WeatherShare Phase 2

Final Report

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EXECUTIVE SUMMARY

The California Department of Transportation (Caltrans) has contracted with the Western Transportation Institute (WTI) at Montana State University (MSU) to develop the "WeatherShare System." The System aggregates weather information, including current and forecast conditions, into a web-based interface for use primarily by Caltrans personnel. Weather information is collected from a variety of public sources, including the National Weather Service, and tailored to the needs of DOT personnel, particularly traffic management center (TMC) operators. Emphasis was placed on providing "at-a-glance" capability to recognize weather conditions. Quality control procedures were implemented to assess the accuracy of sensor readings. Alerts were implemented to demonstrate the potential for condition-based alerting. The system was designed to present weather data from multiple sources in a single, consistent web-based interface..

The goal of the WeatherShare project is to streamline and integrate available road weather data in the Northern California area into a single source that is easily accessible by incident responders and potentially the traveling public.

WeatherShare Phase 1 was a proof-of-concept system that showed promise for increasing the efficiency of situation assessment for a variety of purposes including incident management, highway maintenance, emergency medical services, traveler information and, possibly, homeland security applications. While Phase 1 covered seven counties in District 2 and 13 counties in the adjacent Caltrans districts, Phase 2 expands on this to include the full state of California with all 12 districts and 58 counties. During Phase 2 additional data sources were added providing recent conditions and data available for 24-hour forecasts.

This report discusses the various activities that occurred during the course of the WeatherShare Phase 2. WeatherShare is a component of the Redding Incident Management Enhancement (RIME) program, which consists of technology initiatives designed to improve public safety in the Redding area. RIME organizations include: Caltrans Division of Research and Innovation, Caltrans District 2, Caltrans Redding Transportation Management Center, California Department of Forestry & Fire Protection, California Highway Patrol, Shasta Area Safety Communications Agency, and NorCal Emergency Medical Services.

At the conclusion of Phase 2, all project deliverables will have been delivered, and the project will have achieved its goals.

1. INTRODUCTION

The purpose of this document is to summarize the work completed as part of Phase 2 of the WeatherShare project.

1.1. Project goals

The WeatherShare Phase 1 system integrates surface weather readings from nearly 700 weather stations in Northern California. Data is imported from MesoWest, a repository of western U.S. weather information housed at the University of Utah; the National Oceanic and Atmospheric Administration (NOAA) Meteorological Assimilation Data Ingest System (MADIS); and Caltrans Road Weather Information System (RWIS) stations.

The goal of Phase 2 was to add additional stations to WeatherShare to cover the full state of California. In addition the user interface was changed to make navigation to different data layers and visual interpretation of the data more efficient.

1.2. Project tasks

The work plan for WeatherShare Phase 2 consisted of the following five tasks:

- Task 1: Project Management
- Task 2: Business Case Development
- Task 3: On-going Development and Documentation
- Task 4: On-going Outreach, Training and Support
- Task 5: Evaluation

1.3. Report organization

This report presents a summary of activities that were and were not completed during the WeatherShare Phase 2 effort. As Project Management activities encompassed work related to budget maintenance, communications with the project sponsor, scheduling and the like, a discussion of the work completed for that specific task has been excluded. Remaining chapters of this report will summarize each of the other tasks listed above.

2. BUSINESS CASE DEVELOPMENT

At a high level, the WeatherShare system is consistent with Caltrans' mission and goals of safety, mobility, delivery, stewardship and service. At a lower level, WeatherShare benefits to users in terms of situation awareness are apparent. For instance, WeatherShare can be used to anticipate and recognize situations such as fire, fog, landslides, and snow, all of which impact the highway system and traveler safety.

The WeatherShare system is also consistent with stated goals in the Federal Transportation Reauthorization Bill. In particular, Section 1702, "Real-Time System Management Information Program," calls for nationwide capability to "… support improved response to weather events, and facilitate national and regional traveler information."

In a separate document, the project team presented a preliminary business case and other information gathered in preparation for a Feasibility Study Report (FSR), as is required by Caltrans for the mainstream implementation of new technology. Since the FSR is an internal Caltrans document, it was not the intent of the authors to present a complete FSR within that document. It was the intent to provide supporting information that Caltrans can use in preparation of a final FSR for the WeatherShare system. There is certain information required in the final FSR that only Caltrans can supply. The referenced document does follow the general outline of an FSR and includes placeholders for information that will subsequently be supplied by Caltrans, as well as several inline comments.

3. ON-GOING DEVELOPMENT AND DOCUMENTATION

This section documents the overall process and decisions made during the ongoing development in the transition from WeatherShare Phase 1 through Phase 2. An overview of some of the features that are a part of Phase 2 is given, and some of the challenges encountered along the way are pointed out.

3.1. Review Phase 1 feedback

Survey feedback and stakeholder interviews from the end of Phase 1 of WeatherShare identified areas that should be improved in Phase 2 to make the Weather Share system more useful to a wider audience. This feedback served to identify some overall guidelines needed for the success of the next phase. It also served as a starting point for identifying additional features and data to be incorporated in Phase 2.

Some of the items identified were:

- Improving the site layout to make it intuitive, while maximizing the amount of data that is viewable.
- Improving the access time.
- Expanding the alarm feature.
- Determining and potentially adding additional data—more sites and/or more layers.
- Improving the presentation of quality control information to assist in identifying sites where maintenance needs exist.
- Improving the presentation and usefulness of historical data reports.
- Enhancing the map to show data such as areas of fog on regional highways.

3.2. Identify and prioritize other districts and data sources for inclusion

WeatherShare Phase 1 covered seven counties in District 2 and 13 counties in the adjacent Caltrans districts. This consisted of 11 Caltrans RWIS stations in District 2, 39 MADIS stations, 229 MesoWest stations, and 420 CDEC (California Data Exchange Center) stations. A goal identified for Phase 2 was to provide statewide coverage, which it does with the inclusion of all 12 Caltrans districts and 58 counties in California. The Phase 2 system was expanded to include 107 Caltrans RWIS stations, 690 MADIS stations, and 2,474 MesoWest stations. The 420 CDEC stations that were part of Phase 1 were removed due to challenges obtaining a data set for the whole state from CDEC. (CDEC was unable to provide this data as a whole data set directly via the Internet. They suggested a satellite link for the data feed, but it was determined to be unnecessary given the amount of data from other providers. Had an Internet feed for this data been provided, the team would have readily integrated it into the system.)

Additional data sources were identified for recent conditions and for available twenty-four hour forecasts. Data sources included in Phase 2 providing information on recent conditions includes:

- MADIS (690 stations), downloaded every 30 minutes. This data provides Air Temperature, Relative Humidity, Average Wind Speed, Average Wind Direction, Maximum Wind Gust Speed, Max Wind Gust Direction, Dewpoint, Atmospheric Pressure, Fuel Moisture, Fuel Temperature, Precipitation Rate, Precipitation in 24 Hours
- MesoWest (2,474 stations), downloaded every 15 minutes. This data provides Air Temperature, Relative Humidity, Average Wind Speed, Average Wind Direction, Maximum Wind Gust Speed, Atmospheric Pressure, Solar Radiation
- Caltrans RWIS(107 stations), downloaded every 30 minutes. This data includes Air Temperature, Dewpoint, Maximum Temperature, Minimum Temperature, Average Wind Speed, Maximum Wind Gust Speed, Average Wind Direction, Maximum Wind Gust Direction, Relative Humidity, Precipitation Intensity, Precipitation Rate, Cumulative Precipitation, Visibility. Pavement Temperature
- National Weather Service Advanced Hydrologic Prediction Service, downloaded twice in each 24-hour period. This data includes Observed 24-hour Precipitation

While not all of the above data is available from all stations, Phase 2 attempts to download and store as much available data as possible. See the appendix for maps showing weather stations and sensors used by WeatherShare.

