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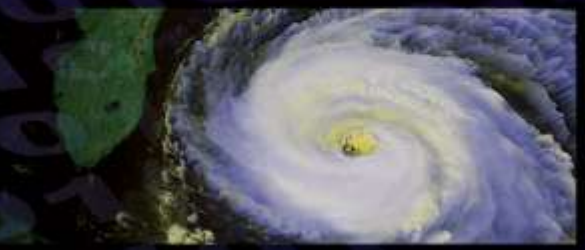

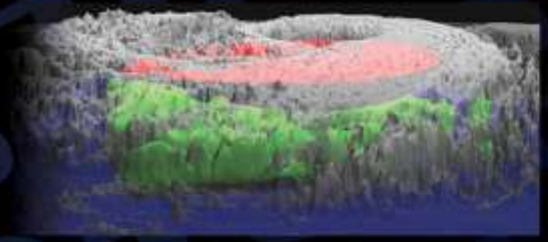

Passenger Bus Industry Weather Information Application (PBI WxApp) Presentation

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Overview

The PBI WxApp demonstrates an important application of *Clarus* system data for the Passenger Bus Industry (PBI). Combined with environmental data from mobile platforms, the PBI WxApp provides "weather windows" for users who need to know real-time weather conditions along routes.

▶The high-level objectives of this project are as follows:

- Integrate mobile platform environmental observations with fixed-site observations in order to create a window of meteorological information along a commercial vehicle's intended route
- Increase situational awareness for drivers, passengers, and dispatchers or other operations personnel who communicate with fleet vehicles
- Improve decision support systems by including mobile platform observations as input data that describe environmental conditions in locations not sampled by fixed-site road-weather equipment

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Stakeholders

- Primary Stakeholders:
  - FHWA
  - Greyhound
  - Con-way
  - Weather Telematics

- Secondary Stakeholders
  - Road-weather community at large
  - RITA (Connected Vehicles)
  - ITS

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Application Development

The PBI WxApp was developed iteratively using an Agile Software Development Lifecycle (SDLC), which has very short development cycles (sprints), where requirements and features are added to each build

- The sprints focused on the following:
  - Integrate data from the three data sources (ASOS stations, *Clarus* system, MoPED system)
  - Choose Google Maps Application Programming Interface (API)
  - Create a list of routes and lag times
  - Develop icons and graphical user interface to make basic selections

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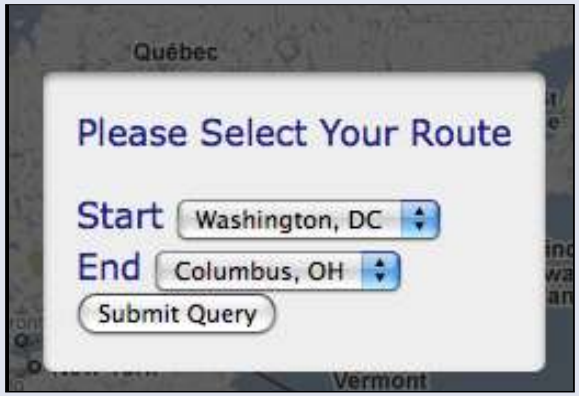
Application Features

- Route Selection Screen
  - Pop-up dialog box for route selection



- Overview Screen
  - Route presented based on selection
  - High-level overview of weather conditions based on site data
  - Quick view for situational awareness

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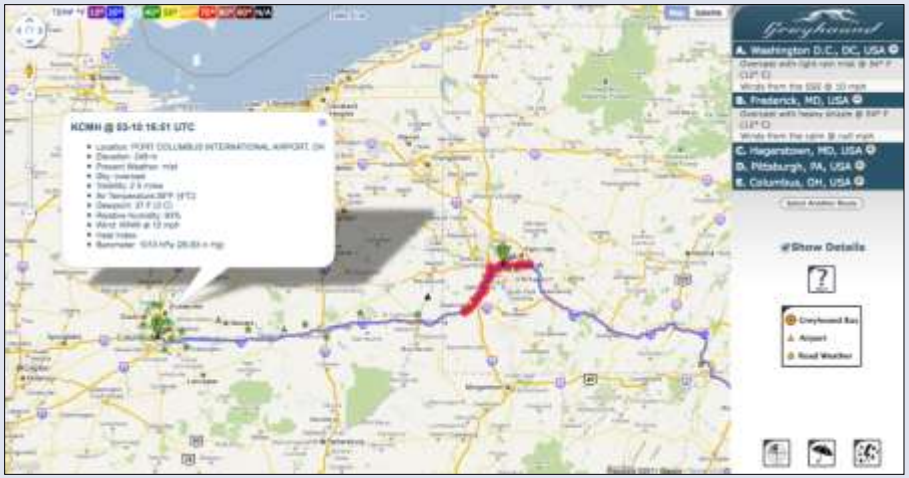
Application Features (Cont.)

