WeatherShare Concept of Operations

Version 2.0 – Baseline

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April 26, 2005

REVISION HISTORY

Version	Date	Description	Author of Changes
0.01	10/15/2003	Draft ConOps prepared for the kickoff meeting	Enzhen Huang, Shaowei Wang, and Lisa Ballard
1.0	01/27/2004	Baseline ConOps in light of feedback from project stakeholders at the kickoff meeting.	Shaowei Wang, Lisa Ballard, and Xianming Shi
2.0	04/26/2005	Implemented changes in light of the system requirements approved by the steering committee at the stakeholder meeting in Dec. 2004, and the facility study results and next steps discussed with the Caltrans District 2, DRI, and Headquarter IT team in March 2005.	Xianming Shi

PREFACE

This document is a baseline Concept of Operations (ConOps), and its format generally follows the standard defined by the IEEE Guide for Information Technology Concept of Operations Document.

The objectives of ConOps are as follows:

- Document the existing system.
- Identify the high-level needs to be addressed.
- Provide a conceptual overview of the desired system.
- Define users and operational scenarios of the proposed system.
- Present operational impacts of the proposed system.
- Analyze advantages and limitations of the proposed system.

The ConOps and requirements analysis documents will form the foundation for the WeatherShare system design and development.

As a living document, the ConOps has been and will be updated as appropriate throughout the duration of the project, in order to incorporate changes resulting from newly available information or an improved understanding of the scope.

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1. SCOPE

Western Transportation Institute at Montana Statue University (WTI) is under contract to Caltrans Division of Research and Innovation (Sacramento) for the development of WeatherShare, of which Caltrans District 2 is the primary technical contact. The goal of the WeatherShare project is to streamline and integrate currently available road weather data in the Northern California area into one single source easily accessible by incident responders and potentially the traveling public. WeatherShare covers 7 counties in District 2 as well as 13 counties in the adjacent Caltrans Districts.

Caltrans District 2 includes the northeastern counties of California, all the way to the Oregon border. This mostly rural district includes the Cascade Range and the northern portion of the Central Valley. The region features weather extremes (i.e., frequent snow and ice during the winter) and difficult terrain, which make weather information crucial to meet the challenges in highway maintenance and incident management operations.

1.1. Identification

The Concept of Operations document applies to the proposed WeatherShare system which will be implemented for Caltrans District 2. The information regarding road and weather conditions in the WeatherShare system will be collected based on available data from the Caltrans Road Weather Information Systems (RWIS), California Data Exchange Center (CDEC), MesoWest, and the Meteorological Assimilation Data Ingest System (MADIS).

1.2. Document Overview

The purpose of the Concept of Operations (ConOps) document is to provide a user-oriented description of the WeatherShare system. This document is meant to communicate WTI's understanding of the needs of RIME organizations and how WeatherShare will operate to fulfill those needs. The intended audience for this document is the end users and developers of the WeatherShare system. The format of this document follows the IEEE Standard 1362-1998. The concepts in this document are the sole property of WTI, the "Contractor."

This document contains a description and analysis of the existing situation and proposed system. Information is organized into eight chapters. Chapter 1 provides the scope of this document and the system being analyzed. Chapter 2 lists the references used or referred to in this document. Chapter 3 describes the current situation related to the use of road and weather information. Chapter 4 describes the justification for WeatherShare. Chapter 5 describes the concept for the proposed system. In Chapter 6, scenarios for how WeatherShare should operate are presented. Chapter 7 summarizes the impact of the system on the users. Chapter 8 analyzes the benefits and limitations of the proposed system.

1.3. System Overview

Utilizing currently available technologies and based upon Caltrans' specifications, WTI will provide Caltrans District 2 with a surface transportation weather system that will allow users to view a compilation of available road weather data from various sources in the region. This pilot system is expected to increase the efficiency of situation assessments for a variety of purposes, including incident management, highway maintenance, emergency medical services, traveler information, and, possibly, homeland security applications. Variation of the user interface will depend on the user's needs and specifications.

Figure 1 shows the envisioned data flow for the proposed web-based application, or WeatherShare system. The highest priority users for the system are Caltrans District 2 traffic management center (TMC) staff. Other users may include staff from Caltrans maintenance division, emergency medical services (EMS), Shasta Area Safety Communications Agency (SHASCOM) dispatch, California Highway Patrol (CHP) dispatch, and California Department of Forestry & Fire Protection (CDF) as well as the general public.

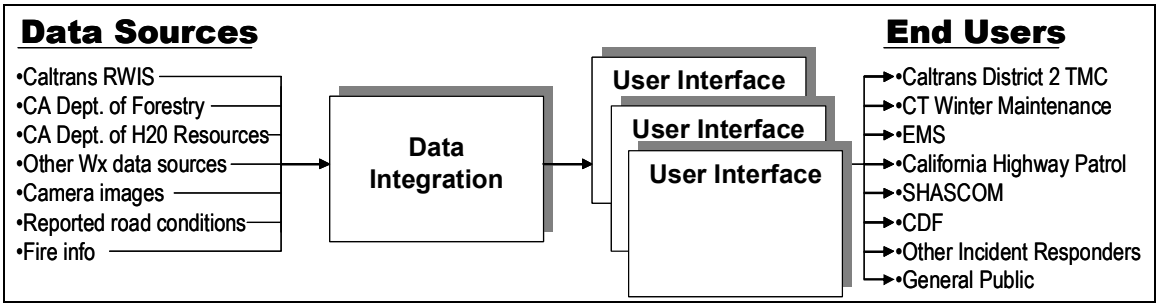


Figure 1: Envisioned Data Flow for WeatherShare

WeatherShare is a component of the Redding Incident Management Enhancement (RIME) program, which consists of a group of technology initiatives designed to improve public safety in the Redding area. The structure of the RIME program is shown in Figure 2.