Phase 2 saw the addition of forecast data from the National Digital Forecast Database. The following forecast data, updated every 60 minutes, was added:

- Air Temperature, Humidity, Average Wind Speed, Average Wind Direction, Maximum Wind Gust Speed, Maximum Wind Gust Direction, Sky Cover. Forecasts are made in three-hour intervals; every download is 24 hours of data or eight forecasts.
- 12-hour probability of precipitation. Forecast in 12-hour intervals; every download is 24 hours of data or two forecasts.
- 6-hour amount of precipitation. Forecast in six-hour intervals; every download is 24 hours of data or four forecasts.
- Snow. Forecast in six-hour intervals; every download is 24 hours of data or four forecasts.
- Weather. Forecast in three-hour intervals; every download is 24 hours of data or eight forecasts.
- Fog Warning. Forecast in three-hour intervals; every download is 24 hours of data or eight forecasts.

Note that this information is displayed both as a raster image for the entire state and as point forecasts at postmile and sub-postmile resolution along state and federal roads.

In addition to the above data, National Weather Service forecast warnings and alerts are downloaded every fifteen minutes. Included in this data is the following:

- Warnings: Tornado, Flash Flood, Blizzard, Winter Storm, High Wind, Storm, Avalanche, Severe Weather Statement, Flood, Red Flag, Heavy Freezing Spray
- Watches: Flash Flood, Winter Storm, Flood, High Wind, Fire Weather, Coastal Flood Statement, Special Weather Statement, Short-Term Forecast
- Advisories: Winter Weather, Flood, High Surf, Small Craft, Brisk Wind, Lake Wind, Wind

3.3. Evaluate user interface for usability and effectiveness

With the added data and the geographical coverage extended to cover the full state of California, the user interface needed to be redesigned. The goal was to create a system that would:

- be intuitive with little or no instruction necessary,
- be able to show as much information as possible graphically "at a glance,"
- be able to show as much geographical area as possible,
- provide users with a way to return to a favorite view with a minimum of effort,
- be compatible with standard web browsers (Mozilla Firefox and Microsoft Internet Explorer were specifically targeted),
- and, perhaps most importantly, provide an interface that is familiar to users.

3.4. Implement user interface improvements

Phase 1 used Scalable Vector Graphics (SVG) and required the Adobe SVG Viewer, JavaScript and Internet Explorer or Firefox on client machines. Note that Adobe later discontinued support for its SVG viewer. There are other efforts to provide in-browser SVG capability, but none appear to be widely supported. Internet Explorer still does not include native SVG support at this time.

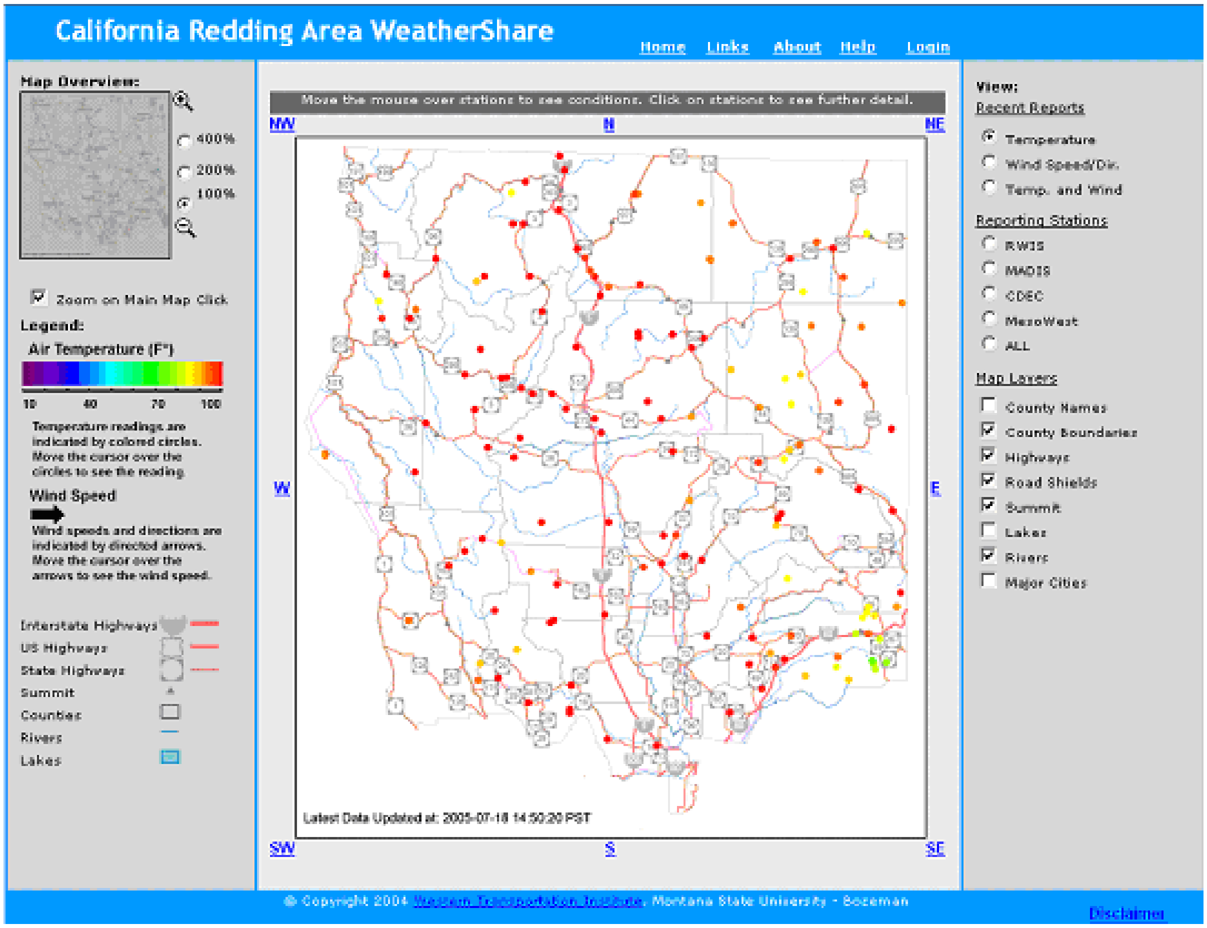

Figure 1: Phase 1 User Interface

Phase 2 utilizes Google Maps using the Google Maps API, HTML, DHTML, JavaScript, AJAX, and Web 2.0. The system was implemented to work within Internet Explorer or Firefox browsers. This solution implements more robust mapping with Map, Satellite, Terrain, or Hybrid views of the mapped area. The Google Maps API facilitates the easy use of controls for Panning and Zooming into a desired section of the map. Users are generally already familiar with the Google Maps interface.

An iterative approach was used while attempting to balance ease of navigation and use of controls, and maximize the amount of map viewed. Initial implementations were similar to Phase 1, with the Google Maps pane in the center of the display flanked by panels containing layer and zoom controls. See Figure 2 and 3. The next iteration had the Google map taking up the right two-thirds of the screen and the zoom and layer controls residing in a pane on the left third of the screen. See Figure 4.

