The Integration of Multi-State *Clarus* Data into Data Visualization Tools

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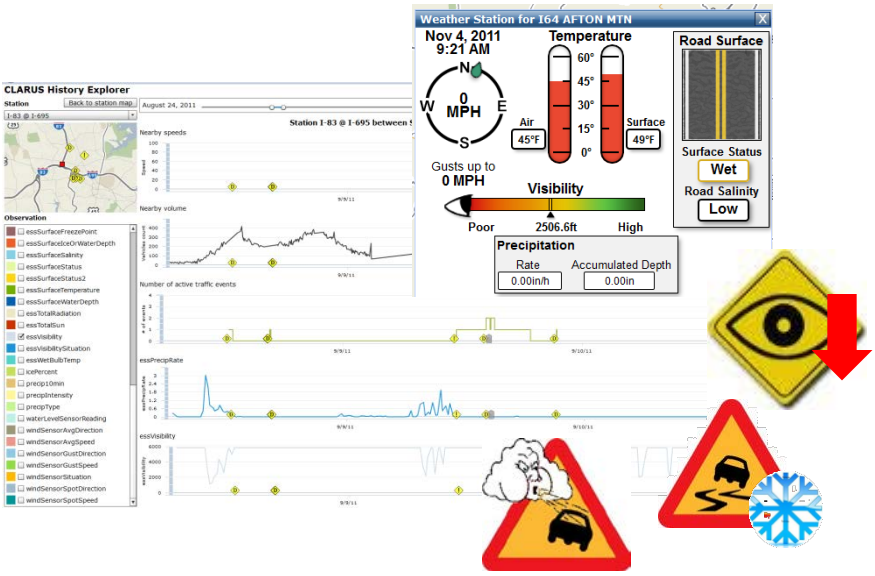
Final Report — December 9, 2011

FHWA-JPO-12-008



U.S. Department of Transportation
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The Cover Image is a composite of screen captures from the Regional Integrated Transportation Information System (RITIS). All remaining figures are RITIS screen shots and system diagrams provided by the CATT Laboratory.

Notice

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16. Abstract: This project focused on the integration of all *Clarus* Data into the Regional Integrated Transportation Information System (RITIS) for real-time situational awareness and historical safety data analysis. The initial outcomes of this project are the full integration of RITIS and *Clarus* datasets into a massive database, the creation of a series of real-time situational awareness tools built around the integrated data sources, and the creation of several visual analytics tools that allow users to explore the relationships between weather, speed, volume, and incident datasets. The incorporation of *Clarus* data into the RITIS platform means that there are now thousands of transportation operations specialists, university researchers, and metropolitan planning agencies that have the ability to view real-time road weather data within the broader context of other transportation system information.

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Executive Summary

In 2010 FHWA issued a Broad Agency Announcement (BAA) soliciting proposals to use the Clarus System in new/transformative ways. The goal of the BAA was to (1) foster collaboration between transportation engineering, computer science, and atmospheric science disciplines, and to (2) support research and scientific study on the use of *Clarus* System data to improve surface transportation weather management and operations, create innovative interfaces, and/or develop new applications including weather-responsive traffic management tools. "The Integration of Multi-State *Clarus* Data into Real-time and Archived Regional Integrated Transportation Information System (RITIS) Data Visualization Tools," was one of the projects awarded funding by FHWA as a result of this BAA.

The University of Maryland Center for Advanced Transportation Technology Laboratory (CATT Lab) has integrated all *Clarus* Data into their Regional Integrated Transportation Information System (RITIS) for real-time situational awareness and historical safety data analysis. RITIS is a data fusion engine that ingests transportation data in real-time. The data is stored in its native format for agency-specific performance reporting, but it is translated and fused into a standard format for enabling regional analysis and visualization.

The initial outcomes of this project are the full integration of RITIS and *Clarus* datasets into a massive database, the creation of a series of real-time situational awareness tools built around the integrated data sources, and the creation of several visual analytics tools that allow users to explore the relationships between weather, speed, volume, and incident datasets.

The incorporation of *Clarus* data into the RITIS platform means that there are now thousands of transportation operations specialists, university researchers, and metropolitan planning agencies that have the ability to view real-time road weather data within the broader context of other transportation system information. Researchers are also developing visual analytics tools surrounding these combined data sets that will enable new forms of data analysis and discovery.

Background

Just as the National Research Council report titled "Where the Weather Meets the Road" describes the need for a robust, integrated road weather observational network and database management system, so have many traffic management center and transportation researchers recognized the need for a similar real-time and archived observation system for other transportation event, incident, and traffic-related data. The Regional Integrated Transportation Information System, developed by the University of Maryland Center for Advanced Transportation Technology Laboratory, came about in part because many of the National Capital Region's transportation agencies had implemented stand-alone incident and traffic management programs to mitigate the effects of incidents, improve emergency response, and manage congestion. Each agency operates its systems separately, using its own data collection and processing systems. However, conditions in one jurisdiction affect travel in others and sometimes throughout the entire region. Disruptions on one part of the network often have significant effects on one or more other jurisdictions on another part of the network. Such regional disturbances required a regional solution.

Similarly, transportation planners and researchers have long struggled with coordinating data collection, fusion, and analysis when disparate sources, multiple agencies, or multiple jurisdictions were involved. These tasks were not only troublesome for analysts, but also for the "owners" of the data who were burdened with repeated requests from planners, researchers, and even the public to provide data in one form or another. Valuable resources were being wasted on time-consuming, mundane, repetitive requests that were only made worse by stove-piped systems and bureaucracy.