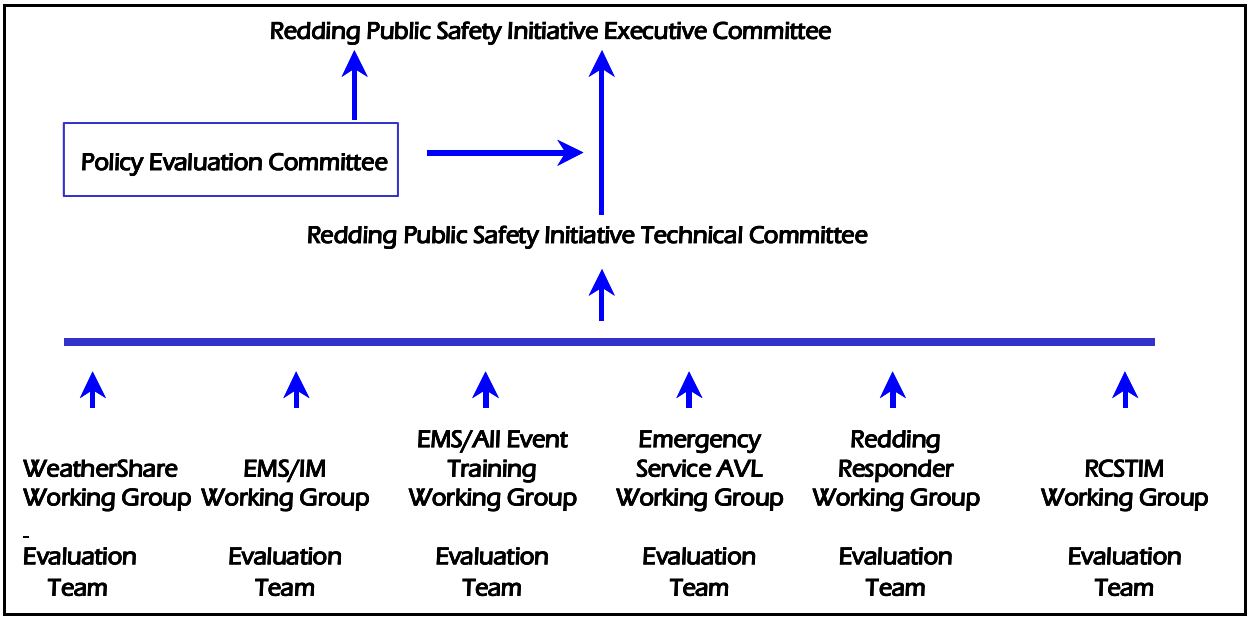


Figure 2: Structure of the Redding Incident Management Enhancement Program

The project will provide road weather information for the RIME region, which includes 11 California counties: Butte, Colusa, Glenn, Sierra, Tehama, Plumas, Trinity, Shasta, Lassen, Siskiyou, and Modoc. The first four counties are covered by Caltrans District 3 while the rest of the RIME Region is covered by District 2. Since the weather events normally begin in the west, weather conditions in some District 1 counties west of RIME region are of interest to this project as well. Figure 3 depicts the region of interest for WeatherShare.

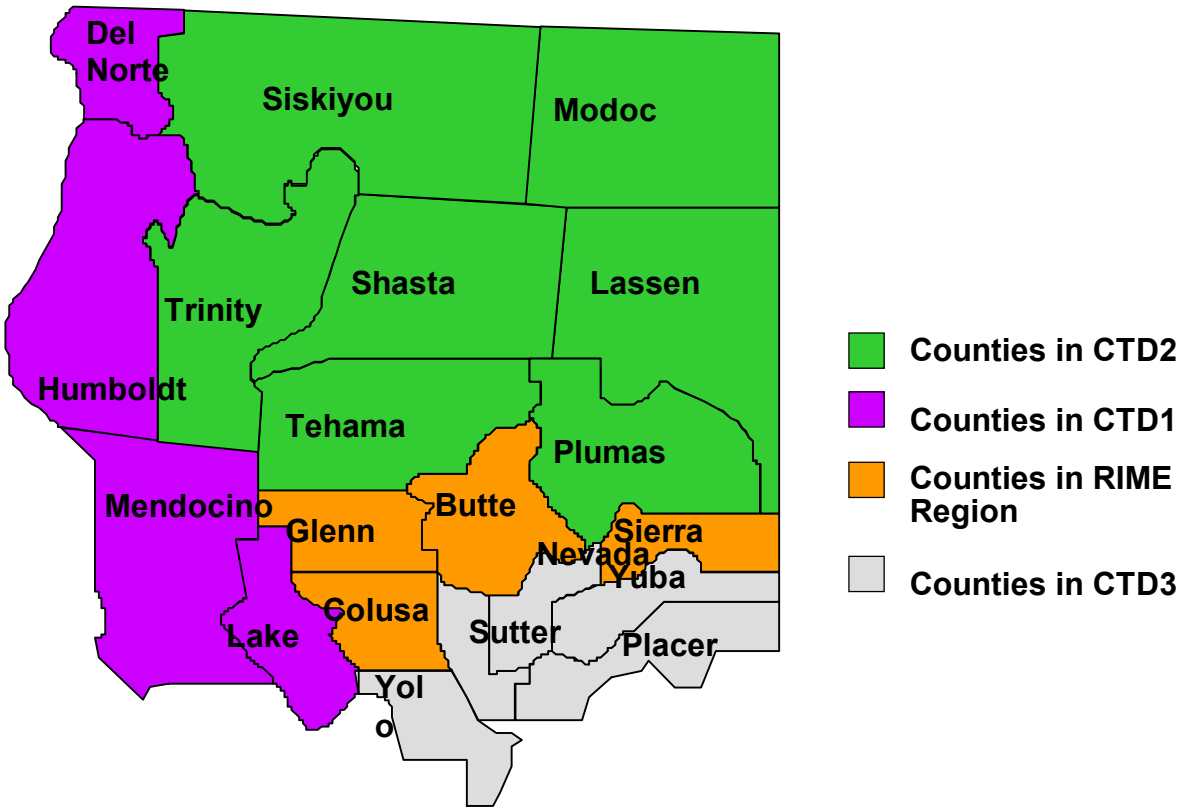


Figure 3: Region of Interest for WeatherShare

This project uses a phased approach. Initially, a prototype application with basic functionality was developed, tested, and deployed to gather user requirements. While developing the initial system, WTI worked with Caltrans and other incident responders to identify necessary upgrades to the system. Then WTI implements these upgrades, including utilization of additional data sources, more user-identified functions, as well as improvements to the user interfaces.

2. REFERENCED DOCUMENTS

The following documents were used to develop this document or are referenced in the document.