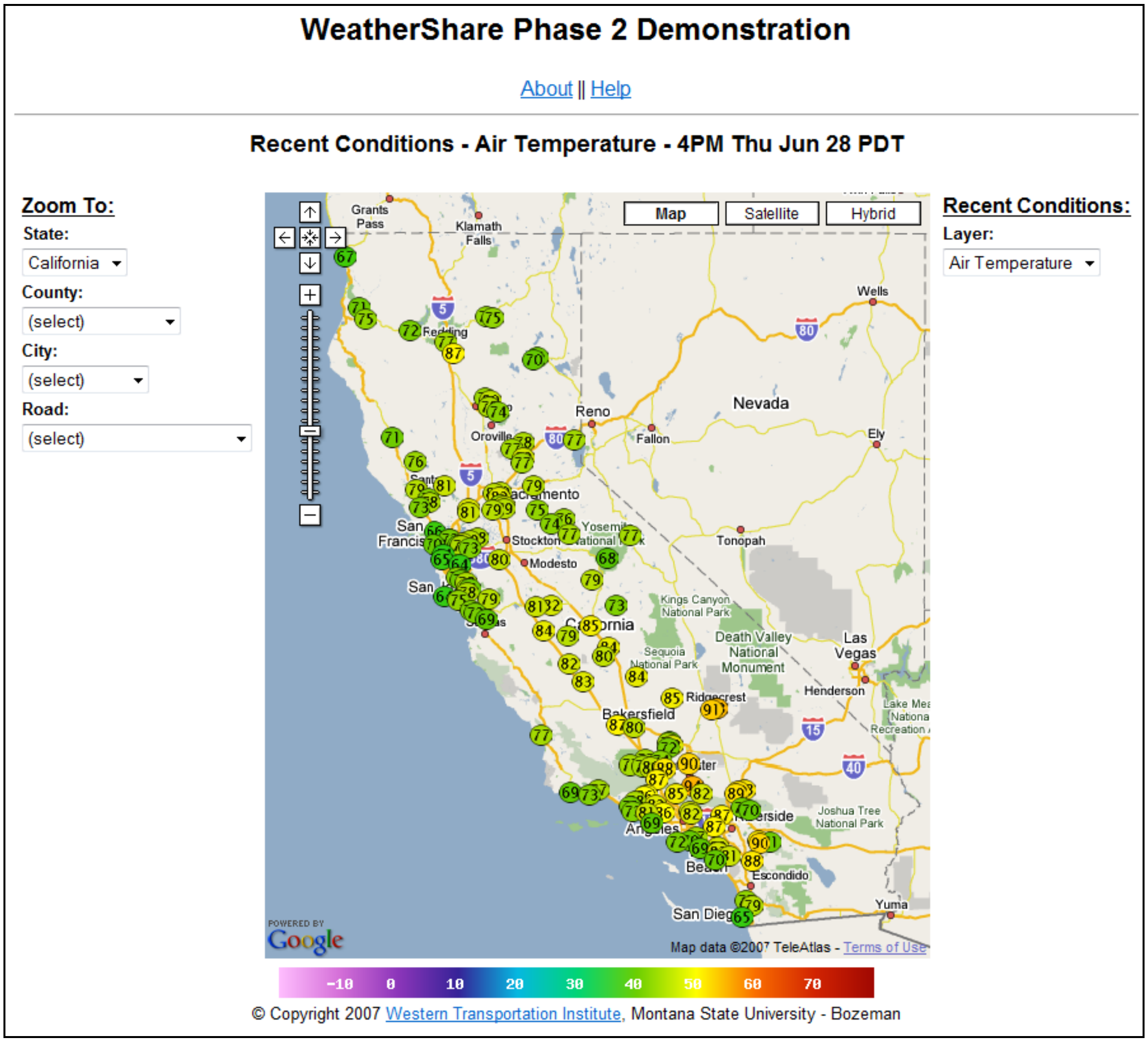

Figure 2: First Phase 2 Interface

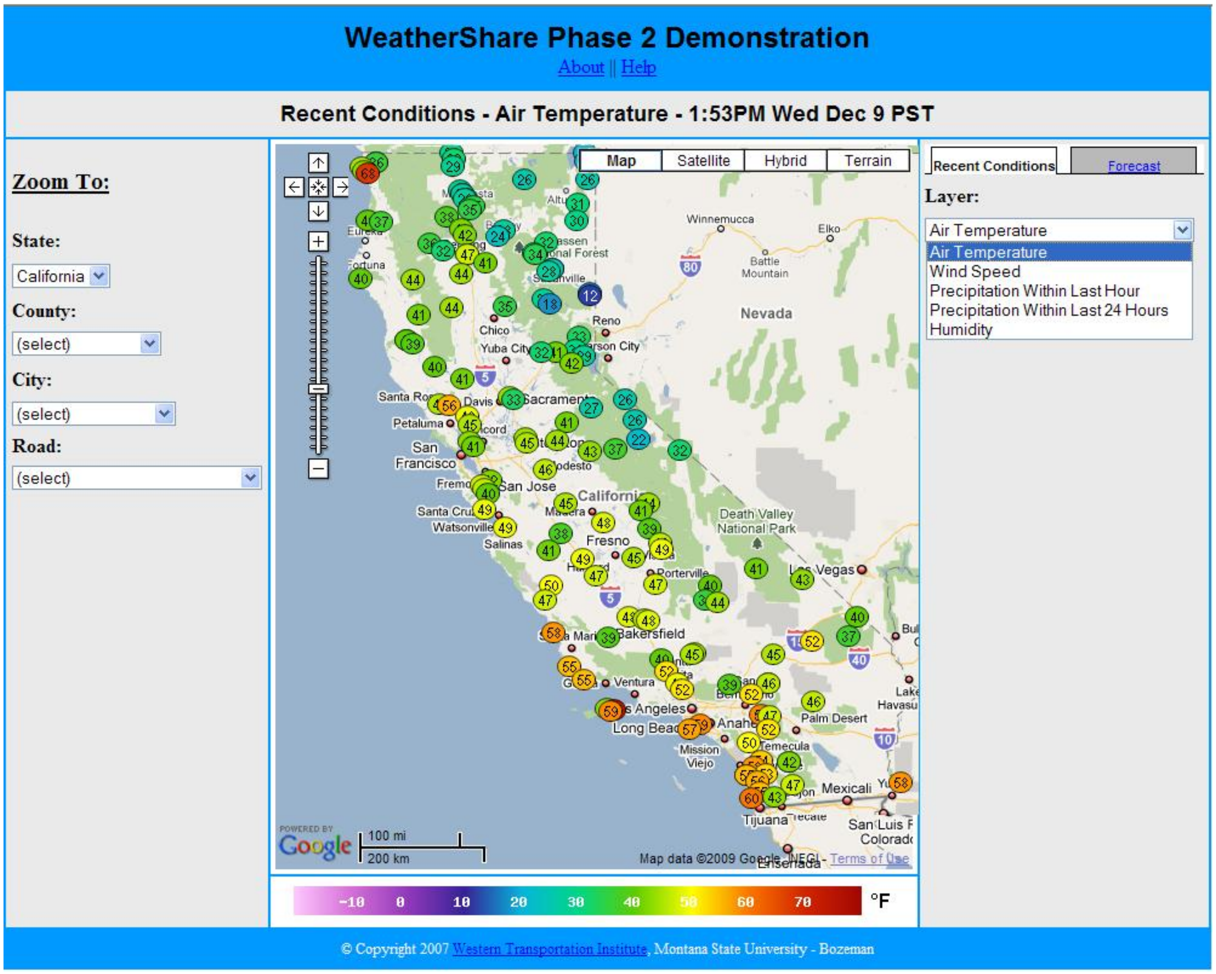

Figure 3: Second Phase 2 Screen Layout

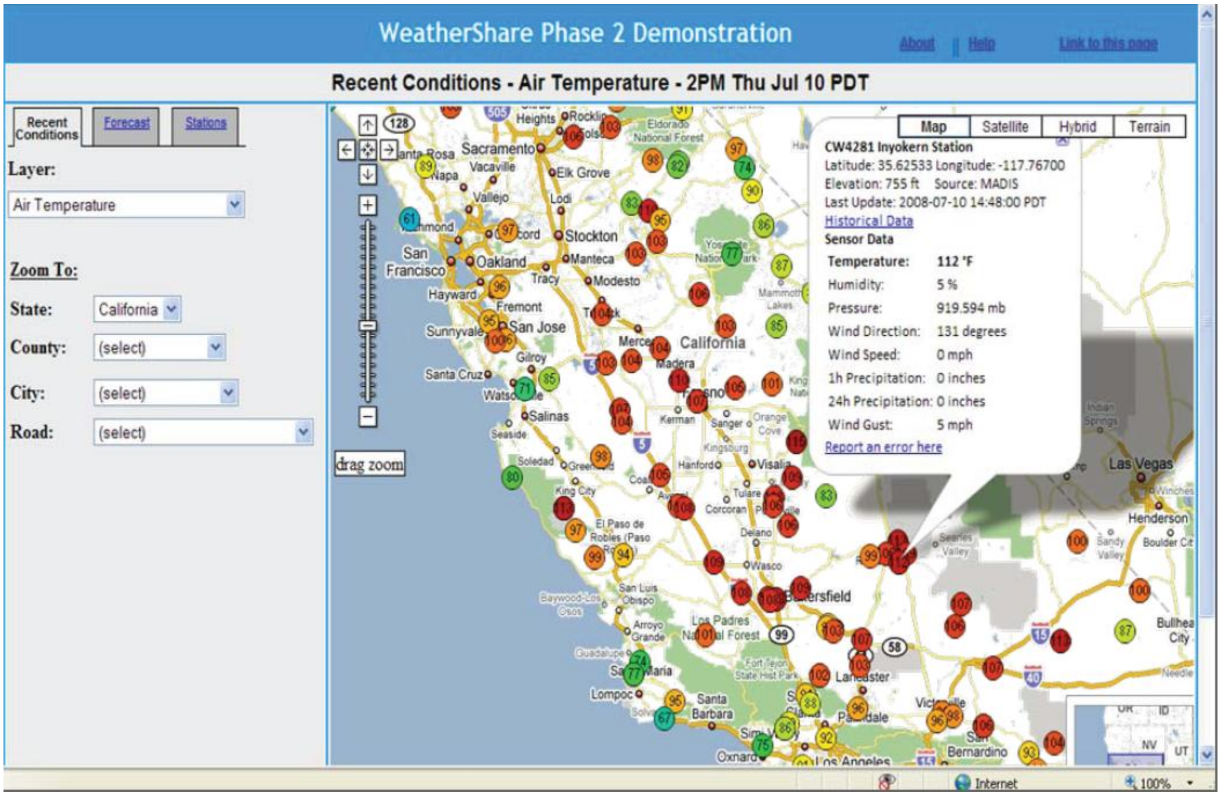

Figure 4: Third Phase 2 Screen Layout

Eventually zoom and layer controls were put into a pop-up menu control so they would only be on the screen when needed, and the Google Map is now displayed using the full screen width. This is seen as particularly useful when zoomed into a portion of the state. See Figure 5.