- Detail Screen
  - Legend differentiates among three data sources:
    - ASOS (Airport)
    - *Clarus* system (RWIS)
    - MoPED system (Greyhound, Con-way)
  - Detailed information per site or mobile platform
  - Attributes prioritized to highlight precipitation, present weather (incl. sky cover), visibility, and temperature
  - Highlight segments of travel routes that present hazardous situations (currently conceptual rendering only automatically)



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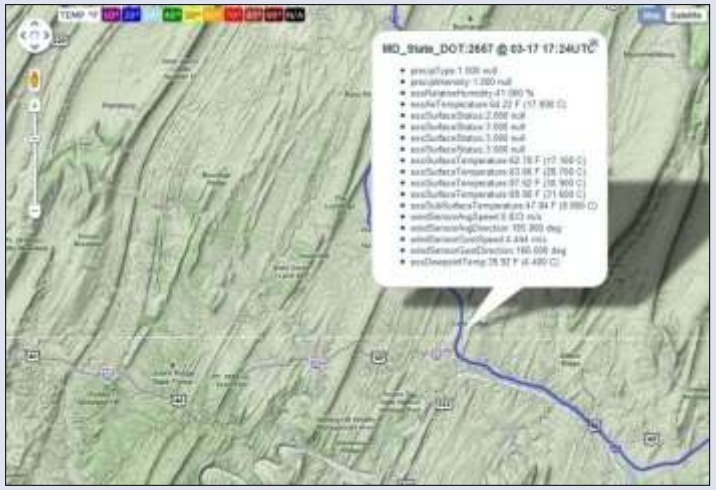
Application Features (Cont.)

- Detail Screen (Continued)
  - Topographical reference with Google Maps to place weather conditions in context of in-situ terrain
  - Help tool that steps users through application functionality
  - Links to NOAA for radar imagery, watches/warnings, and graphical forecasts



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Instrumentation

- The PBI WxApp project initially had Greyhound buses as the mobile platforms with environmental instrumentation installed by Weather Telematics.

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Instrumentation

- The PBI WxApp project initially had Greyhound buses as the mobile platforms with environmental instrumentation installed by Weather Telematics.
- Today, Con-way Cascadia Freightliner trucks serve as the mobile platforms. Limited participation by Greyhound.

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Mobile Platform Data Attributes

- Mobile Platform data attributes from Weather Telematics
  - **Road temperature:** IR detection of pavement temperature
  - **Air temperature:** Vehicles measure ambient temperature with precision greater than OEM equipment
  - **Relative humidity:** Vehicles accurately detecting high relative humidity near 100% in fog
  - **Dewpoint (derived):** Derived attribute from air temperature and relative humidity
  - **Barometric pressure:** Vehicles measure 'station' pressure
  - **Sea-level pressure (derived):** SLP is computed from barometric (station) pressure and GPS elevation
  - **Ambient light:** Vehicles are able to determine cloudy versus sunny areas, and degrees of cloudiness (generically)
  - **Precipitation:** Vehicles are able to detect areas of precipitation, and intensity of precipitation (generically)
  - **Other Environmental:** Vehicles measure surface ozone, which affects health

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Mobile Platform Data Attributes (Cont.)

- Vehicles provide great detail when traveling through interchanges, particularly temperature differences between bridges and underpasses. Mobile platform data supplements detail to RWIS.

