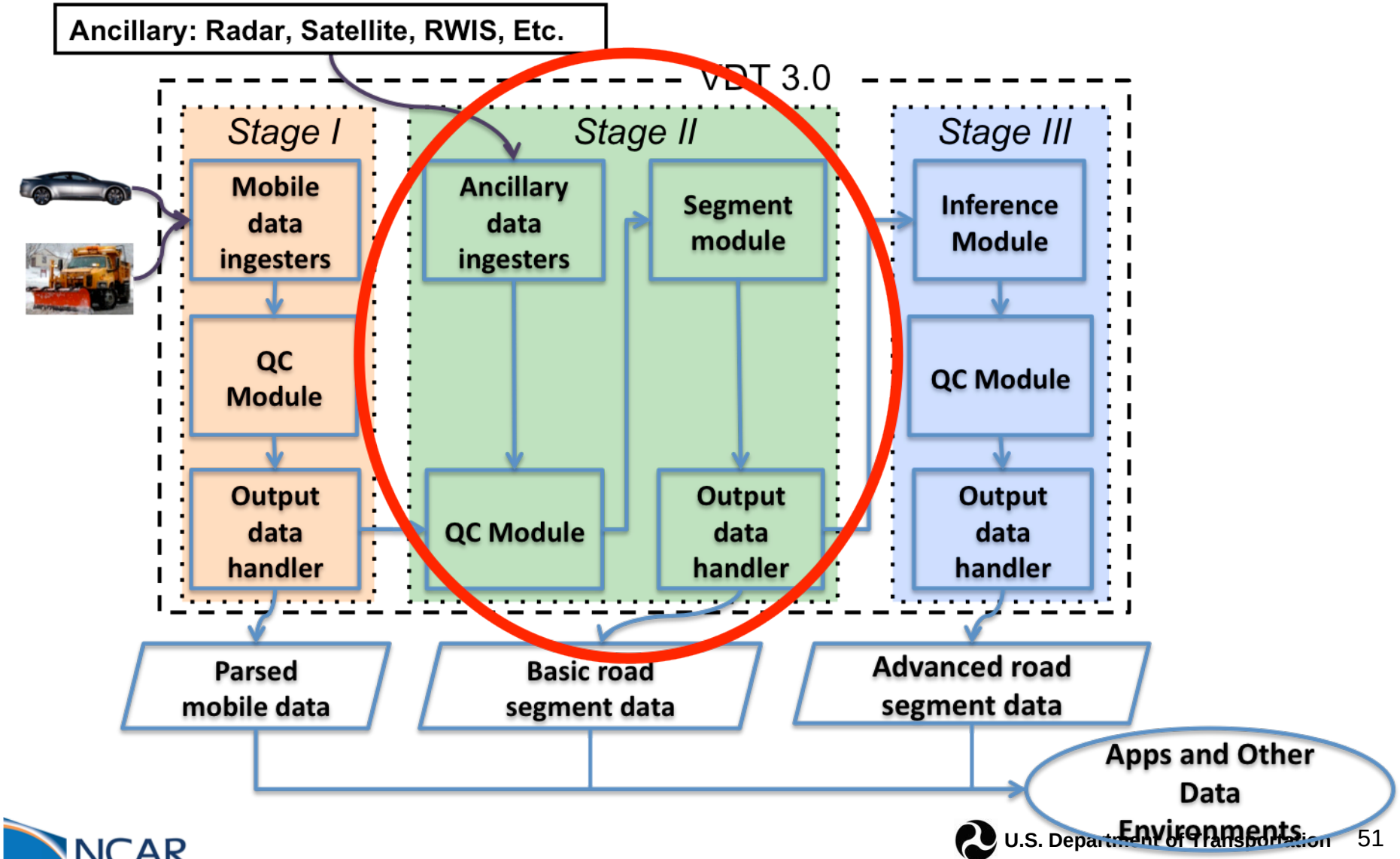


- Ingest vehicle data from CANBus & aftermarket sensors
- Data parsed, sorted/binned
- Sorted by time, road segment and grid cell
  - Segments & grids user defined
- All processed data available for other applications