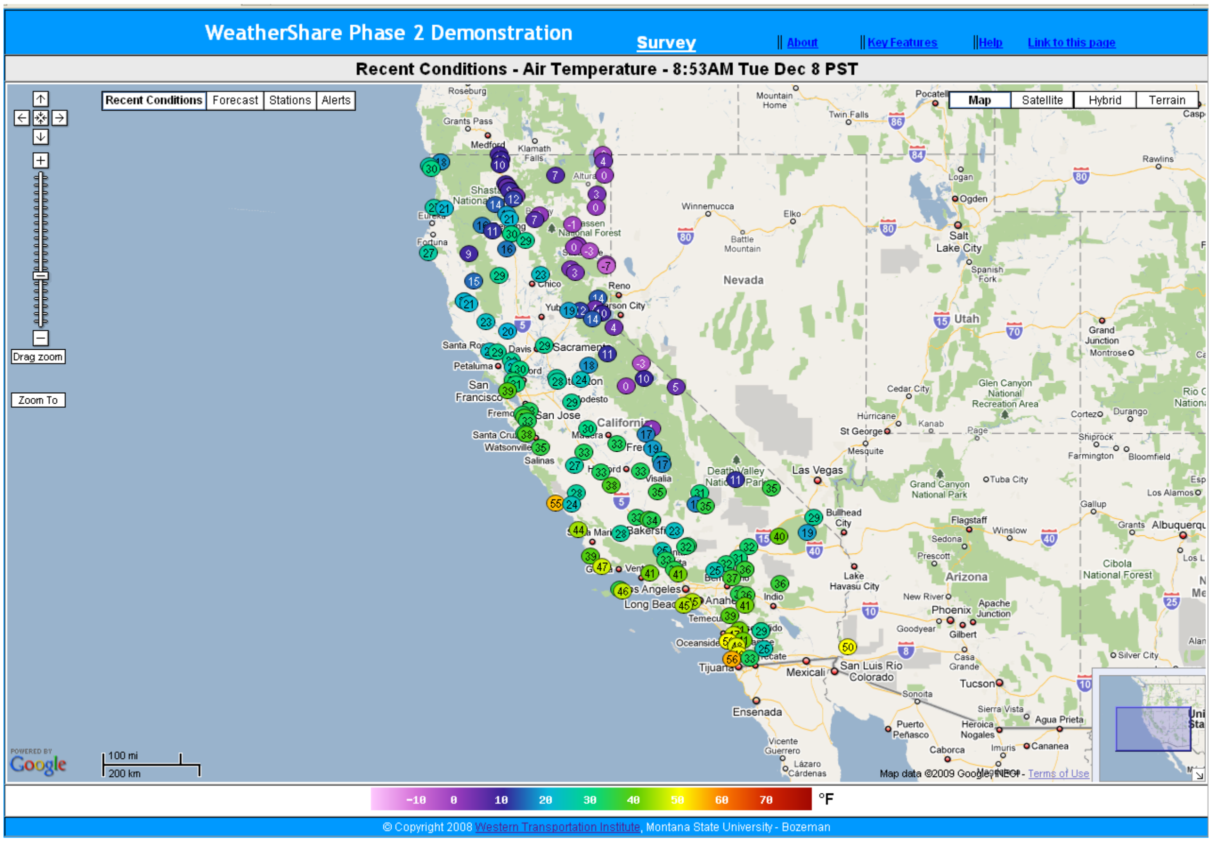

Figure 5: Final Phase 2 Display Layout

With the addition of full state coverage, controls were needed to allow users to view desired portions of the state efficiently. While the Google maps zoom and pan control, located on the top left of the screen, can be used for basic navigation, an additional “Zoom To” menu was developed to allow users to zoom to a particular county, district, city, road by district, or road by county. A “Drag Zoom” option was also added to allow selection of a zoom rectangle.