Vehicle 789 passing through an interchange near NYDOT 3239 RWIS

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Quality Control and Standards

- ASOS, RWIS and MoPED values are processed in the PBI WxApp without filtering or modification from their respective systems
- *Clarus* system does not filter or remove suspect values from RWIS stations
  - *Clarus* system provides attribute quality flags, but these were not acquired or integrated into the PBI WxApp
  - The integration of *Clarus* system quality flags can be considered for future versions of the PBI WxApp
- MoPED data are subject to internal quality control procedures by GST, but only for evaluation of data quality

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- Fixed-site stations make use of NOAA standards for ASOS and FHWA standards for RWIS
- Mobile platform observations use the standards developed by GST for the NOAA

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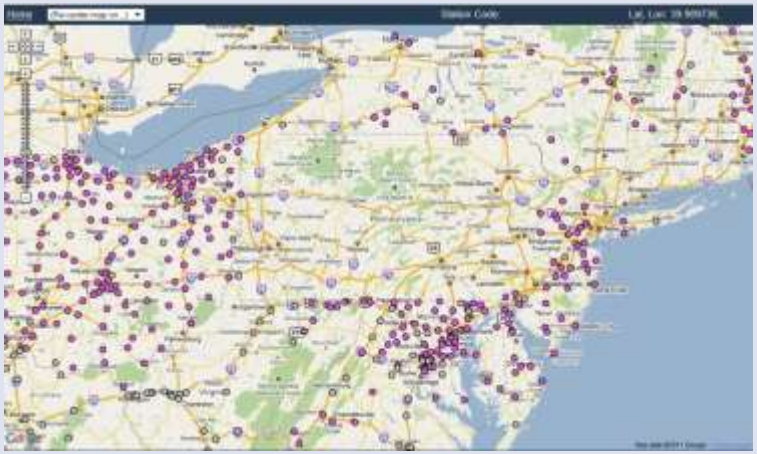
PBI WxApp Findings

Understanding geographic coverage

- Contributions from multiple sources with varying geographic coverages
  - The Clarus system is national, but there are a few states that do not provide data (i.e., Pennsylvania), which causes gaps in the PBI WxApp
  - ASOS stations provide national coverage
  - MoPED gathers data from vehicles that travel from fleet terminals. Very dependent on spacing between terminals



CLARUS RWIS locations

Current Mobile Platform Deployment Hubs

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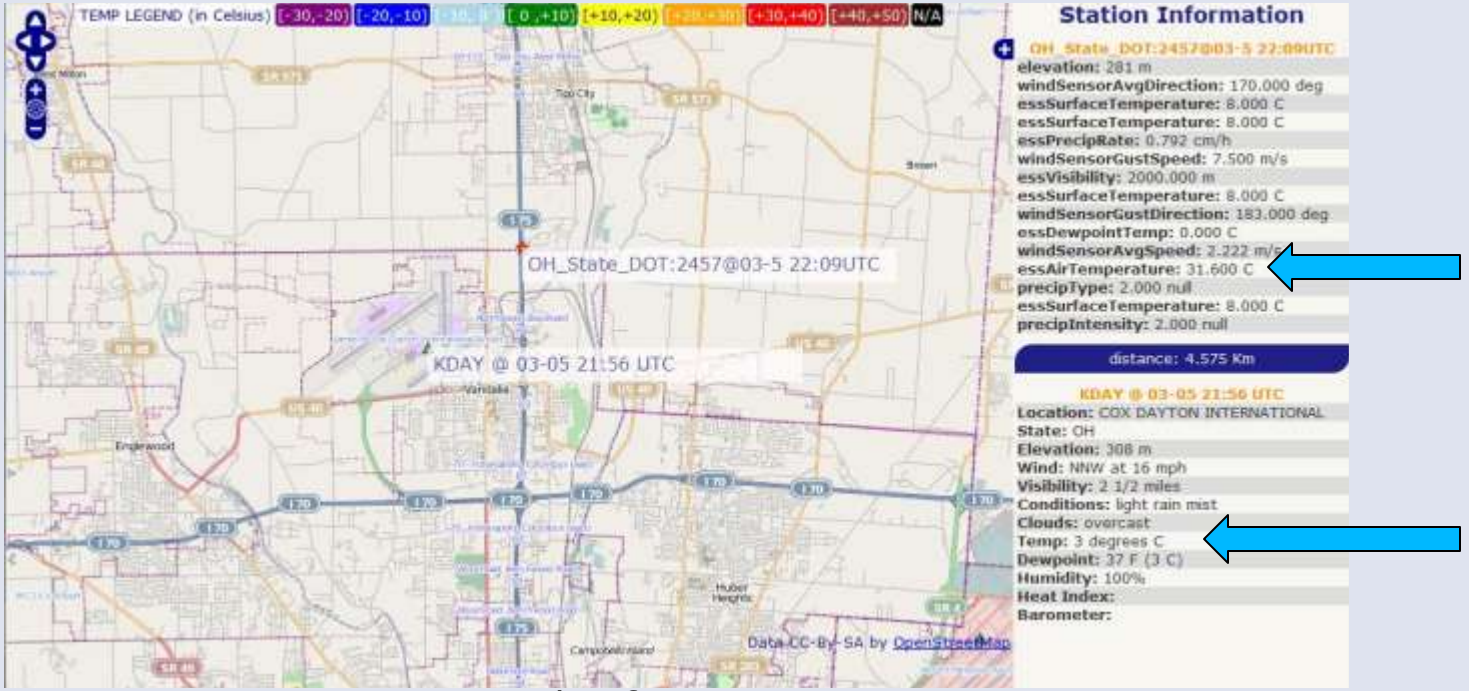
PBI WxApp Findings (Cont.)