While there has been an ongoing nationwide interest in regional transit and traffic management since the early 1990's, few multi-state regions have made significant progress. In the Washington D.C. metropolitan area, each transportation agency maintained its own equipment and software for monitoring traffic and travel conditions and for making operational adjustments. Information sharing between transportation agencies was ad hoc and relied on personal relationships between staff from the various transportation operations centers. However, this method of "information sharing" was not a timely, reliable, consistent mechanism for sharing operational data.

This need for regional management of Washington, D.C.'s transportation system was the impetus for the Regional Integrated Transportation Information System (RITIS). RITIS is an automated data fusion and dissemination system that compiles transportation data from each participating agency, standardizes it, and makes it available to other participating agencies back through each agency's existing transportation management systems (Figure 1). RITIS does not collect data directly from field devices; rather, participating agencies collect data from their field devices or enter information into their incident management system and make it available to RITIS. A critical component of RITIS is the archiving capability built for perpetual data storage that can be used in transportation-related studies,

after action reviews, and other performance evaluations. RITIS can easily be equated to the *Clarus* Initiative in that it is a multi-state integration, fusion, and archiving platform for transportation data.

The RITIS program has focused on usability and ease of access. Developers have created an impressive suite of real-time visualizations that allow emergency operations personnel to have greater situational awareness and to provide the public with more comprehensive traveler information.

All data that is part of the RITIS program is archived indefinitely. This archive is then made available to responders who wish to do after action reviews on incidents. The data is also made available to researchers so that they may use it for studies of any nature. CATT Laboratory developers have taken considerable care in providing the data in a manner that affords users the freedom to explore the data in simple yet powerful ways. Users can simply download raw data, or they can take advantage of a suite of powerful visual analytics tools that have been created. The value in these analytical tools is that they provide users the ability to mine through complex geospatial, temporal, and categorical datasets with the ease of a few mouse clicks. Users aren't burdened with collecting, formatting, and merging disparate data. They simply get to spend their time doing serious analysis. .

Hundreds of users access both the RITIS real-time and archive applications on a daily basis, and the consistent complaint that is voiced is, "why can't I explore the relationships between traffic flow, incidents, and weather events?" While the RITIS system does include National Weather Service Radar images, this information is not always granular enough to explore relationships between road weather conditions and their impact on events, incidents, travel times, response plans, or other variables. Similarly, RADAR weather data alone is not sufficient to manage real-time operations. While developers at the CATT Laboratory are not directly answering any of these challenging research questions, we do wish to enable others to be able to do so by solidly integrating all data from the *Clarus* Initiative into 1) the real-time RITIS program, and 2) integrate all fields resulting from this integration effort into our existing archived data visualization and exploration web applications. This integration effort was nontrivial, and required significant research into appropriate data fusion algorithms and appropriate data representation methodologies in the visualization tools.

Integration

The University of Maryland Center for Advanced Transportation Technology Laboratory (CATT Lab) integrated all *Clarus* Data into their developed a Regional Integrated Transportation Information System (RITIS) for real-time situational awareness and historical safety data analysis.

The incorporation of *Clarus* data into the RITIS platform means that there are now thousands of transportation operations specialists, university researchers, and metropolitan planning agencies that have the ability to view real-time road weather data within the broader context of other transportation system information. Researchers are also developing visual analytics tools surrounding these combined data sets that will enable new forms of data analysis and discovery.

The initial outcomes of this project are described below. It should be noted that there is still a significant amount of work that is being done to further explore what can be done with this wealth of new information. This project, however, has enabled these questions to be asked and has paved the way for years of research.