The Phase 1 screen had data views for temperature, wind speed and direction, and temperature and wind with simple icons to represent different conditions and radio buttons for selecting the data. The additional data layers in Phase 2 were organized into display layers and are accessed by separate tabs.

The layers for the “Recent Conditions” tab are: Air Temperature, Wind Speed, Precipitation Within Last Hour, Precipitation Within Last 24 Hours, Humidity, and NWS Observed 24-hour Precipitation.

The layers for the “Forecast Conditions” tab: Air Temperature, Wind Speed, Wind Gust Speed, Humidity, Sky Cover, 12-Hour Probability of Precipitation, 6-Hour Amount of Precipitation, Snow, and Weather.

A “Stations” tab was created to display a graphical view of stations that are up to date, not updating, or up to date but with one or more sensors failing quality control. A table on the screen gives a quick summary of the up-to-date stations broken down by source.

An "Alerts" tab was created to view alerts. For recent conditions there are alerts for Ice Warnings (Districts 1, 2, 3, 6, 7, and 8 only) based on the RWIS surface status, and an adjustable wind warning that allows users to select values for wind advisory, wind watch, and wind warning alerts. For forecast conditions there are alerts for Fog, National Weather Service Alerts and Warnings, Red Flag Potential Index, and Crosswind. The Red Flag Potential Index is an estimate of the red-flag fire danger based on the combination of relative humidity and wind speed. The Crosswind alert looks at the forecasted wind speed and direction and compares them with calculated road bearing to determine if the winds would be blowing across the road at greater than 35 miles per hour. This alert was intended to demonstrate how road geometry could be incorporated into a derived layer.

With the improved look of the Google Maps display, one goal was to make more information available at a glance. Icons were created to be as descriptive as possible, including both color and text for views of most data. Wind icons are arrows showing the direction of the wind with the color and size of the arrow indicating the wind intensity. Forecast displays have a background raster with icons mapped to postmiles displayed on top of the raster. For forecast weather, icons were used to represent various weather conditions such as snow, sunshine, cloudy, smoke, etc. Consistency with colors and scales used by the National Weather Service was largely achieved in these icons and associated raster images. Detailed data bubbles were created to be displayed when a user clicks on an icon. All available data for the given station is displayed in the detail bubble. All recent condition observation data is saved; a link to view or download historical data is available in the detail bubble.

3.4.1. Challenges

While the implementation of WeatherShare using Google Maps offers an improved look and feel for the application, there were some challenges to overcome.

3.4.1.1. Icon Display

With the potential for receiving data from over 3,000 stations across the state or for tens of thousands of postmile and sub-postmile locations on roads, attempting to display an icon for each site on the upper zoom level proved problematic in a couple of ways. The Google Maps Marker Manager was used for displaying icons on the map, but it had limitations. Attempting to display too many icons at once caused script execution to halt. To work around this limitation, several algorithms had to be applied to limit the number of icons shown based on the zoom level. These algorithms had to ensure an even distribution of icons and accurate data across the state while handling the fact that not all stations are always updating. It was decided that Caltrans RWIS stations would be displayed at all zoom levels. MADIS and MesoWest stations would be selected to ensure an even distribution across the state. As the user zooms in closer, more stations within the view area appear until eventually all stations within the view area are displayed. An example where this was important was precipitation displays; early efforts that used random sampling or similar methods skipped over stations that had some precipitation, leading the user to believe that there was no precipitation at all in the area.

Another challenge was choosing icons that were descriptive. For most data layers this meant using a colored circle with the color matching the value from the color gradient of the legend. Note that the same legend/colors as the National Weather Service are used where possible. The data value is shown in the circle, so the icon must be large enough to read the value without being so large that it dominates the screen. For wind it was decided to use icons of different color and size to better represent the intensity. The wind icons are arrows showing the wind direction. For icons representing forecast weather it was a matter of searching and experimenting until appropriate icons were found for each weather condition.

Error! Reference source not found. shows an early prototype of wind icons for WeatherShare. A dramatic improvement is seen in the final version, shown in **Error! Reference source not found.**.

Figure 6: An Early Prototype of Wind Icons

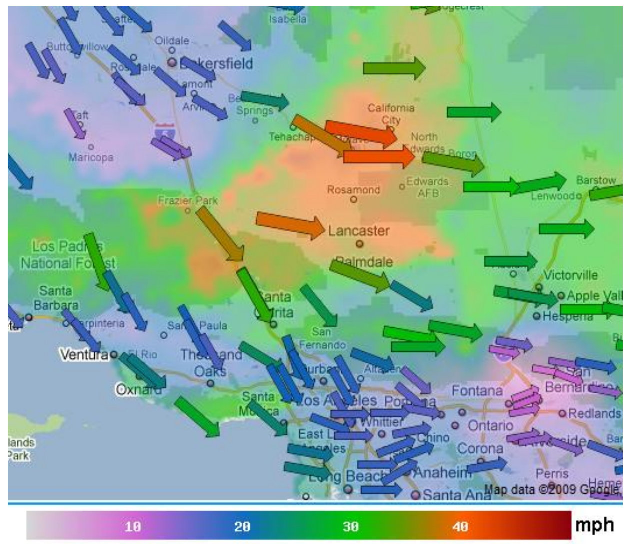

Figure 7: Final Wind Icons

3.4.1.2. User controls and customization

WeatherShare Phase 2 tried to add adequate user controls to allow users to access the information they need in an efficient manner. Various zoom control options were added to give users a choice of methods for accessing different geographical areas. With statewide implementation and the potential for use by the general public, user profiles were not continued in Phase 2; with the potential for a large number of users, the management of users and passwords was seen as a problematic, and perhaps unnecessary, complication. A “Link to this page” control was added to allow users to bookmark their current screen configuration and return to it later. The lack of user profiles affected the alert capability, as individuals couldn’t customize the alerts to meet their desired conditions in the same fashion they could in Phase 1. As an experiment for the adjustable wind warning alert, cookies were stored on the local machine to keep track of the wind alert parameters. The “Link to this page” option provided similar functionality and was determined to be sufficient.

3.4.1.3. Browser compatibility

An important consideration for any-web based application is compatibility with commonly used browsers. WeatherShare was developed for and tested primarily on Mozilla Firefox (ver. 3.x) and Microsoft Internet Explorer (v 6.x and above). Various small issues came up that required separate code paths depending on the browser being used; there are different style sheets for Internet Explorer and Firefox that were necessary to keep a consistent appearance, and the use of different methods to attach/detach an event to an object required branches in the JavaScript code.

3.5. Quality control

Reliability and user confidence in the data being displayed is important for the overall success and acceptance of the WeatherShare system. Sensor values that fail quality control are not displayed in primary layers. Up to three levels of quality control are applied to incoming data depending on the data type.

Level 1 quality control consists of range checks to verify the validity of the data.