1 Bristow, Jeff and Lisa Ballard. March 12, 2003. *A Proposal to Develop WeatherShare.* Bozeman, Montana: Western Transportation Institute, Montana State University for the California Department of Transportation.

2 Shi, Xianming, Enzhen Huang, and Lisa Ballard. October 13, 2003. *WeatherShare Project Plan (Version 0.1 – DRAFT).* Bozeman, Montana: Western Transportation Institute, Montana State University for the California Department of Transportation.

3 Shi, Xianming. April 25, 2005. *WeatherShare Project Plan (Version 2.0 – Baseline).* Bozeman, Montana: Western Transportation Institute, Montana State University for the California Department of Transportation.

4 Institute for Electrical and Electronics Engineers. 1998. *IEEE Guide for Information Technology - System Definition - Concept of Operations (ConOps) Document.* New York: IEEE. Standard 1362-1998.

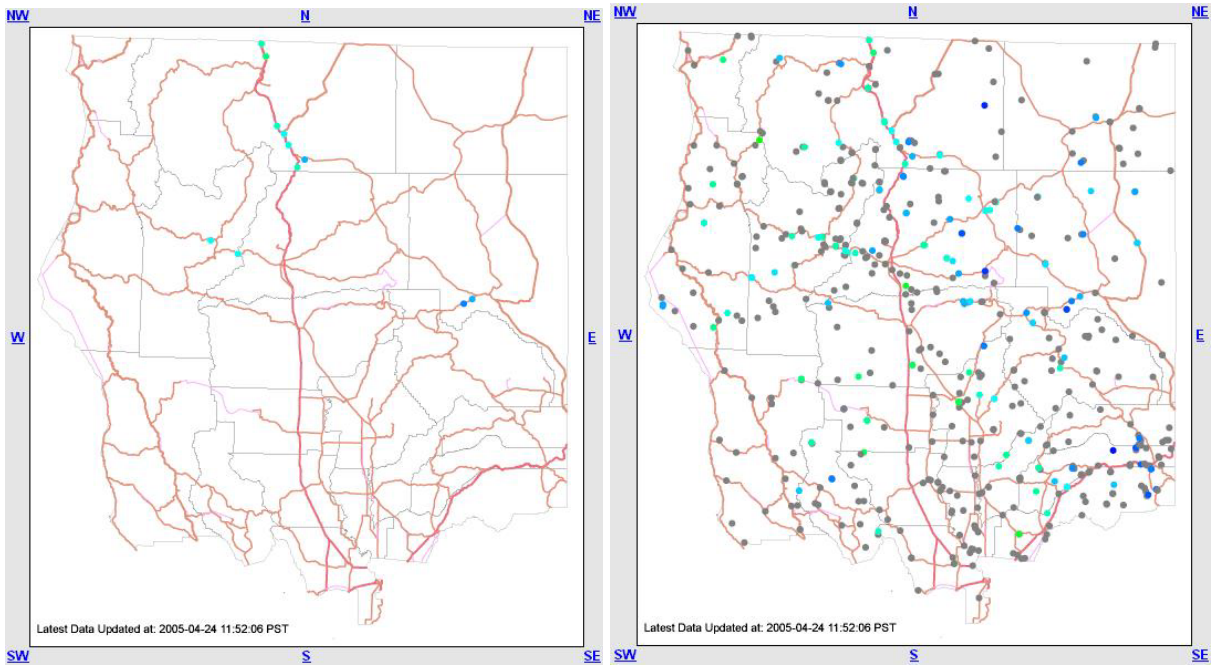
5 Ballard, Lisa et. al. 2002. *Handbook and Final Report: Assess Caltrans RWIS.* Bozeman, Montana: Western Transportation Institute, Montana State University for the California Department of Transportation.

3. CURRENT SITUATION

3.1. Background, Objectives, and Scope

The RIME organizations in northern California are collectively responsible for maintaining the state highways, responding to incidents on the state highways, and responding to other emergencies. Because of these responsibilities and because these organizations represent people who must travel on the roads in all weather conditions, knowledge of current, forecasted, and historical road and weather conditions assists in the completion of the organizations' missions. Furthermore, Caltrans can use road and weather information to make the roads safer for the traveling public and to inform travelers of potentially dangerous conditions.

In adverse weather events or natural disasters, the call-takers and dispatchers at Caltrans, CHP, and SHASCOM need detailed road and weather conditions. Currently, tools used include websites and subscription services from NWS and commercial meteorological companies. In addition to the 11 Caltrans District 2 RWIS stations, users can also search different Internet sites to find hundreds of weather stations in the region operated by various state and federal agencies.



(a) Caltrans District 2 RWIS Stations (b) All Available Stations in WeatherShare

Figure 4: Weather Stations in the Region

As illustrated in Figure 4, an abundance of road and weather information is available in the region. However, currently the information must be accessed through separate sources, making it inefficient and time-consuming to assess road and weather conditions.

3.2. Operational Policies and Constraints

A number of agency users of weather information, including Caltrans District 2, CDF, SHASCOM, NorCal EMS, and CHP, are evaluated in this document. Another group of users, the general public, is not evaluated. Table 1 summarizes policies and constraints that affect the current situation.

Table 1: Summary of Current Operational Policies and Constraints

Organization	Hours of operation	# of Users of Weather Information	Weather System Computer Constraints	Constraints on Operational Facilities
Caltrans District 2 Maintenance	24 hours from Dec. to Mar.; 7:30AM-4PM rest of year as weather dictates	12 users are trained to use ScanWeb (6 trained to maintain it); 3 users access the computer hosting Meteorologix application	Weather information via Internet and TV; ScanWeb RWIS interface runs on a web-based application; Meteorologix application runs on a dedicated computer.	Data must be accessible from 60 users from 25 sites; some with low-speed dial-up connection
Caltrans Redding TMC	7:00AM-5:00PM plus incidents	10 operators in total; typically 2 at a time	TMC has 4 workstations, all running Windows 2000 systems with Internet capabilities.	None
CDF	Not available at this time	Not available at this time	Contracted some weather forecasting work to the Dessert Research Institute (DRI) to produce the California Hourly Fire Danger Map.	NA
SHASCOM	24 hours	Less than 40 supervision dispatchers and line dispatchers	Weather information is accessed through the Internet and television. Only one supervisor uses stand-alone PC for internet access	Firewall issues.
NorCal EMS	24 hours	12 staff members	Weather information is accessed through the Internet and television. All workstations have Internet access.	Dial-up Internet connection
CHP Redding Calling Center	24 hours	All call-takers and dispatchers	Weather information is accessed through the Internet and television. All workstations have Internet access.	Dial-up Internet connection. 15 offices with 486 Uniformed Officers.