- **Recognizing data accuracy**
  - If RWIS, ASOS, or mobile platforms give an inaccurate reading, the inaccuracies will be natively carried into the PBI WxApp. No filtering or ingest of Clarus quality flags.



Example of Inaccurate Data
(RWIS site reports an air temperature of 31.6˚ C while it is 3˚ C at the airport)

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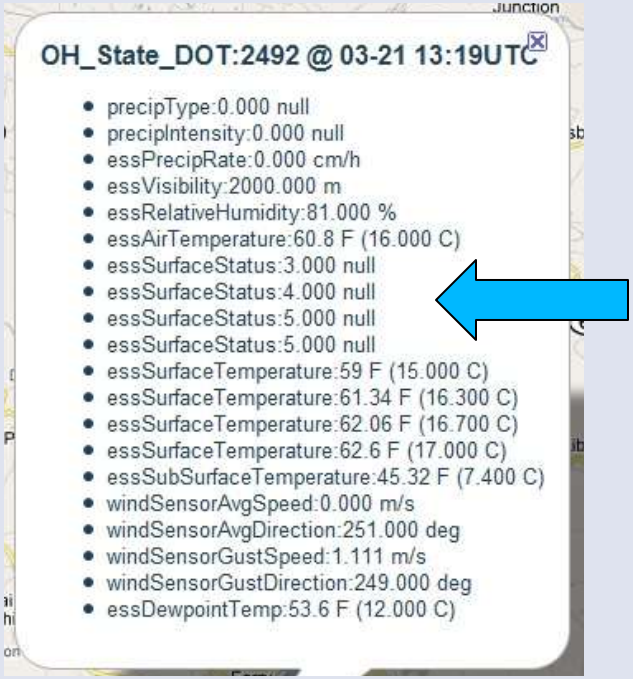
PBI WxApp Findings (Cont.)

- **Understanding data 'conflict'**
  - RWIS stations can report multiple surface status (essSurfaceStatus) conditions and multiple surface pavement temperatures (essSurfaceTemperature), which can result in confusion or apparent conflicting information.
  - It is difficult to resolve conflicts without metadata directly showing if the road sensors are sheltered in any way.



Example of Data Conflict

Four surface status sensors with three separate conditions (dry, trace moisture, wet). Where???

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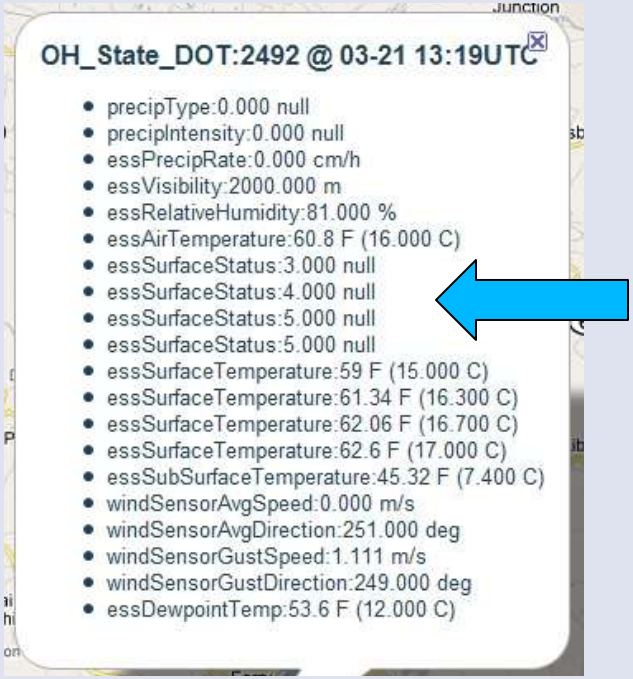
PBI WxApp Findings (Cont.)