The following range checks are applied to incoming data:

- Location: Latitude 0° to 90° N; Longitude 20°W to 120°E
- Pressure: 6.8 inches (568mb) to 32.5 inches (1100mb)
- Air Temperature: -60°F to 130°F
- Soil Temperature: -40°F to 150°F
- Dewpoint: -80°F to 90°F
- Relative Humidity: 0 to 100%
- Wind Direction: 0° to 360°
- Wind Speed: 0 to 250 knots
- Maximum Gust: 11 to 250 knots
- Visibility: 0 to 100 miles
- Accumulated Precipitation (24 hour): 0 to 44 inches

Level 2 quality control consists of temporal checks. The level 2 checks applied are:

- Air Temperature: maximum change of 20°F/hour or no change for 24 hours fails quality control
- One-hour precipitation: positive value and no change over 24 hours fails quality control

Level 3 quality control consists of spatial consistency checks using a multivariate linear regression model. This method uses the surrounding values and tries to predict an acceptable range of values for the value being checked. The Level 3 quality control is currently implemented for air temperature only.

WeatherShare applies Level 3 quality control in a two-step process:

Step 1:

First, all temperature observations within the past 90 minutes for all current weather stations as well as the station location data (latitude, longitude and elevation) are gathered through a query to the database. Using this data, a multivariate linear regression model is calculated, and the residuals (observed value minus predicted value) are calculated. For every station with an absolute residual larger than 40, a further normality check is processed as Step 2.

Step 2:

All nearby (within 25 miles) station temperature observations within last 90 minutes are gathered through a query to the database. The resulting temperature observations as well as latitude, longitude, and elevation data are used to estimate a new multivariate linear regression model. With this new model, if the reported temperature data is different from the predicted regression value over the last 90 minutes by over 10°F, the observation is flagged as "failed."

Tuning and selecting proper parameters for this method is not trivial and there may be no "right answer" to the choice of specific values. A trial-and-error approach was used to select values that balanced false positives with false negatives. The value of 40 degrees for the first step is large and not ideal, but was chosen for this reason.

3.5.1. Quality control challenges

The results from Level 3 quality control are experimental and both the Level 2 and Level 3 quality control methods have limitations. Currently, only Level 2 checks to air temperature and one-hour precipitation readings are applied. Neither Level 2 nor Level 3 quality control checks are suitable for wind speed due to the nature of the data—which are stochastic and non-continuous—and there is no uniform quality control standard available for this as far as the project team could identify. Level 3 quality control uses the multivariate linear regression model that has been applied by Utah Mesonet for its data quality control (See http://www.met.utah.edu/mesowest/quality/regress.html) and has already proven useful. However, false positives and false negatives exist within the current model, and it requires further investigation.

3.6. Identify, prioritize, and implement additional functionality

Two additional displays were created to help maintenance staff identify stations that are in need of attention. Currently these displays show current snapshot information, but they could be extended to help identify stations or sensors with intermittent or random failures.

3.6.1. Stations display

The "Stations Display" tab gives an overview showing the distribution of stations across the state with an indication of which stations WeatherShare is receiving updated information from. A control was added to allow this information to be filtered by source: Caltrans, MADIS, or MesoWest. The station icons indicate the stations that are sending updated information but have one or more sensors failing quality control. Clicking on a station icon brings up a detail bubble with the failing sensor highlighted in a color indicating the level of quality control that it failed.

3.6.2. Station report

An additional display was developed that lists by district the sensors found to be failing quality control. For each sensor there is an indication of which level of quality control failed. Clicking on the detail link gives additional information about past values and values for nearby stations, with a link to the map to show the station in question and those nearby.

3.7. Performance improvements

WeatherShare Phase 1 users indentified access time as an area that should be improved. A few different efforts were made to ensure adequate performance of the system. Current condition observation data is stored in a MySQL database on the WeatherShare server. At various stages during development the structure of the database was analyzed and modified to achieve the best performance of queries. On the client side, JavaScript code was optimized where possible and browser memory usage was monitored to find and eliminate memory leaks that slowed performance.

Perhaps the biggest performance improvement was obtained by the purchase of a new server for the WeatherShare system. This server is housed at and maintained by WTI. The configuration of the old server was: Dual Intel® Xeon™ 2.40 GHz CPU, 80GB x 2 hard drives, 1 GB of memory. This was upgraded to a server with the following configuration: Dual Quad Core Intel® Xeon™ 3.0 GHz x5450 CPU, 2 x 300GB Raid 1 hard drives, 16GB memory.

Further improvements could be made, including offload of routine processing to another machine, allocating more machines to form a cluster, etc. For now, the system appears to be performing in a satisfactory fashion.

3.8. Update user guide

During the Phase 2 development of the WeatherShare system, a new user guide was developed and kept up to date as changes were made to the system. The user guide was created as a Microsoft Word document. An online “Quick Start Guide” was created and linked to the “Help” link on the WeatherShare main page. A “Key Features” link was added to the WeatherShare main page to allow users to quickly identify new features that have been added to the system.

3.9. Create a system management guide

A rudimentary system management and maintenance guide was created as a tool for WTI personnel to use in maintaining the WeatherShare system. This document lists steps and procedures used to ensure system uptime and reliability, including monitoring of system performance, monitoring weather data updates, backing up of system and data files, and maintaining the database in case of corruption or failure.

4. ON-GOING OUTREACH, TRAINING AND SUPPORT

Throughout Phase 2, numerous outreach efforts to potential users were conducted. Generally, this was done through industry-recognized conferences. Following is a summary of Phase 2 outreach efforts:

A presentation of the WeatherShare system was given at ITS America's summer meeting in Palm Springs in June of 2007. WeatherShare was also presented at the Western States Forum in 2009, the National Rural ITS (NRITS) conference in 2009, and was included with other Caltrans demonstrations at AASHTO 2009 in Palm Desert in October.

Further outreach efforts include:

- July 2008: AASHTO, Subcommittee on Maintenance, etc., Monterey, CA
- August 2008: Clarus meeting in Reno, NV;
- August 2008: AASHTO, Subcommittee on Systems Operations and Management, Special Committee on Wireless Technology Annual Meeting, San Francisco
- October 2008: Caltrans Statewide TMC/ TMS meeting
- March 2009: Region III RDMHS meeting in Red Bluff

The project team and the Caltrans project manager and project champion have actively promoted system usage and awareness to existing and potential stakeholders. For instance, WeatherShare updates are given annually at COATS steering committee meetings.

5. EVALUATION

Evaluation of the WeatherShare system was done through a survey implemented in SurveyMonkey and administered during the fall of 2009. The questions in the survey were intended to gain statistics and information on the following:

- The primary focus of responsibility of the agencies that those who were surveyed work for.
- The frequency of use of the WeatherShare system by those surveyed.
- When and for how long the WeatherShare system is used by those surveyed.
- How useful the data from WeatherShare is to those surveyed.
- How useful the features of WeatherShare are to those surveyed.
- The opinions of those surveyed on WeatherShare organization and ease of use.
- Further comments on how the system can be improved.

There were a total of 33 respondents to the survey questions, most of them from Caltrans. For a further breakdown of survey responses, see the *WeatherShare Needs and Requirements Summary, Evaluation Summary, and Website Statistics* document. Responses were generally favorable.