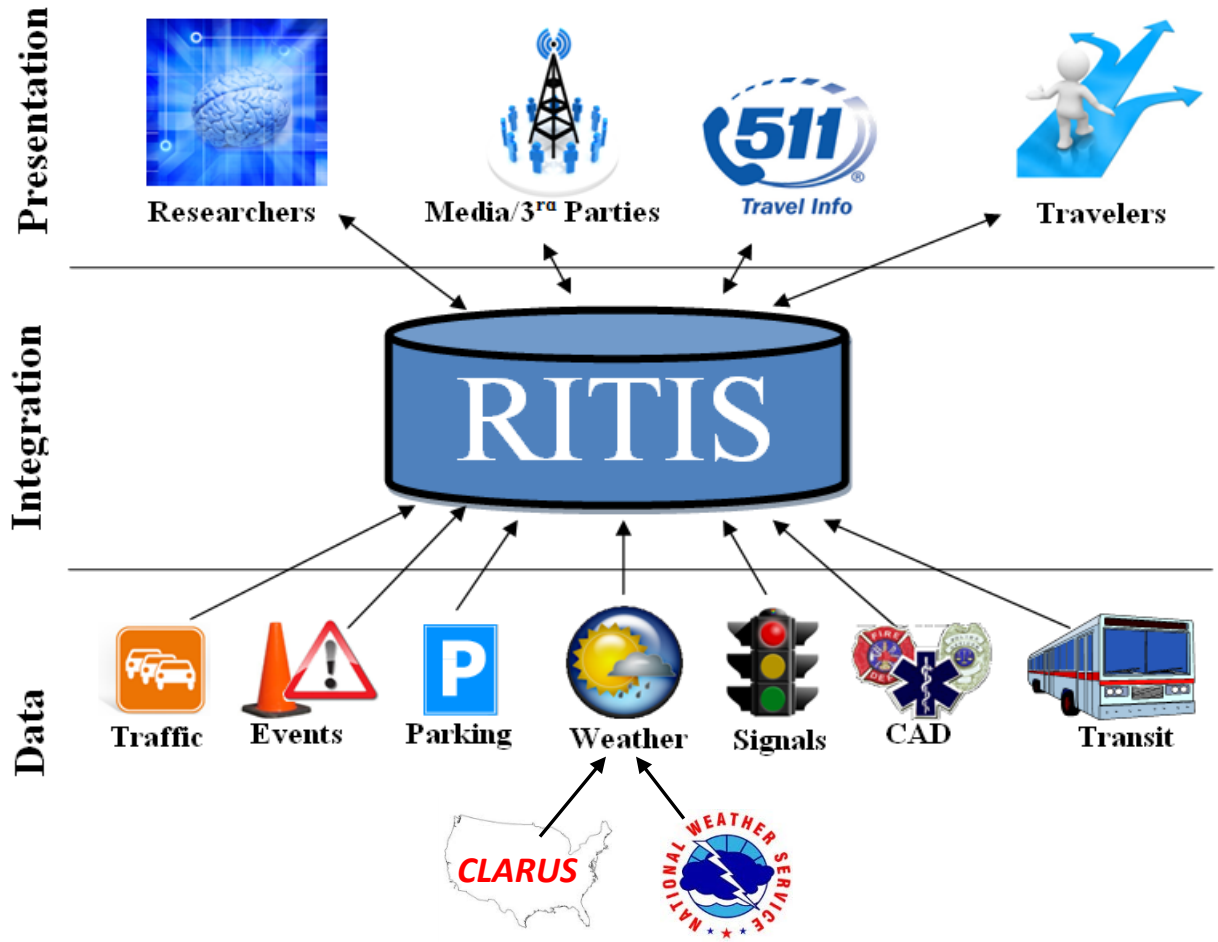

Figure 1: High level RITIS architecture with *Clarus* data as one of two primary weather sources.

User Needs Assessment

Before development began, a series of user groups were identified from both Operations and Planning Departments from the greater Washington D.C. Metropolitan Area. The majority of the users who were interviewed came from the Virginia Department of Transportation, the Maryland Department of Transportation, the District of Columbia Department of Transportation, the Washington Metropolitan

Area Transit Authority, and the Metropolitan Washington Council of Governments. All users were interviewed in group settings on multiple occasions to gather ideas and user needs. After each interview, the developers would spend several weeks prototyping specific functionality and user interfaces, then return to the same user group to present their ideas for feedback. This process was repeated three times. The sections below are the end results of these focus groups and design iterations.

Real-time Situational Awareness

Nationwide (and Canadian) Road Weather Information System (RWIS) data is now available on our production RITIS servers. The following images show how the data is represented. To meet the needs of different types of users, we are giving the individuals multiple ways to view the data.

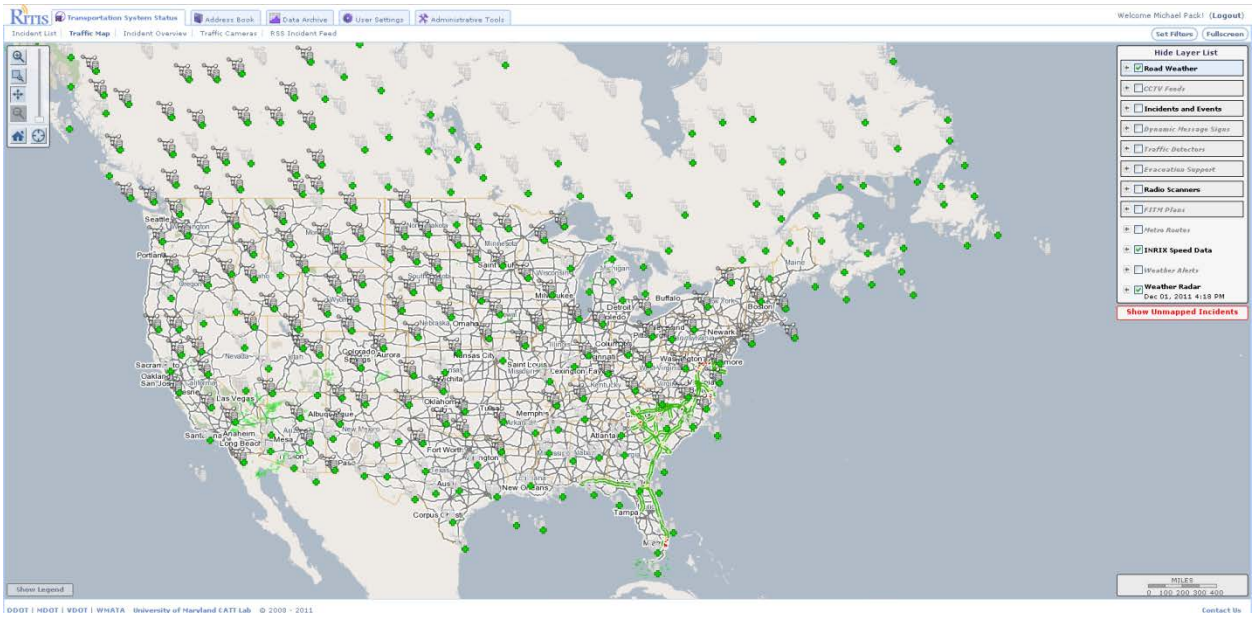

Figure 2: Nationwide view of *Clarus* RWIS stations.