Vehicle Data Translator (VDT) – Version 3.0



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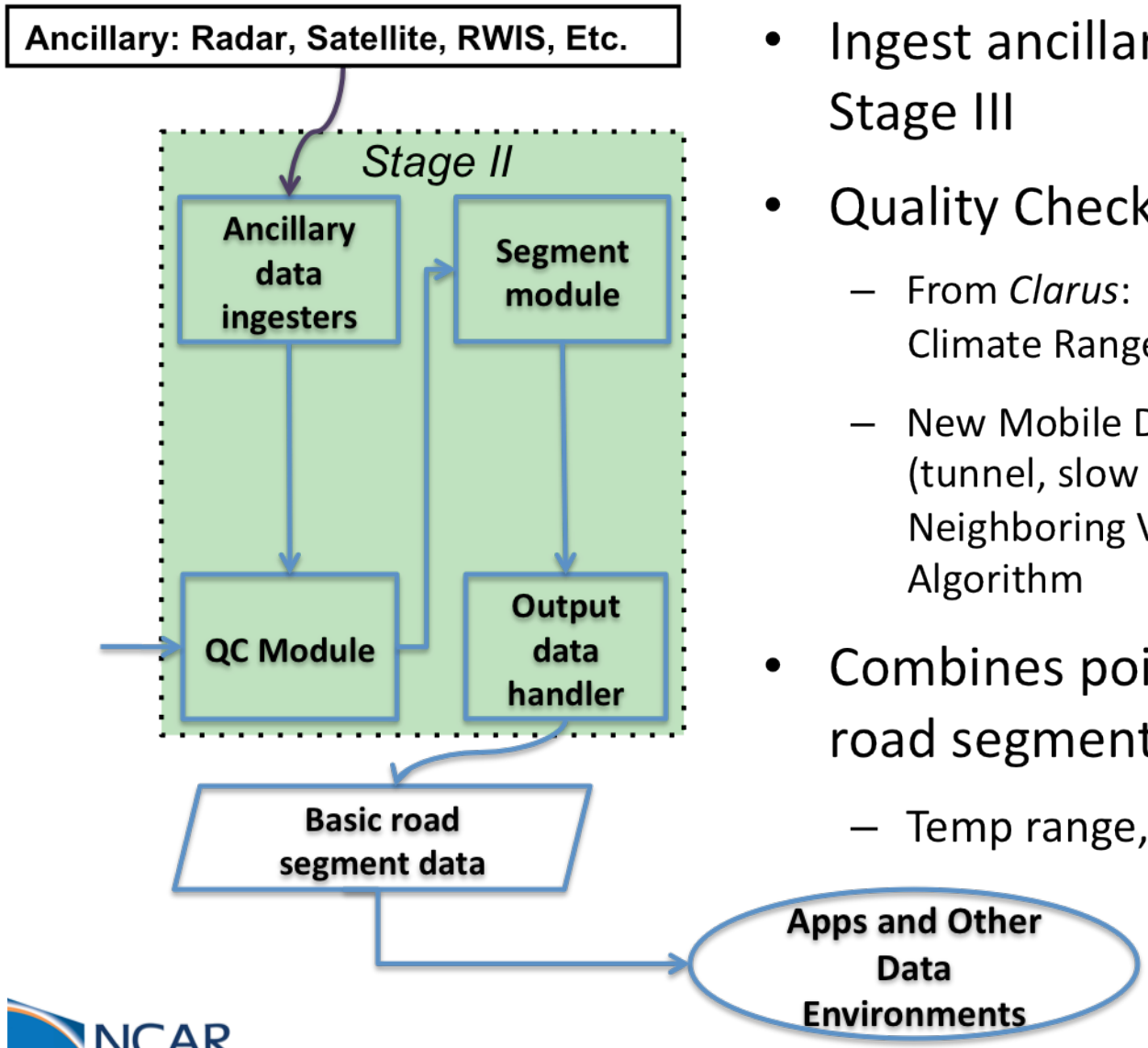
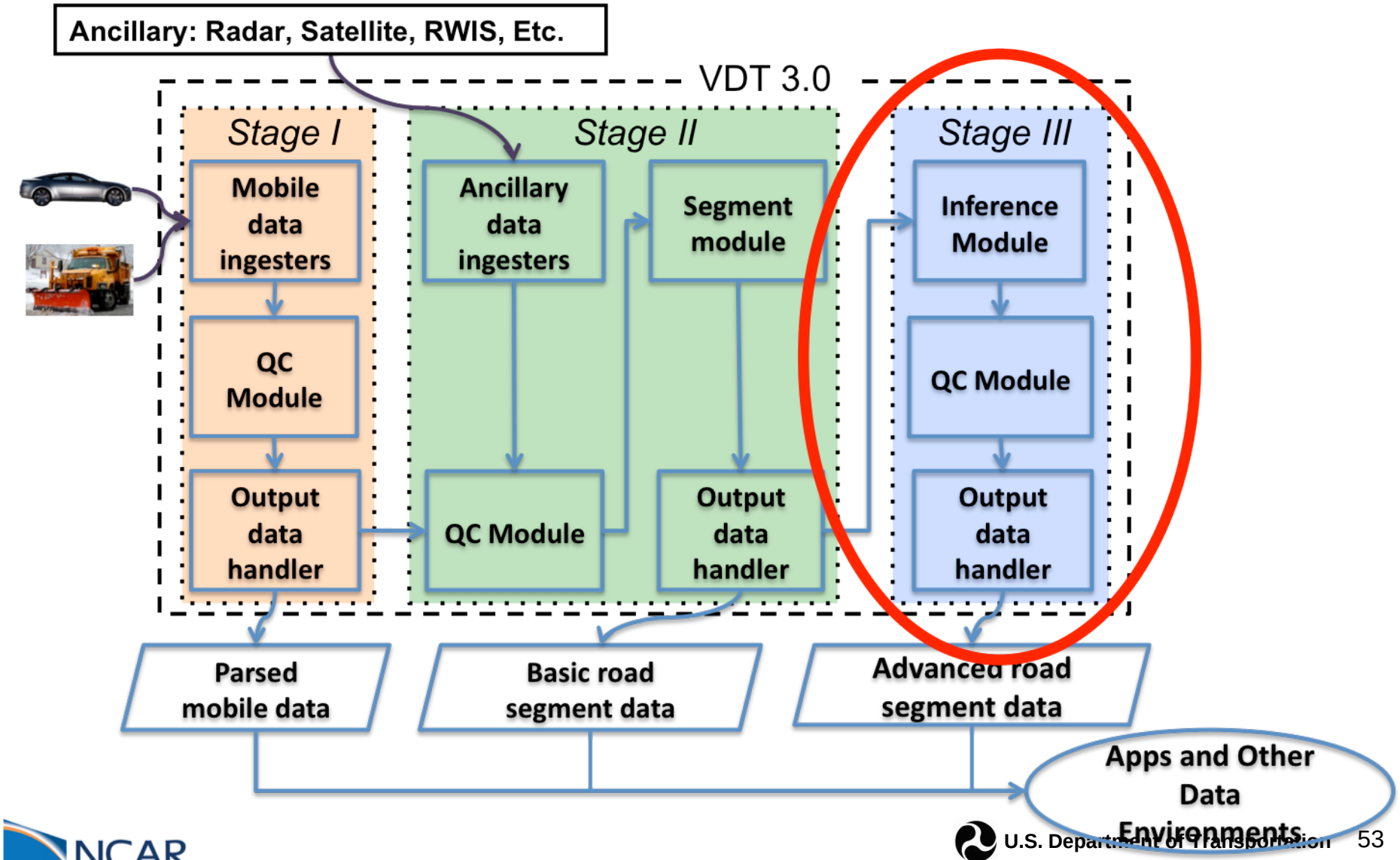
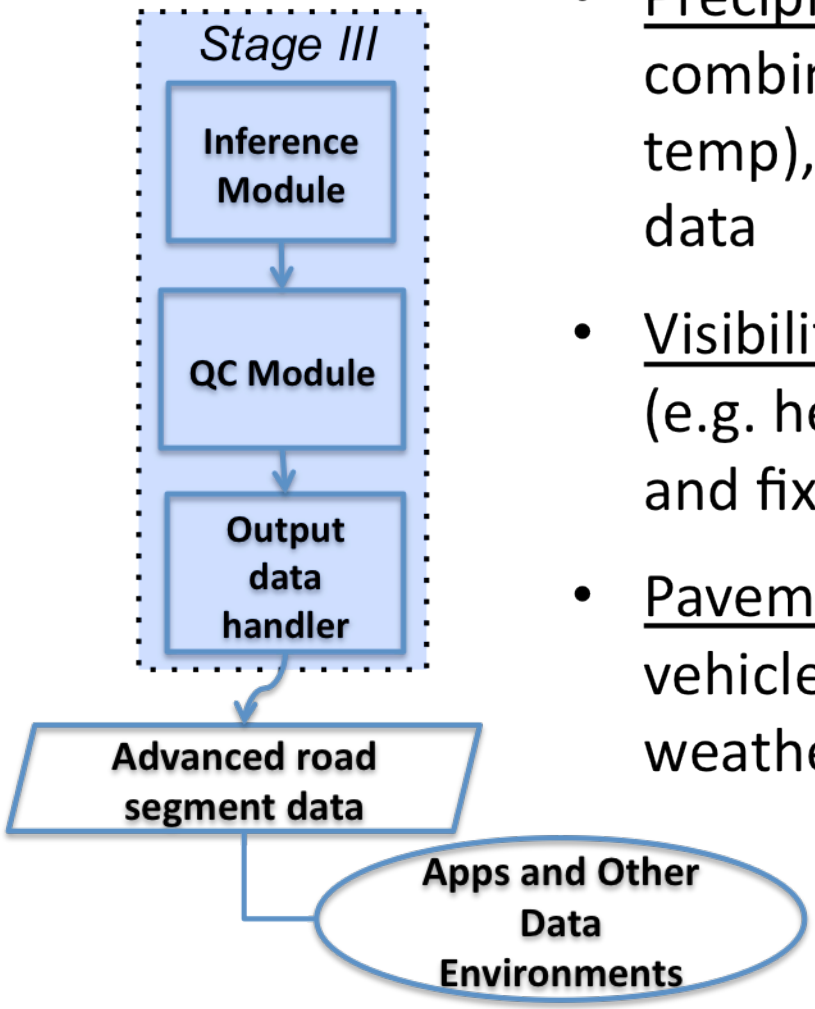