* The Caltrans RWIS system collects pavement measurements (temperature, presence of ice and chemical, etc.) but does not provide the information on their Internet site due to liability concerns. Any Caltrans employee can access the information via the Caltrans Intranet.

3.3. Current System

Caltrans District 2 plays a number of significant roles in transportation in the Redding area, as it is responsible for the road maintenance, traffic management, and incident response and dispatch. District 2 staff also has to travel under all weather conditions. District 2 does not have an automated traffic management system (ATMS), but subscribes to services including Surface Systems International (SSI) and Meterologix for weather information. In addition to the SSI ScanWeb / ScanCast applications, District 2 uses a Meterologix product that provides weather monitoring and satellite images in a format that can be configured to meet the needs of the District. District 2 staff also uses TV weather reports and non-Caltrans Internet weather sites to gather work-related weather information.

Currently, Caltrans District 2 primarily uses RWIS and other available weather data to control snow & ice and identify high wind conditions. Options for de-icing treatment include solid salt, magnesium chloride, cinders, and salt brine. In choosing when to apply and how much chemicals and/or abrasives to use, some maintenance supervisors rely on the RWIS measurements of chemical factor, pavement temperature, and subsurface temperature. The pavement sensors, although important, have reliability problems and sometimes are covered in paving and sealing work. The District is testing truck-mounted infrared pavement temperature sensors to alleviate this problem.

Caltrans District 2 began using RWIS in 1993 and currently has 11 operational RWIS stations, with approximately 50 additional stations in the construction, design, or planning phases, as shown in Figure 5. SSI deployed the entire system, including the sensors in the field, communications system, database, and user interface. Users can access data from six stations through ScanWeb and two other stations on the old, non-Internet Scan system. ScanCast pavement temperature forecasts are provided for the six sites. There are four *close circuit television camera* (CCTV) units co-located with current RWIS sites. The District plans to install CCTV on all new and existing RWIS sites.

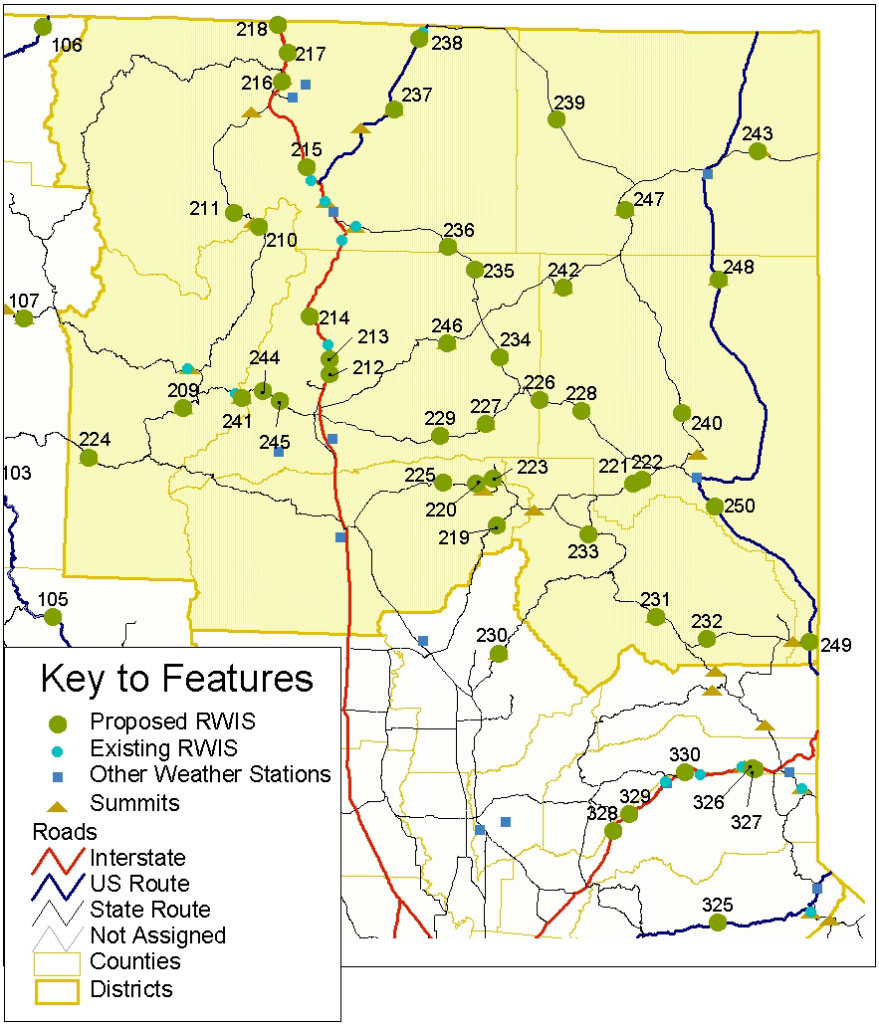


Figure 5: Caltrans District 2 RWIS Locations

One problem noted is that the user interface of ScanWeb is not satisfying. Furthermore, access to the information is limited to the vendor-provided application and historical weather data are only available through the vendor. Recently, the District developed web pages that allow the general public to access traffic camera images (http://www.dot.ca.gov/dist2/cctv/traffic_cams.shtml), winter chain control maps (http://www.dot.ca.gov/dist2/chainup/all_cntys.htm), as well as part of the RWIS data (http://www.dot.ca.gov/dist2/rwis/rwissites.php), as shown in Figure 6 to Figure 9. The public website does not provide information regarding the pavement temperature and chemical factor or the forecasts for the six sites, but such information is available within Caltrans.