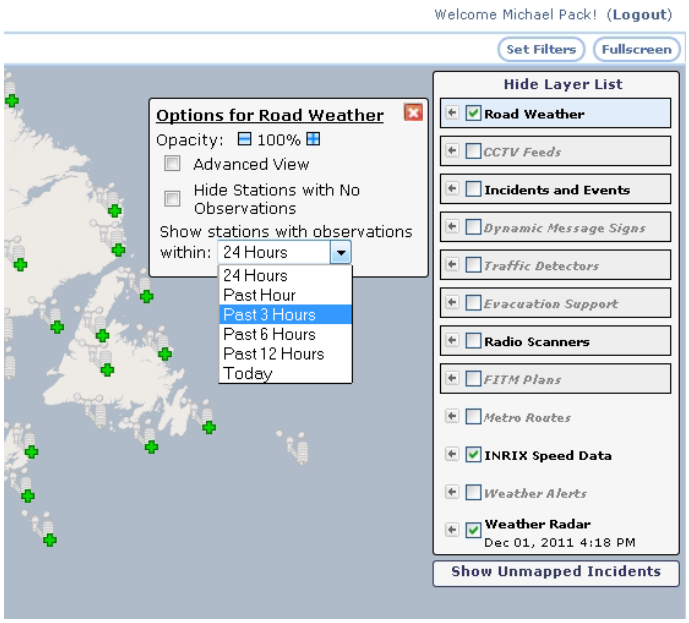

Figure 3: Adjusting user settings to control which stations are shown.

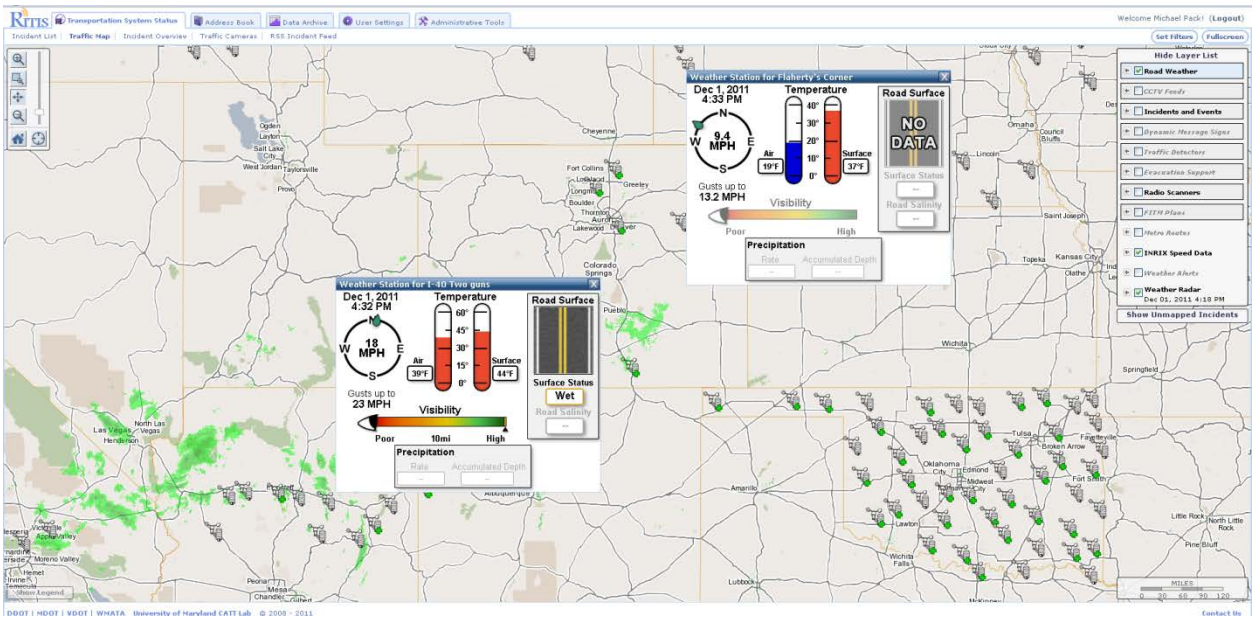

Figure 4: Clicking on a weather station brings up a graphical view of surface weather conditions.

In the above view, the data is represented in a simplistic graphical form. When roads are icy, a picture of the road becomes icy. When roads are wet, a picture of the road becomes wet. Dangerous

conditions are indicated by highlighted and flashing animations. Visibility meters indicate relative visibility distance. These layers can be turned on and off. Note that not every variable is displayed (like barometric pressure). Only elements deemed most critical to the everyday user is presented.

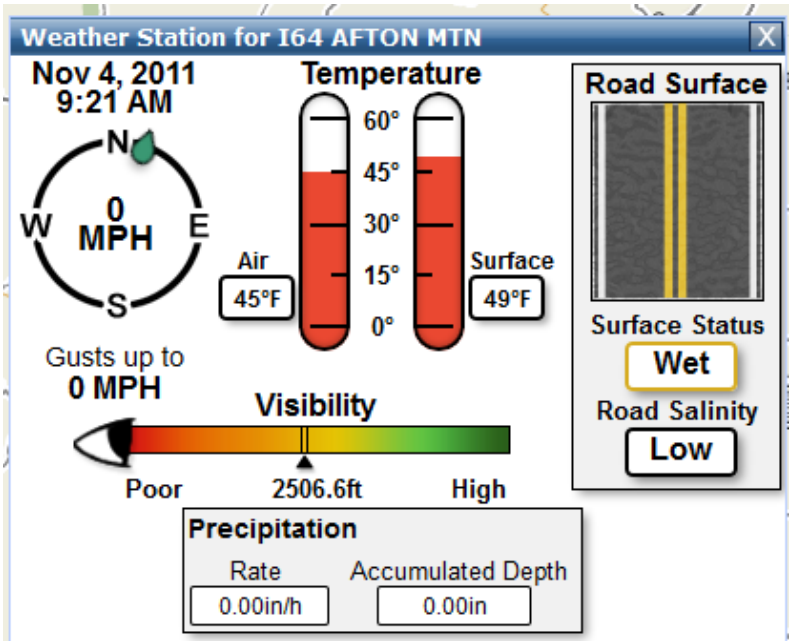

Figure 5: Close up view of RWIS data popups.