6. CONCLUSION

A number of deliverables were produced during the course of the Phase 2 effort, including:

- Final Report
- Quarterly Reports
- Documentation for FSR
- Long Term Maintenance and Management Plan
- Final User Guide
- System Management and Maintenance Guide
- Preliminary Training Materials
- Final Training Materials
- Evaluation Summary
- Needs and Requirements Analysis Summary

In several cases, these deliverables were combined and the documents produced were:

- WeatherShare Needs and Requirements Summary, Evaluation Summary, and Website Statistics
- WeatherShare User Guide and Training Materials
- WeatherShare Business Case and Documentation for Caltrans FSR
- WeatherShare Administration and Maintenance Guide
- WeatherShare Phase 2 Final Report

These reports, along with the WeatherShare system that was developed are the primary products of this research and development effort.

The WeatherShare system was the first of several efforts funded by Caltrans to present weather and other relevant conditions and information to transportation professionals and eventually to the general public. In the Integrated Corridor Management (ICM) project, a prototype system was developed to present data from changeable message signs (CMS), road weather information systems (RWIS), chain control, construction and incident reports, closed-circuit television (CCTV) images, and weather information including current conditions, forecasts and alerts. The area of interest for that project was the California – Oregon border, with a focus on the exchange of information between maintenance and operations crews on both sides of the border. Aside from RWIS data and National Weather Service alerts, no other weather data was incorporated into the system for Oregon.

The One-Stop-Shop project expanded on WeatherShare and ICM by focusing on route-based trip planning. A Trip Planner was implemented to show conditions along a route between a user-selected origin and destination. In addition to an elevation profile along the route, forecast information from the National Weather Service's National Digital Forecast Database was mapped to the route planner to show forecast conditions along the route.

Expanding in a different direction, the Integration of AWOS with RWIS project focused on providing weather information for pilots in rural, under-served areas, including heliports and emergency medical service (EMS) operations. Building on what WeatherShare accomplished for surface conditions, this project resulted in a prototype that presented additional aviation layers in conjunction with existing surface layers. Aviation layers added to the system included wind and temperature aloft forecasts, satellite and radar rasters, PIREPS, TAF AND METAR reports.

It is evident from these efforts that there is a continued interest in providing weather information in a single, unified interface for use by transportation professionals. For surface transportation, WeatherShare has generally met the need while serving as a building block for other efforts. At the time this report was written, it was further anticipated that WeatherShare and OSS would be expanded to cover more states including Oregon, Washington and Nevada. And, it was anticipated that there would be a second phase of the AWIS and RWIS project, in which the prototype system would be prepared for regular, production use in California.

For all of these projects, interface design has been a challenge and an interesting research and development topic. To design and implement an application, particularly a web application, that presents such diverse information as that in WeatherShare and the related projects has been a challenge. The decision between Phase 1 and Phase 2 of WeatherShare to use Google Maps as a basis for presentation has generally been a good one, relieving the project team from implementing and hosting related GIS server and display functionality. The selection of proper, professional-looking icons and raster images to convey weather information to users at a glance proved to be a challenging and time-consuming process. In the end, this has been viewed as key to the success of these projects.

In conjunction, quality control – the automated procedures for checking sensor values for errors – has also proven to be important and challenging. Quality control has been perhaps the most challenging and research-worthy aspect of WeatherShare, and arguably deserves further research and development. Despite implementing a number of documented, best-practice methods for quality control, the project team continues to discover what appear to be obvious errors that are not identified automatically by the implemented quality control measures. This may be a natural consequence of several key aspects of the problem at hand. First, California is a large and geographically diverse state, with coastal areas, rain forests, high mountains and generally irregular terrain. It should be no surprise that California is meteorologically diverse as a result. Within less than 100 miles in southeastern California, you will find both the highest and lowest points in the lower 48 states. Temperature can vary dramatically in that short distance, as it can also vary between coastal areas and points 100 miles inland. Furthermore, sensor readings can vary dramatically depending on their type. While some degree of spatial and temporal consistency may be expected for each reading type, certainly there will be great variation when comparing temperature readings versus precipitation readings versus wind speed and direction readings, and so forth. As a result, one original goal of the project was not fully-realized – providing robust capability for identifying problematic sensors so that agencies, Caltrans in particular, could better monitor and maintain their sensors. The project team acknowledges this deficiency and lists it as the foremost topic for further research and development, in conjunction with the investigation of more accurate methods for implemented quality control checks for all sensor types stored in and displayed via WeatherShare.