Figure 6: Map of Selectable Camera Locations on the Caltrans Website

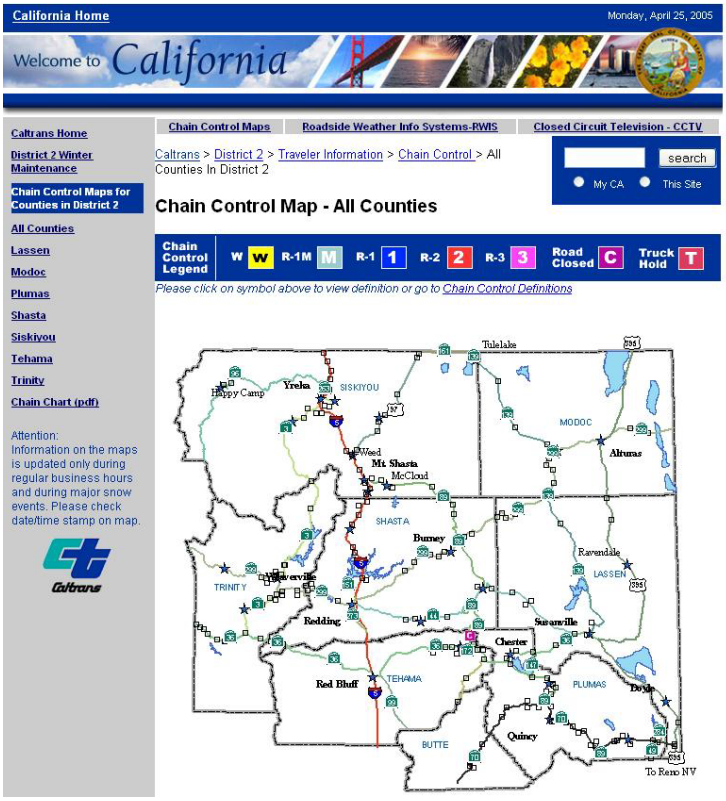


Figure 7: Map of Winter Chain Control Locations on the Caltrans Website

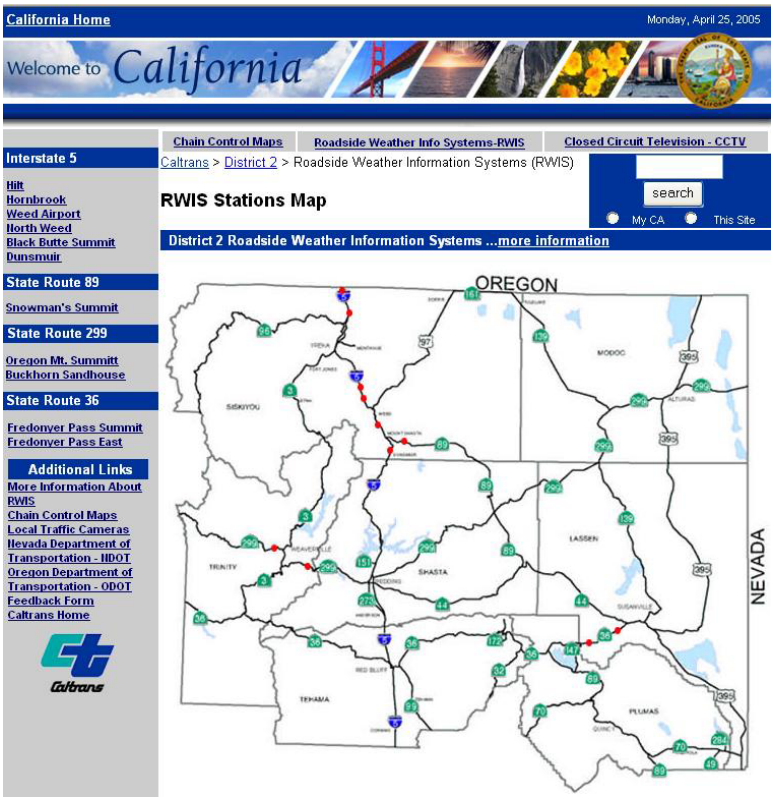


Figure 8: Caltrans District 2 RWIS Web Page for the General Public

Figure 9: Sample of RWIS Data Available through the Caltrans Website

RWIS uses environmental sensor stations (ESS) positioned alongside the highway to collect local atmospheric and pavement data. Each RWIS station utilizes sensing devices, which are placed below the highway surface, or on towers 33 feet (10m) above the roadway. Road sensors are used to determine if the roadway surface is wet, dry, frosted, snow-covered, or iced. At the tower's height, weather data such as air temperature, rainfall, and wind speed are measured and collected. Some of the stations use video cameras to relay visual information about weather and road conditions such as fog, rain and snow. Information gathered from the RWIS equipment allows the Traffic Operations and Maintenance staff to make informed decisions during the winter. For instance, the RWIS stations monitor air and pavement temperatures to make it possible to forecast how the winter storms may impact the highways. The road sensors inform maintenance personnel of road conditions and existing concentrations of deicing chemicals, such as salt, and help them determine when the road surface will freeze.

CDF collects data from Remote Automated Weather Stations (RAWS), while using cameras as a highly valuable resource to watch sites. Currently, CDF contracts some weather forecasting work to the Desert Research Institute (DRI) to produce the California Hourly Fire Danger Map (http://www.cefa.dri.edu/HourlyFD/). CDF also identifies the Redding Fire Weather Center (http://www.fs.fed.us/r5/fire/north/fwx/) as a possible resource to tap into.

CHP is responsible for traffic enforcement and highway safety throughout the state. Duties include issuing traffic citations, arresting alcohol- and drug-influenced drivers, investigating traffic accidents and vehicle theft, and providing assistance to the motoring public. CHP also provides general law enforcement assistance to local agencies upon request. Currently, CHP dispatchers gather information from the existing system to assist officers in responding to incidents.

SHASCOM is a joint dispatch center for the county of Shasta and the city of Redding. Responsible for the public safety communications and dispatch, SHASCOM operates 24 hours a day, 7 days a week. Due to firewall issues (mobile data terminals must be secure), internet access is not allowed for most computers. Only one supervisor uses a stand-alone PC for internet access. SHASCOM dispatchers normally call Caltrans and CHP to find out road and weather conditions or, in the case of flooding, SHASCOM would send someone from roads to check. It is desirable for first responders in very remote areas to be able to check the relevant information, such as how high the river will rise, when the rain will stop, etc., through an interactive application.