For users who are more comfortable reading specific RWIS values, an "advanced" data display can be chosen from the layer drop-down menu.

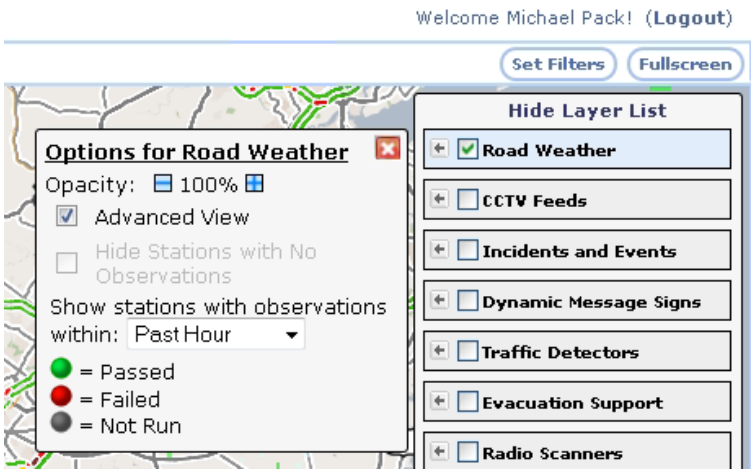

Figure 6: Switching to the "Advanced View" to see more details.

In the Advanced View, the data is presented to the user in the same manner that it is presented within the *Clarus* system; however, we have changed the representation of the variable names so that they are more easily readable. As within the *Clarus* system, the RWIS layer can be turned on and off by the user within the RITIS map.

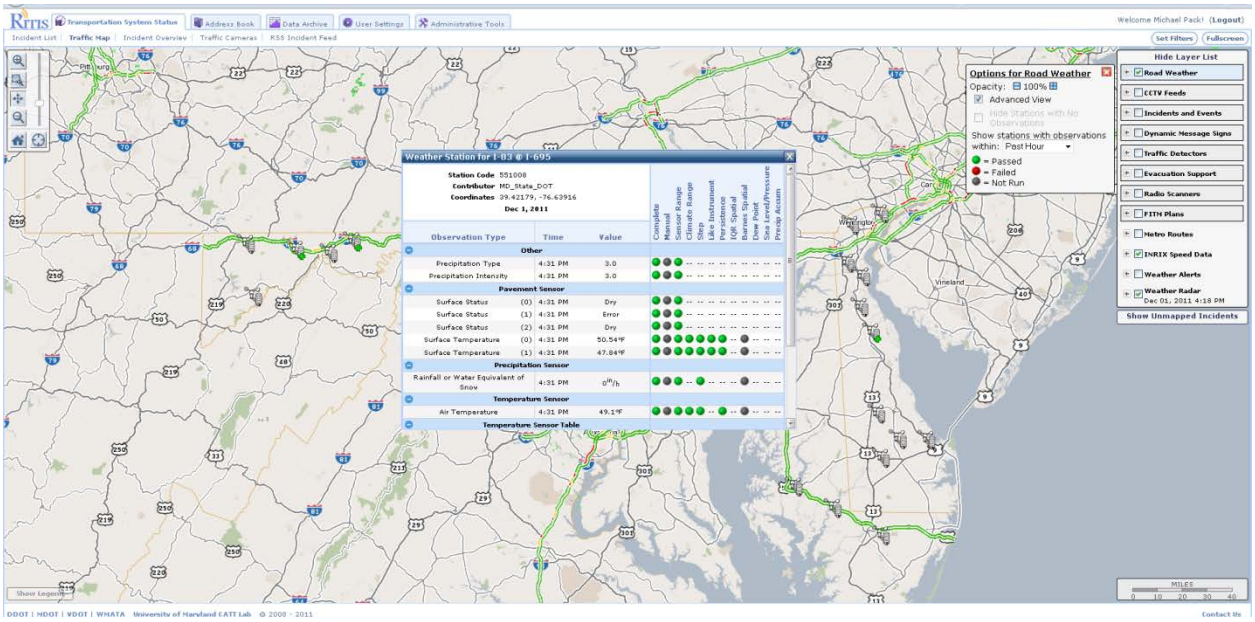

Figure 7: Screenshot of the advanced data view popup window.