- Ingest ancillary data for QC and Stage III
- Quality Checks
  - From *Clarus*: Sensor Range, Spatial, Climate Range
  - New Mobile Data Tests: Data Filtering (tunnel, slow speeds), Model Analysis, Neighboring Vehicle, Combined Algorithm
- Combines point data into basic road segment products
  - Temp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

Vehicle Data Translator (VDT) – Version 3.0

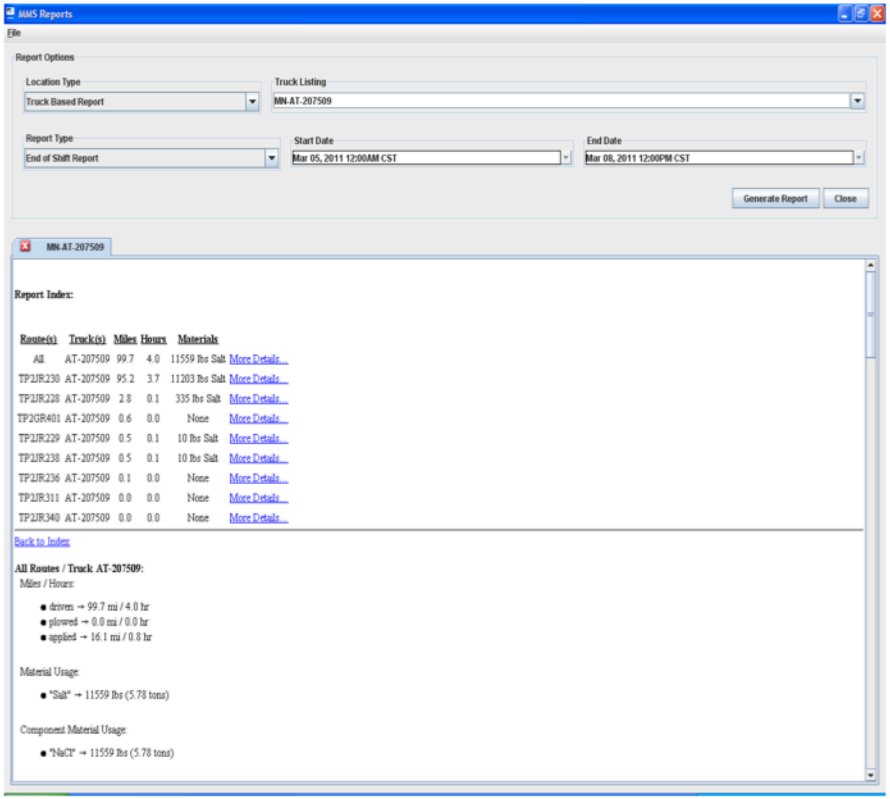


Vehicle Data Translator (VDT) – Version 3.0



- 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

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

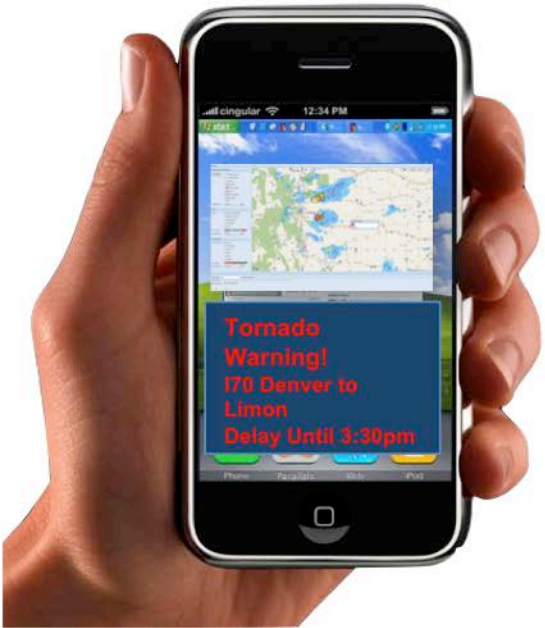
Not just for the everyday driver!

APPLICATIONS

Winter Maintenance – Where are we losing the road?

APPLICATIONS

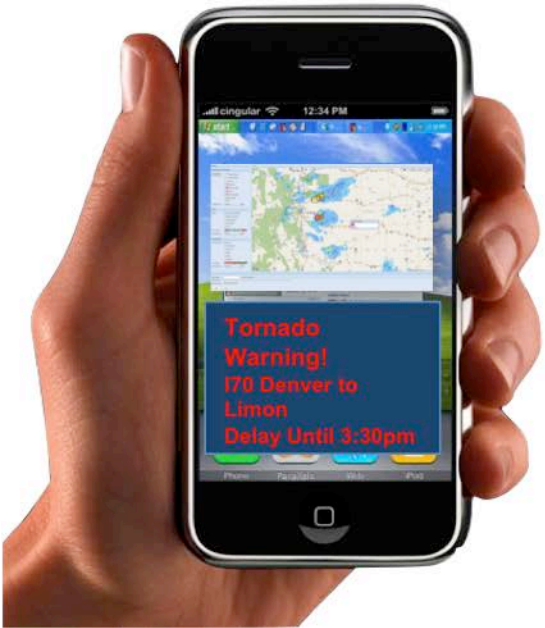
Winter Maintenance – Where are we losing the road?