NorCal EMS is a private, non-profit, public-benefit Corporation. While not a direct emergency responder, NorCal EMS is a regulatory agency that deals with pre-hospital care matters in 11 Northern California counties. It serves a variety of functions in the regional EMS community, and has three major responsibilities.

- Communications: It owns a number of mountain-top radio repeaters, pays the rent and keeps the UHF communications system operating;
- Medical Regulation; and
- Occasional medical service roles and projects.

For the EMS community, WeatherShare could be very useful in at least two scenarios. First, in response to natural disaster or large events, NorCal EMS would be the conduit with other agencies for getting extra resources and facilitating the provision of pre-hospital medical care. WeatherShare would allow NorCal EMS staff to make informed decisions regarding surface transportation. Second, when a patient needs to be transferred from location A to location B, WeatherShare would help the EMS organizations get a better idea of the road weather conditions to make informed decisions accordingly, e.g., whether to take a 4 wheel-drive or 2 wheel-drive vehicle. In the second scenario, the users of WeatherShare would be staff in ambulance quarters, EMS dispatch centers, and medical helicopters.

In addition to the RWIS stations operated by Caltrans, there are hundreds of weather stations in the region operated by other state and federal agencies. For instance, CDF and U.S. Bureau of Land Management (BLM) currently operate Remote Automated Weather Stations (RAWS) in the region, which collect meteorological data such as wind speed and direction, precipitation, temperature, relative humidity and fuel moisture to help fire and resource specialists manage fires. (A large network of 1,150 stations, the RAWS network is managed by the National Interagency Fire Center, or NIFC, located in Idaho.) Natural Resources Conservation Service operates a few Snowpack Telemetry (SNOTEL) stations in the region, which automatically collect snowpack and related climatic data. Furthermore, Bay Area Marine Institute, Federal Aviation Administration (FAA), and National Weather Service (NWS) operate weather stations in the region as well.

From the users' perspective, there is an increasing need for easier accessibility of weather information in the region. Currently, there is overlapping and lack of integration in the existing weather data sources, such as the weather data networks including MesoWest, the Meteorological Assimilation Data Ingest System (MADIS), and CDEC. MesoWest (http://www.met.utah.edu/mesowest/) is one of the largest mesonets in the western United States, operated by the University of Utah and the National Oceanic and Atmospheric Administration (NOAA). In the region, MesoWest provides real-time weather data from more than 200 stations from Caltrans RWIS, APRSWXNET, RAWS, DRI, SNOTEL, NWS, FAA, California Air Resources Board (CARB), California Irrigation Management Information System (CIMIS), California Nevada River Forecast Center (CNRFC), and Mt. Shasta Avalanche Center (SHASAVAL). APRSWXNET is a public service weather network of amateur radio operators and private citizens operating home weather stations. MADIS (http://www-sdd.fsl.noaa.gov/MADIS/) is dedicated toward making value-added data available from the NOAA Forecast Systems Laboratory (FSL) for the purpose of improving weather forecasting. In addition to hundreds of MesoWest stations, MADIS provides real-time weather data from 39 stations in the region from APRSWXNET, RAWS, FSL Ground-Based GPS, Multi-Agency Profiler Surface Observations, and Weather for You, among others. Operating more than 400 real-time reporting stations in the region, the California Data Exchange Center (CDEC, http://cdec.water.ca.gov/) under the California Department of Water Resources (CDWR) operates an extensive hydrologic data collection network including automatic snow reporting gages for the Cooperative Snow Surveys Program and precipitation and river stage sensors for flood forecasting, as well as some RAWS stations.

3.4. Involved Personnel (Users)

3.4.1. Organizational Structure

The stakeholders analyzed in the current system include Caltrans District 2, CHP, CDF, NorCal EMS, EMS Providers, SHASCOM, Caltrans Division of Research & Innovation, NWS, APRSWXNET, CDEC, and Traveling Public. Their roles and weather data uses are listed in Table 2.

Table 2: Organizational Roles in the Current System

	Roles					Data Uses				Data Provider	
Stakeholder	**Road Maintenance**	**Traffic Management**	**Incident Responder**	**Dispatch**	**Travel During Poor Wx**	**RWIS Wx Measurements**	**RWIS Roadway Measurements**	**RWIS Forecasts**	**Other Weather Service w/ Cost**	**Operates Wx Stations**	**Other Roles**
Caltrans District 2	X	X	X	X	X	X	X	X	X	X	
CHP		X	X	X	X	X					
CDF			X			X				X	
NorCal EMS											Supports Emergency Responders
EMS			X	X	X	some					
SHASCOM				X		X			X		
Caltrans Division of Research & Innovation											Oversees research in District 2
NWS						X				X	
APRSWXNET						X				X	
CDEC										X	
Traveling Public					X	X					

As the primary end user and stakeholder, Caltrans District 2 consists of four divisions: Maintenance & Traffic Operations, Planning, Program & Project Management and Administration. The Maintenance and Operations Division includes 7 offices and is responsible

for maintaining and operating the state highway system. The Planning Division plans for the future of transportation in the District. The Program & Project Management Division focuses on managing capital projects from initial planning through the end of construction. The Administration Division is responsible for supporting the Caltrans family.

The CHP Northern Division consists of 15 offices with 486 Uniformed Officers and a calling (dispatch) center in Redding. NorCal EMS does not use road and weather information frequently, as it is not a direct emergency responder, but rather a regulatory agency that supports emergency medical responders. NorCal EMS has 12 staff members and covers 33,000 sq. miles of Northern California. The SHASCOM team consists of 44 members including a General Manager, Operations Manager, Support Services Supervisor, Supervising Dispatchers and Line Dispatchers. The Board of Directors is comprised of the Shasta County Administrative Officer, Redding City Manager, Shasta County Sheriff, and Redding Fire Chief. The potential users of road weather information are supervision dispatchers and line dispatchers.

3.4.2. Profiles of User Classes

The user classes evaluated in the current system include Agency User, RWIS Monitor, Weather Station Network, and Traveler.

The Agency User class is used to describe the primary users of the current system, including Caltrans Redding TMC staff, Caltrans District 2 Field Maintenance staff, EMS staff, SHASCOM dispatch staff, CHP staff, and CDF staff.