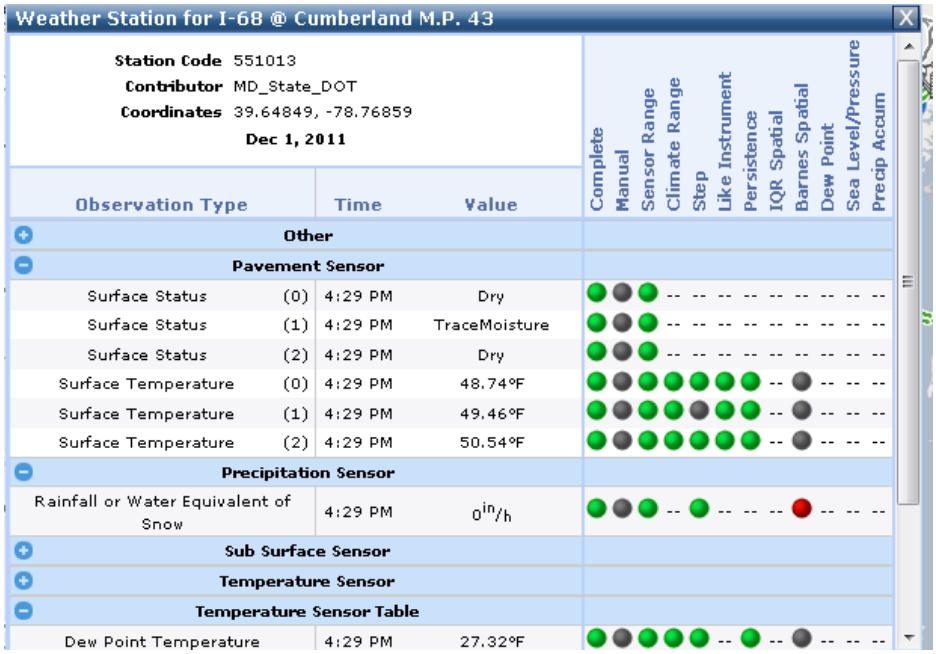

Figure 8: The Advanced View shows specific measurements and the results of quality assurance tests.

The colored balls within the advanced data view table let the user know what types of quality checks have been performed on the data, and whether or not the measurements have passed or failed.

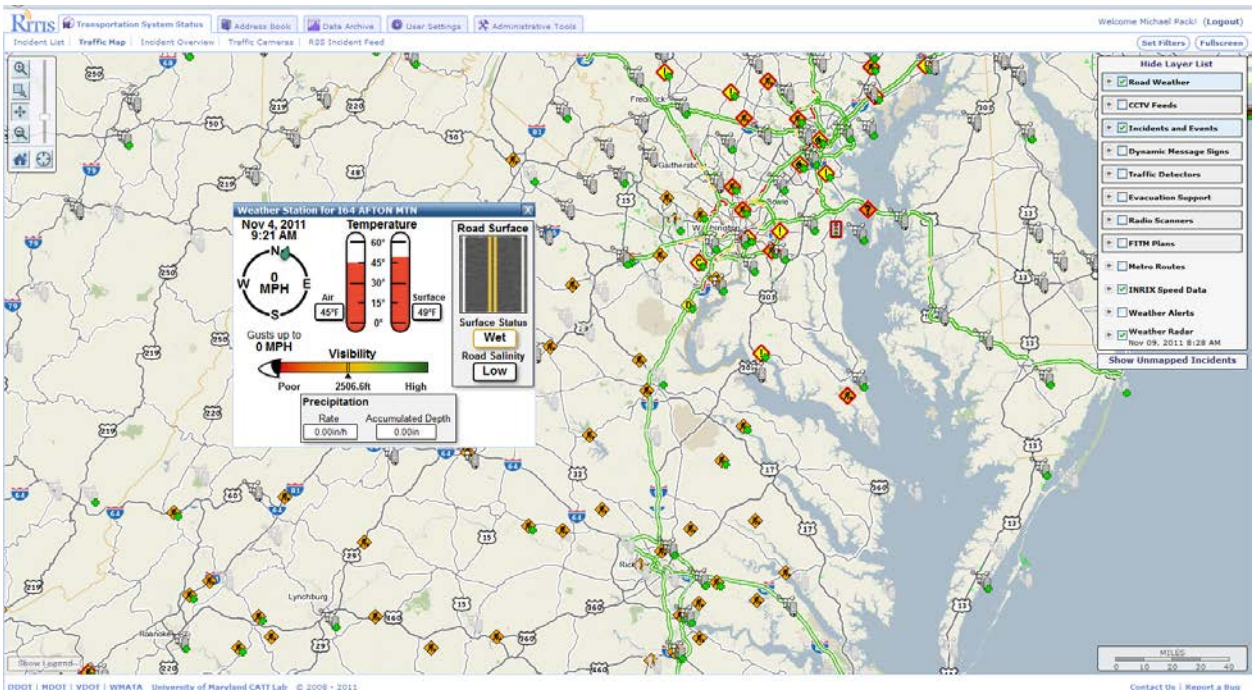

Figure 9: *Clarus* data merged with incident and traffic data.