Route Specific Warnings for…

APPLICATIONS

Winter Maintenance – Where are we losing the road?



Route Specific Impact Warnings for…

School
Buses

APPLICATIONS

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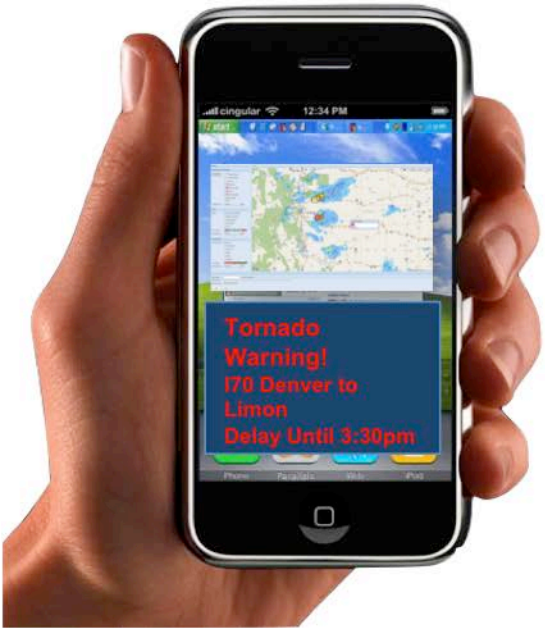
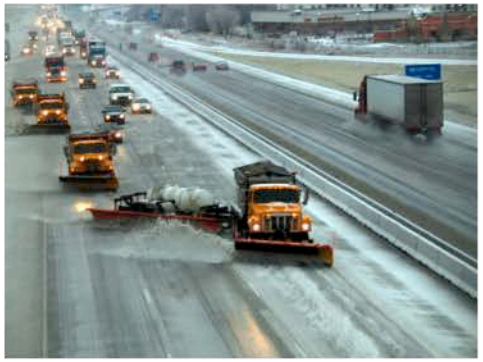


Route Specific Impact Warnings for…

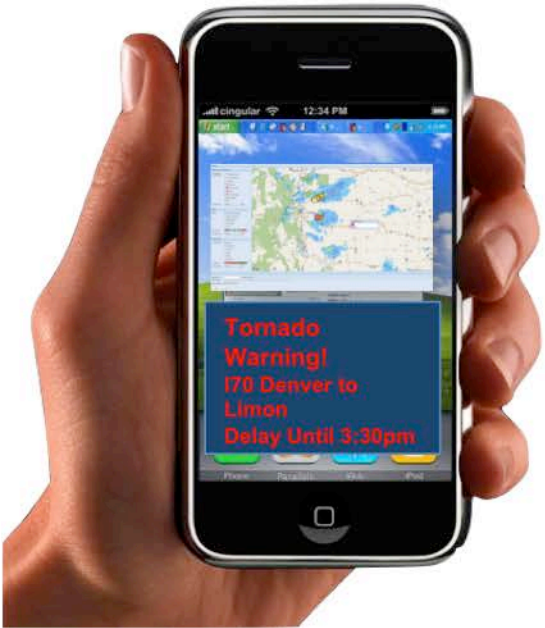
School Buses

Truckers

APPLICATIONS



Winter Maintenance – Where are we losing the road?