Caltrans Redding TMC staff gathers RWIS and other road weather information for the purpose of incident management and traffic management, while Caltrans District 2 Field Maintenance staff uses the information for roadway maintenance, ice/snow control, and response to roadway incidents. Staff of local EMS organizations (often associated with NorCal EMS) gathers the road weather information to provide emergency medical services in a safer and more efficient manner. SHASCOM dispatch staff and CHP staff obtain the road weather information to react to emergencies or other incidents reported. CDF staff primarily uses road weather information to react to fire emergencies.

The RWIS Monitor class is used to describe the Caltrans employee who maintains the RWIS stations, checks the questionable RWIS sensors/stations, and corrects the wrong data.

The class of Weather Station Network includes the sources providing road weather information in the area, such as Caltrans RWIS database, CDF database, APRSWXNET database, NWS weather database, CDEC weather database, and non-weather information sources.

The Traveler class is comprised of the traveling public who access road weather information from the Caltrans website or other organizations' sites to assist in their trip-making decisions.

3.5. Support Concept

Approximately 12 people in Caltrans District 2 are trained to use the ScanWeb RWIS application. Maintenance staff is generally receptive to RWIS. Staff follows the lead of the Chief of Maintenance and Operations, who is an advocate for quality use of RWIS.

SSI runs the current Caltrans District 2 RWIS system and has a support contract. All data is stored on an SSI database in St. Louis. SSI also posts near-real-time data on a secure Intranet site for access by Caltrans staff.

Six Caltrans District 2 personnel are trained in maintaining the system. Caltrans District 2 RWIS data, without pavement conditions and forecasts, are posted on the Caltrans Internet website as part of traveler information provided for traveling public in the area.

4. JUSTIFICATION FOR AND NATURE OF CHANGES

4.1. Justification for Changes

Members of the RIME program identified six pilot projects to "leverage the institutional relationships and technology/communications deployments of the Redding District." This project was one of the first two initiatives to receive funding.

As described in section 3.3, an abundance of road and weather information is available in the region. However, currently the information must be accessed through separate sources, making it inefficient and time-consuming to assess road and weather conditions. Caltrans District 2 and other RIME members identified a need for access to all of the available road weather data from one single source. The existing deficiencies in the current system are listed below.

- Many weather stations exist in the region but access to the information is through various interfaces, some of which are complicated for non-expert users.
- There is overlapping and lack of integration in the existing weather data sources.
- Caltrans RWIS information is available only via the Caltrans website, where relevant road weather information from other sources is not available.
- For Caltrans RWIS, the user can only view weather station data one station at a time (no overall view).
- No one outside of Caltrans can view the pavement measurements.
- Caltrans RWIS data is perceived to be inaccurate at times.
- Access to the Caltrans RWIS information is limited to the vendor-provided application and historical weather data are only available through the vendor.

The use of road and weather data in the area has not yet reached its full potential, leaving room for improvement in integrating existing data from various sources and enabling easier access to the information.

4.2. Description of Needed Changes

By compiling all the road weather data into one user-friendly interface, every RIME agency will have a better tool to use when responding to roadway incidents under adverse weather conditions or in natural disasters. Furthermore, the traveling public will have a better source when making travel decisions. As a framework to improve the quality and accessibility of road weather information provided to transportation decision-makers, the WeatherShare system would facilitate the use of road and weather data and encourage their applications in new programs.

The desired system will allow users to view a compilation of all available road and weather information from various sources in the region. The system will greatly increase the efficiency of situation assessments for roadway maintenance, incident management, emergency medical

response, traveler safety, fire suppression, flood management, and homeland security applications, among others.

The WeatherShare application will assist Caltrans District 2 employees; other incident responders, including CHP, SHASCOM, and CDF; and the general public to make more efficient and better informed assessments of current road and weather conditions in the area. Variations of the user interface will depend on the user's needs. An interactive data-view interface will help the users easily find and understand the information they need.

For Caltrans, the WeatherShare system will increase the efficiency of their roadway maintenance and snow/ice removal activities. For all incident responders, the WeatherShare system will shorten the response time to incidents and save lives. For instance, emergency medical services cannot simply stay off the roads when weather conditions endanger traveling public. Valuable time is wasted when multiple sources must be consulted for road and weather conditions. A single access point for all relevant information would save emergency medical personnel time in finding the safest routes and estimating response times in dangerous weather, thereby increasing the safety of themselves as well as of their patients.

4.3. Priorities among the Changes

Based on discussions at the kickoff meeting and stakeholder meetings as well as results from an end user questionnaire, the features identified by users for the ideal WeatherShare system are listed in order of priority as follows.

1. Allow the administrator to add new stations from existing data sources
2. Allow the user to turn on/off various data layers on the interactive map display, such as air temperature and wind speed & direction
3. Automatically push road weather information to the user every 5 minutes
4. Apply quality control procedures for all the real-time reporting stations
5. Ensure that only authorized users can access the confidential information such as the Caltrans RWIS pavement temperature data
6. Remember the authorized user's profile and automatically load the profile once he or she is logged in
7. Allow the user to display a meaningful graphical representation of a particular data value across a selected region, including air temperature and wind
8. Allow the authorized user to define his or her profile, including default data layers
9. Use a map display that permits the user to zoom into, zoom out of, or pan into the area of interest

10. Allow the user to track historical data for a period of up to one year from present

11. Allow the authorized user to enable or disable user-defined alerts

12. *Allow the user to "replay" the graphical representation of a particular data type for a user-defined time period in an accelerated "movie" mode*

13. Allow the authorized user to define thresholds for alerting status change in air temperature, dew point temperature, and wind speed

14. Backup the road weather data on a daily basis and implement a backup mechanism for the server as well

15. Distinguish between authorized and non-authorized users

16. *Provide a filtering function to allow the authorized user to view only stations adjacent to roads, water bodies, or forest, or on the mountaintop*

Due to technical difficulty and cost & schedule implications, the WeatherShare steering committee agreed that the features 12 and 16 should not be implemented in the proof-of-concept and pilot phase of WeatherShare, but might be desirable for future phases.

For a more comprehensive list, please refer to the document entitled “User Requirements for the WeatherShare System”, in which 44 baseline final requirements are grouped into functional and non-functional requirements, respectively.