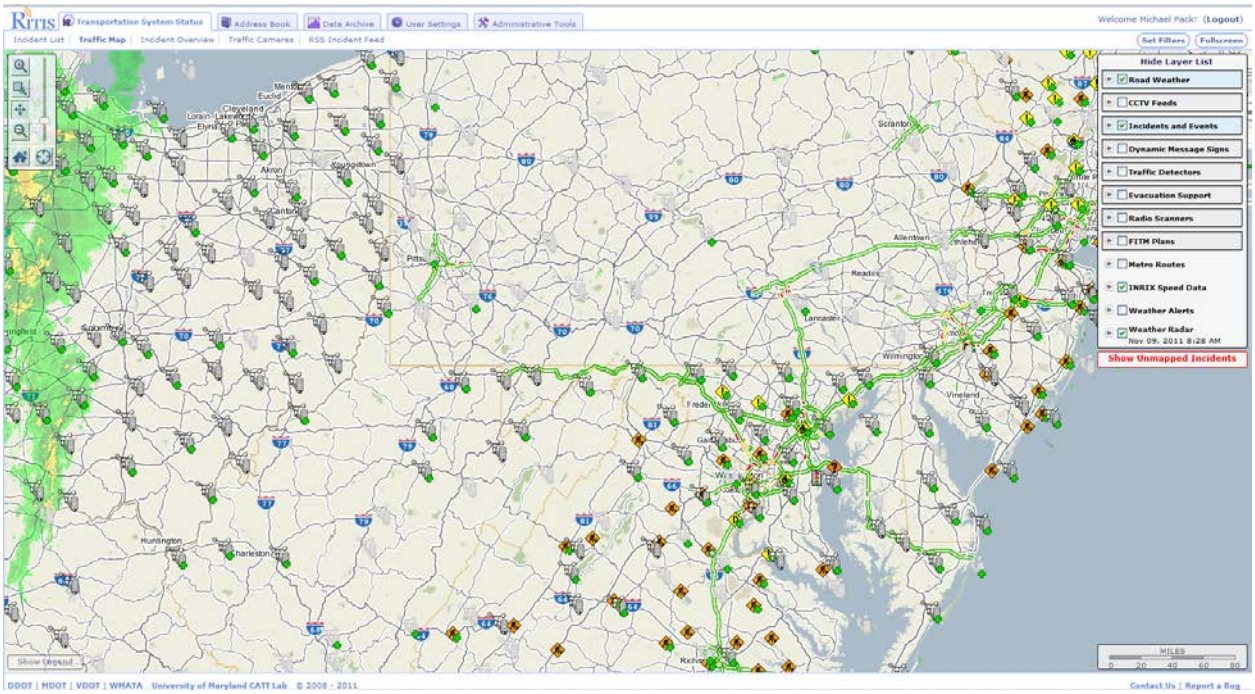

Figure 10: *Clarus* data merged with NWS Radar data.

Alert Mode

Most users do not want to view all of the individual weather station icons on the map at the same time. This creates clutter and can hide other more important data elements. Furthermore, it is not easy for operators to have to "hunt" for weather related problems on the road. To combat this issue, the RITIS design team has created custom alerts for weather stations. Users can define thresholds on specific subsets of station data that should trigger alarms.

In the image below, several weather alerts are being generated from sensors. These alerts can include things like low visibility warnings, icy conditions, and high wind advisories. This functionality means that operators can focus their attention on other critical map elements and only react to weather events when their specified thresholds are met.

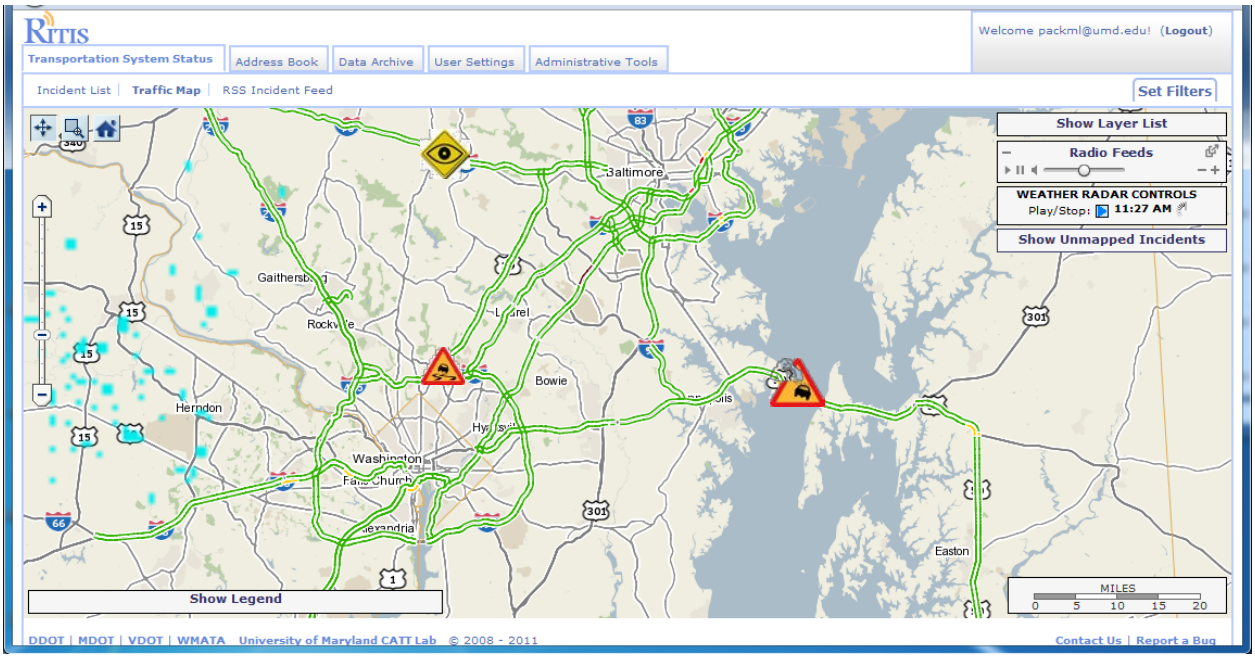

Figure 11: User defined alerts help to unclutter the map.

Figure 141: High wind warning

Figure 122: Icy conditions.

Figure 133: Low visibility.

Historical Analysis

As new *Clarus* data is published through the *Clarus* data feeds, the CATT Laboratory development team is archiving all of it indefinitely for use in other research projects. The CATT Lab has developed a basic historical *Clarus* data explorer that attempts to show the relationship between various weather measurements, traffic speeds, traffic volumes, and incidents. The system is quite easy to use and is web based.