Route Specific Impact Warnings for…

School Buses

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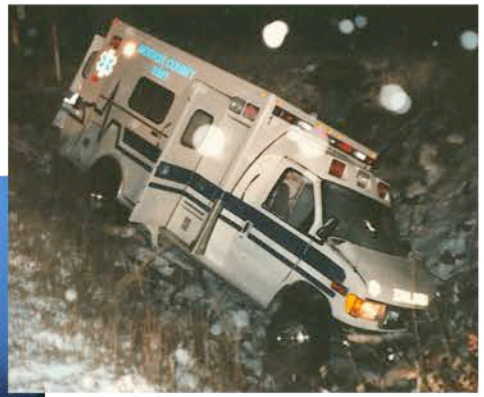
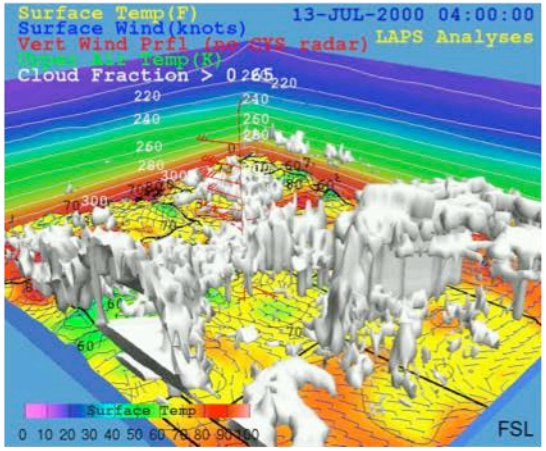