- **Interpreting raw data**
- Need to provide meaning to raw numbers that are not familiar or intuitive
  - RWIS Surface Condition = 3 means “DRY SURFACE
  - MoPED Precipitation = 10 means “LIGHT PRECIPITATION”
- ASOS stations provide an interpretation of intensity (light, moderate, heavy) that might be adopted for the mobile platform rainfall attribute.



Interpreting RWIS values

SurfaceStatus = 3 Dry
SurfaceStatus = 4 Trace Moisture
SurfaceStatus = 5 Wet

Source: NTCIP 1204 v03

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PBI WxApp Findings (Cont.)

- **Reconciling attribute expressions from disparate systems**
  - Naming conventions are very important in the industry
  - What RWIS titles "Air Temperature", ASOS calls "Temperature"
  - Some people might think RWIS "Surface Temperature" is an air temperature … but it is a road surface temperature
  - PBI users are interested in both air and road (pavement) temperature.

- **Prioritizing the most significant attributes**
  - Present Weather (including precipitation, visibility, and temperature) have the greatest impact on PBI users and are prioritized accordingly.

Example of Attribute Prioritization

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Recommendations

- **Integrate metadata**
  - Metadata about sensor location can clarify apparent data conflicts (e.g., when multiple surface conditions are expressed).
- **Improve the expression of 'states'**
  - Some attributes are expressed in numeric values that represent states. Mapping essSurfaceStatus=5 to "wet" is more intuitive to the user.
- **Improve Visibility detection and reporting**
  - PBI WxApp users would need to know that a 2 km visibility reading from RWIS or 6 mile visibility reading from ASOS are upper reporting limits. The actual visibility could be much different. Metadata and live 'webcams' might help here.
- **Integrate Quality Flags into the visualization**
  - When a quality flag is cast by the native system (Clarus), make a simple reference on the PBI WxApp screen display that the data attribute is suspect.

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Recommendations (Cont.)

- **Integrate additional data sources**
  - A link to NOAA's radar Website is included in the PBI WxApp, but future versions might include radar overlay capability on the geographical display itself.
- **Develop monitoring and notification tools**
  - Monitoring and notification tools can reference observed weather to the position of the vehicle. For example, if a given RWIS station indicates the potential for icing, a text-message notification can be sent to the driver when the vehicle is within a configurable distance of that RWIS station.
- **Expand the role and coverage of mobile platform observations**
  - Mobile platforms sample vast amounts of geography in between fixed-site stations, including critical infrastructure (e.g., bridges, overpasses, low areas prone to fog). Pavement Forecast Models and Decision Support Systems (i.e., MDSS) will benefit from the integration of data acquired by mobile platforms.

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Conclusion

- **The current PBI WxApp achieves the objectives of this *Clarus* research project**
  - The PBI WxApp enhances road-weather situational awareness with the combined assets of fixed land stations (ASOS, RWIS) and mobile platforms (MoPED system)
- **The PBI WxApp demonstrates the enhanced ability to provide meaningful "weather windows"**
  - Overview screen for high-level orientation, and Detail screen for individual fixed station or mobile platform observational data display
- **The Findings show good coverage and availability of data**
  - Fixed-site and mobile platform data can be obtained nationwide along many major transportation corridors.
- **The Recommendations include 'next steps'**
  - Data interpretation, reconciliation of attributes from disparate systems, integrated metadata and quality control, use of webcam imagery, and monitoring/notification tools.

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- National Weather Service: 2010. *NWS Instruction 10-1302: Requirements and Standards for NWS Climate Observations*

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