7. APPENDIX – WEATHER STATIONS IN CALIFORNIA

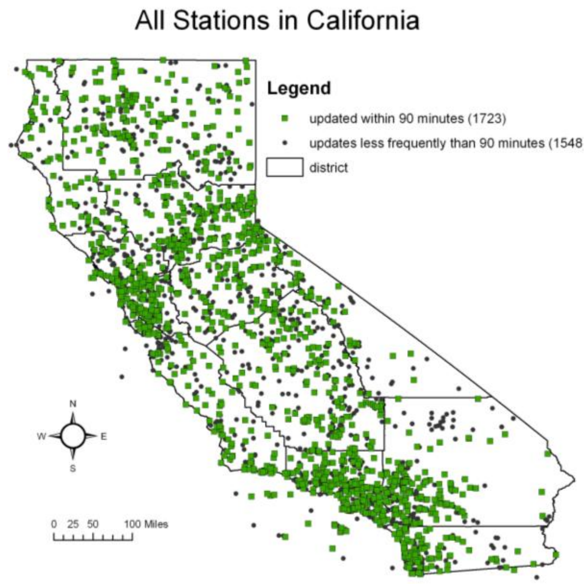

Figure 8: All Stations in California

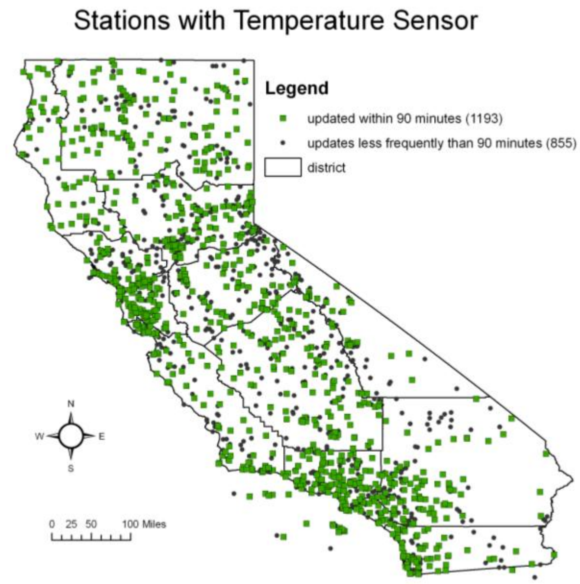

Figure 9: Stations with a Temperature Sensor

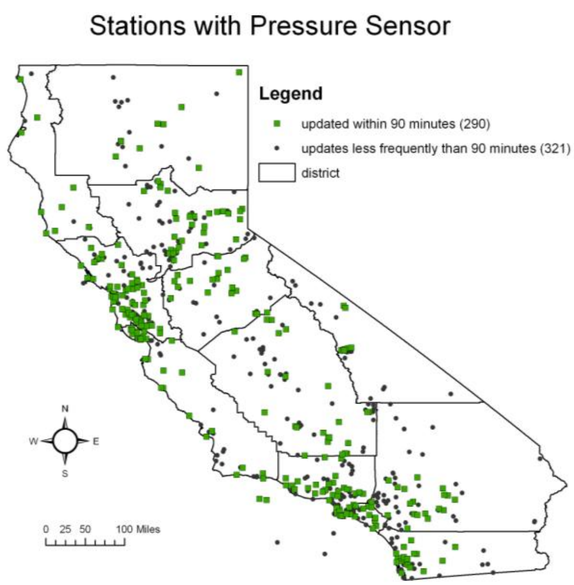

Figure 10: Stations with a Pressure Sensor

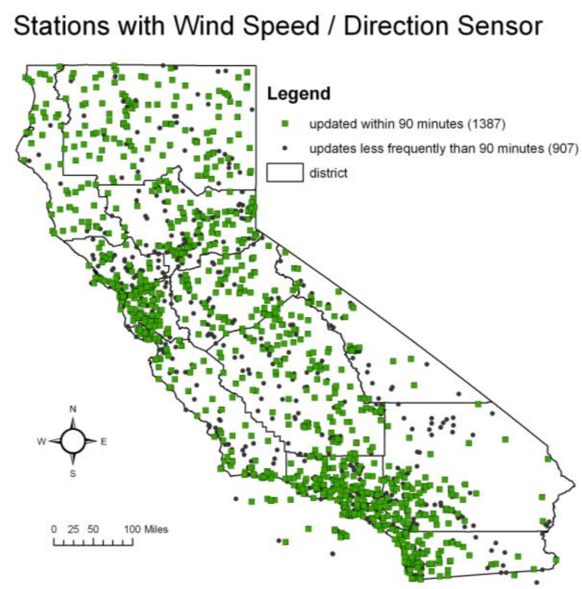

Figure 11: Stations with a Wind Sensor

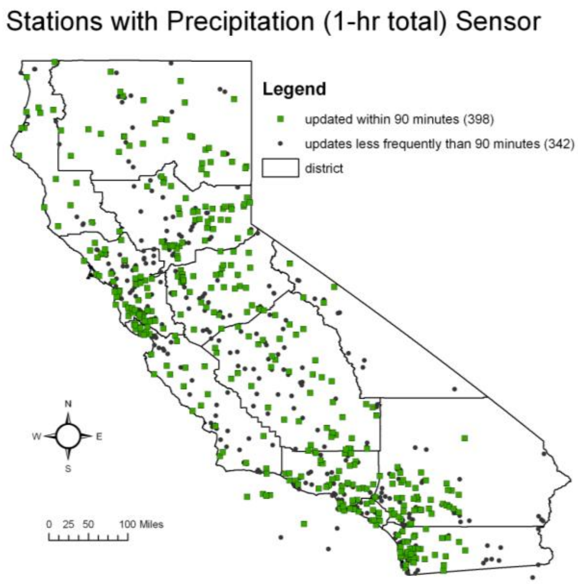

Figure 12: Stations with a 1-hr Precipitation Sensor

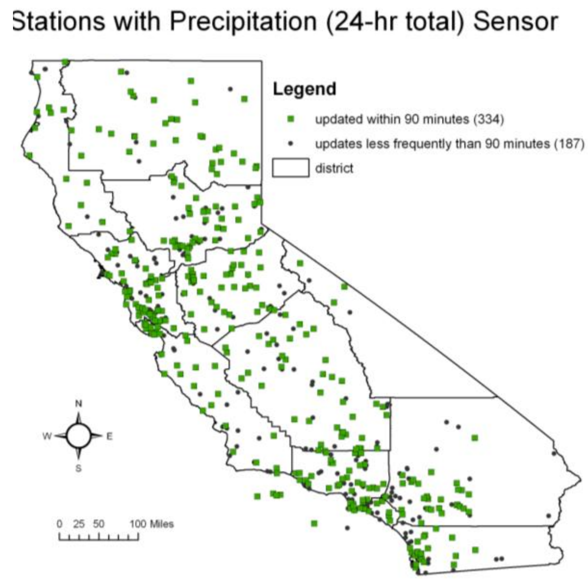

Figure 13: Stations with a 24-hr Precipitation Sensor

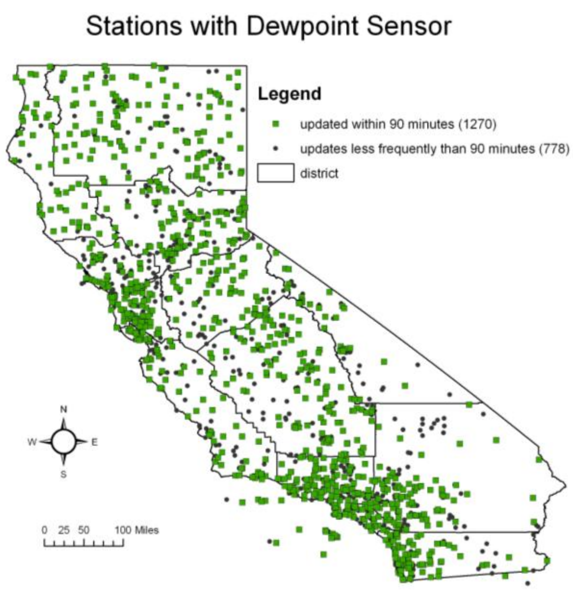

Figure 14: Stations with a Dewpoint Sensor

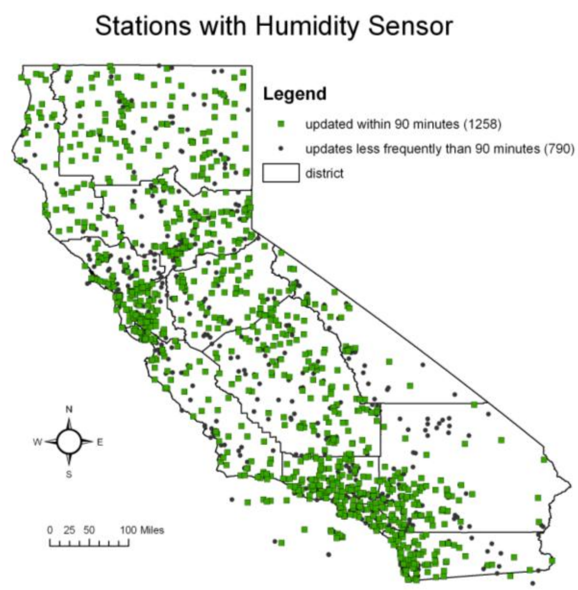

Figure 15: Stations with a Humidity Sensor

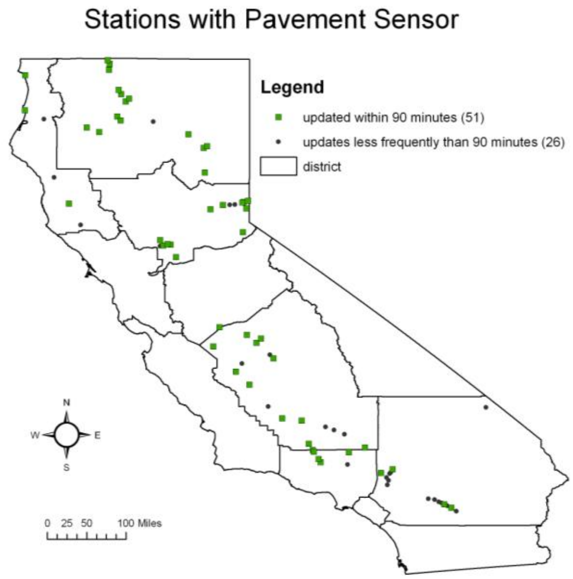

Figure 16: Stations with a Pavement Sensor