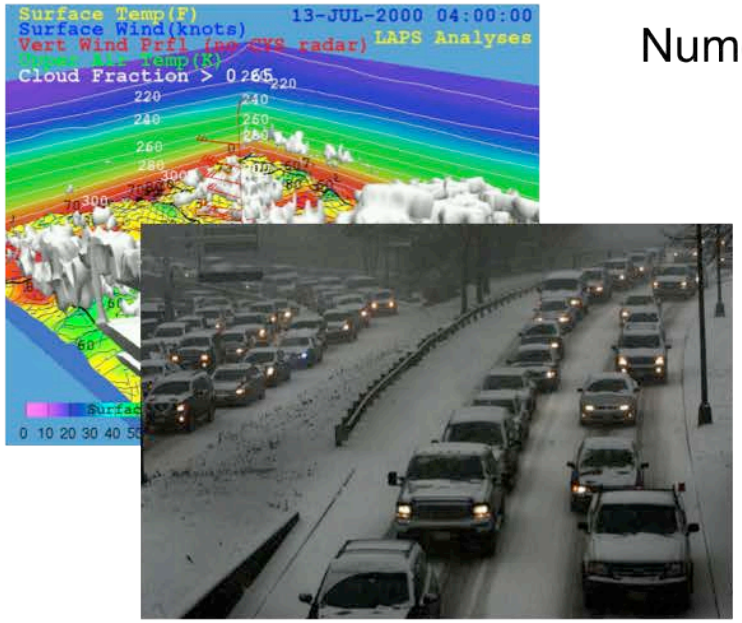
EMS

More APPLICATIONS



Numerical Weather Modeling

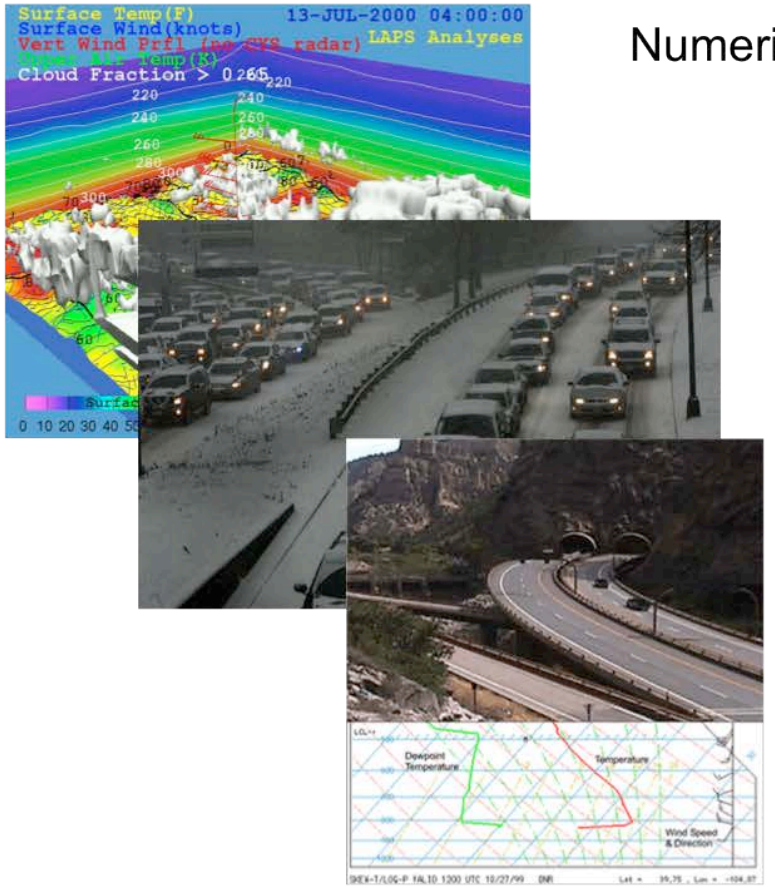
More APPLICATIONS



Numerical Weather Modeling