The user is first presented with a map of all RWIS stations as seen in the graphic below. The user can then choose a weather station to explore.

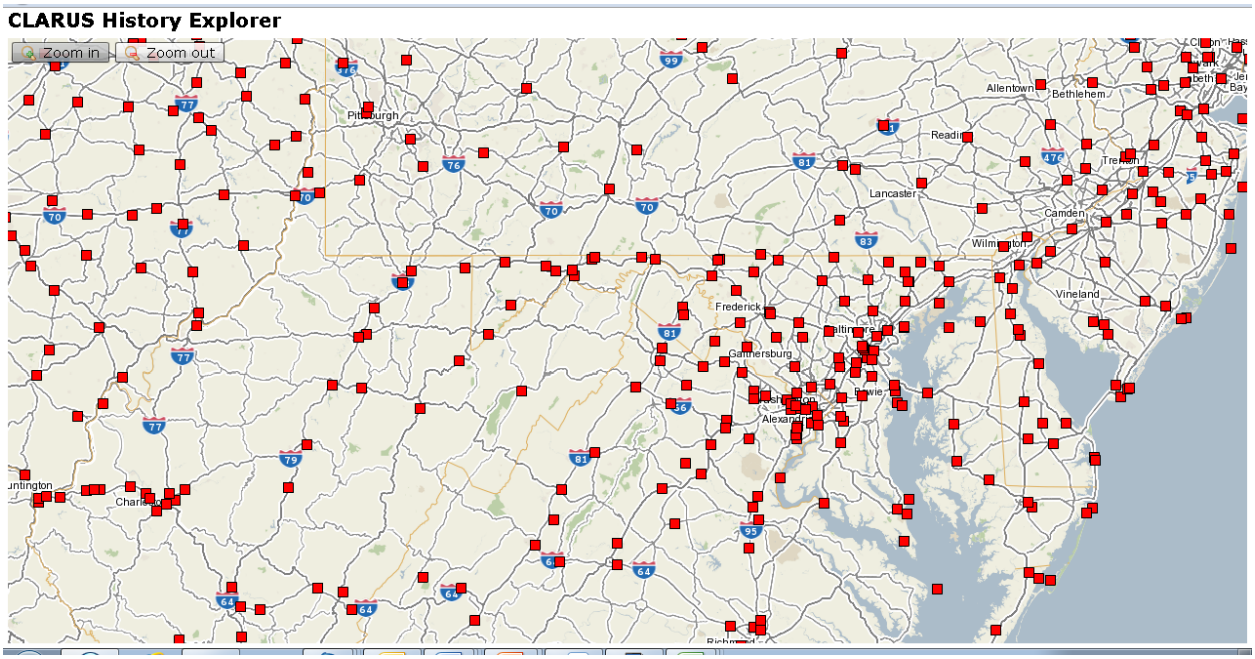

Figure 15: *Clarus* Historical RWIS station selection map.

Once a weather station has been selected, the user is presented with a strip-chart style timeline of weather, traffic, and incident data with a corresponding map insert and a data selection window. The user can use a series of slider bars at the top of the screen to zoom in on a specific period of time anywhere from an hour long to several weeks long.

As the date ranges are selected, the map updates to show where incidents occurred in the vicinity of the RWIS station. Similarly, the strip charts are updated to show when the incidents occurred through time.

The user can then select which data elements should be overlaid onto the time series charts. This allows the user to see, for example, the relationship between heavy rain affecting visibility, traffic speeds dropping, congestion increasing, air temperatures dropping, etc. Each layer can be independently turned on or off, and clicking on portions of the charts and graphs provide details about the data elements, highlight key functions, etc.

Figure 16: Relationships between speed, volume, visibility, precipitation, and incidents can be viewed on a temporal strip chart.

Ongoing Development

Now that this data is being fed continuously to the RITIS platform, thousands of first responders, emergency management agencies, and traffic management experts are beginning to use it for operational purposes. As the winter approaches, we anticipate seeing even greater use out of the system. Already, the CATT Lab development team is hearing positive reviews for the new functionality. Now that these user groups are seeing road weather data (many for the very first time) we are beginning to hear recommendations on how to tweak the system so that it can be more user friendly to responders. The CATT Lab development team is in the process of documenting these comments for use in future development initiatives.

Similarly, a wide variety of researchers are beginning to make use of the newly available merged datasets to analyze everything from the environmental impacts of traffic and weather, safety research related to adverse weather, and even construction maintenance management issues.

Conclusions & Recommendations

The CATT Lab development team had long wanted to integrate RWIS data into RITIS; however, developers had not undertaken the task because of the potentially monumental efforts related to

working with every single state DOT to try to convince them that sharing their RWIS information was necessary. Because of the *Clarus* integration efforts, RITIS was able to cheaply and quickly integrate all RWIS data into a highly visible platform that is viewed daily by transportation, public safety, military, and research personnel who are all operating in the public interest.

Because of the *Clarus*-RITIS data integration effort, other researchers are beginning to freely develop interesting data visualization applications, adding RWIS data into ongoing research projects, and discovering new possibilities that were previously thought impossible. Furthermore, the fact that agency RWIS data is more visible, means that some of the participating agencies are focusing more on RWIS maintenance and calibration issues to ensure that their data is the best possible.

APPENDIX A. List of Acronyms

CATT Center for Advanced Transportation Technology

DOT Department of Transportation

NWS National Weather Service

RITIS Regional Integrated Transportation Information System

RWIS Road Weather Information System

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