Traffic Modeling and Alerting

More APPLICATIONS

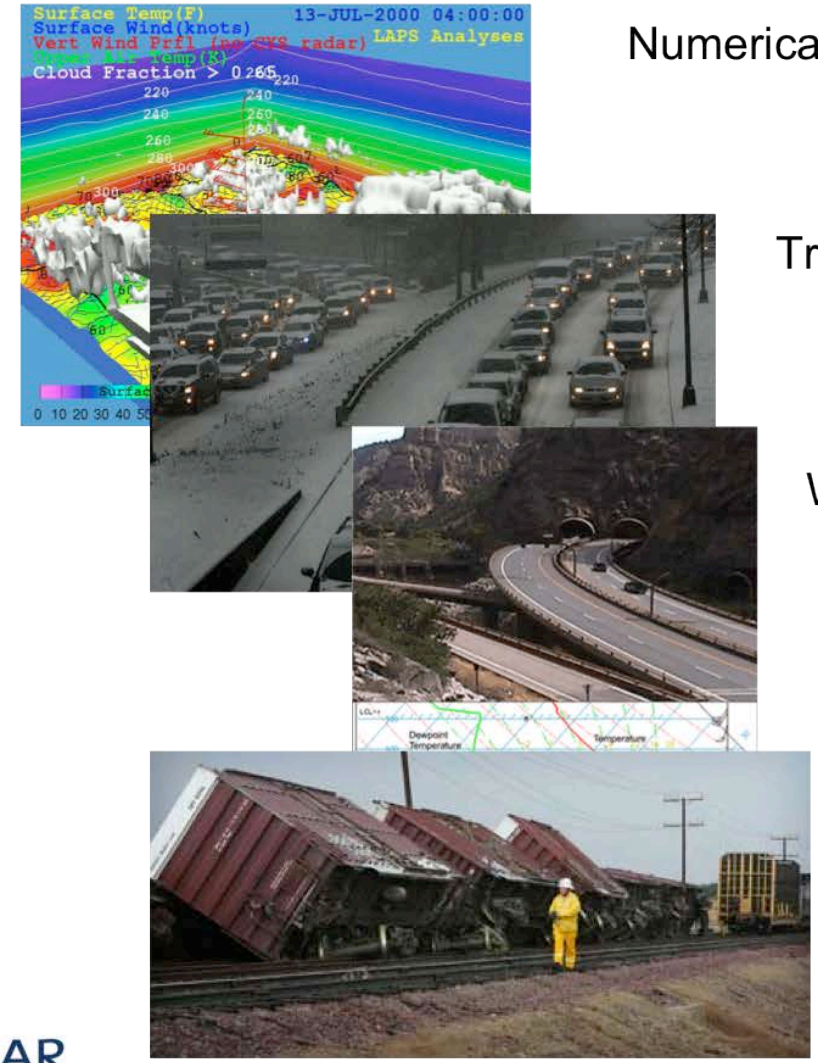


Numerical Weather Modeling

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