5. NEW SYSTEM CONCEPT

5.1. Background, Objectives, and Scope

The goal of the WeatherShare project is to streamline and integrate currently available road weather data in the Northern California area into one single source easily accessible by incident responders and potentially the traveling public. By identifying the user requirements and building the "customer voice" in the system, WeatherShare is designed to increase the efficiency of situation assessments for a variety of purposes, including incident management, highway maintenance, emergency medical services, traveler information, and, possibly, homeland security applications. Variation of the user interface will depend on the user's needs and specifications.

The scope of the new system will focus on providing weather information for the RIME region, which includes 11 California counties: Butte, Colusa, Glenn, Sierra, Tehama, Plumas, Trinity, Shasta, Lassen, Siskiyou, and Modoc. The first four counties are covered by Caltrans District 3 while the rest of RIME Region is covered by District 2. Since the weather events normally starts first from the west, weather conditions in some District 1 counties west of RIME region will be of interest to this project as well. As shown in Figure 3, the region of Interest for WeatherShare covers 20 counties at this stage.

5.2. Operational Policies and Constraints

Caltrans servers are not conducive to implementation of the WeatherShare system because of firewall management regulations at Caltrans. The facilities study, as outlined in the proposal, will identify which organization is best suited to administer and maintain the WeatherShare system when the project is completed.

5.3. Description of the New System

5.3.1. Data Flow Diagram

The new system can be described through the WeatherShare data flow diagram shown in Figure 10. More details of the data flow can be described as follows.

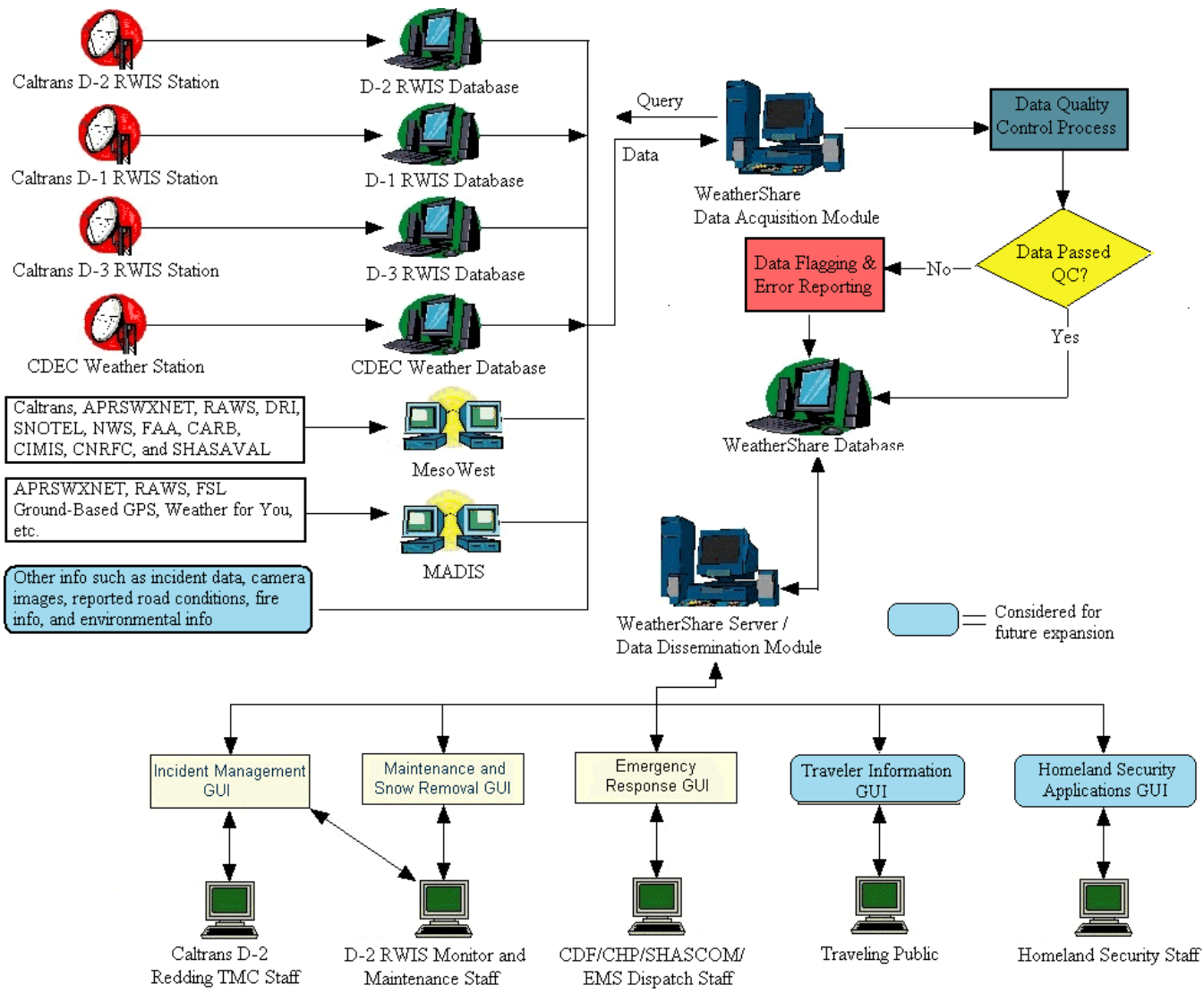


Figure 10: WeatherShare Data Flow Diagram

1. Weather stations, including Caltrans District 2, District 1 and District 3 RWIS stations and CDEC weather stations in the area, monitor road and weather conditions at predefined time intervals and send the data back to their central database.

2. MesoWest and MADIS pull weather data from their upstream data providers' databases, at predefined time intervals.

3. WeatherShare accesses the RWIS and CDEC databases as well as MesoWest and MADIS to collect the near-real-time data through the interfaces provided by these upstream data providers. For Caltrans District 1 RWIS and CDEC, the data are pushed to WeatherShare every 15 minutes. For other data sources, the data are pulled by WeatherShare every 15 minutes.

4. WeatherShare automatically assigns quality control (QC) techniques to the incoming, real-time weather data, in spite of the fact that the observation system of some weather stations may have performed QC procedures. Only the data that pass all the levels of QC procedures will be displayed to the user, when he or she accesses the weather information from the *recent reports* section. However, all the data will be displayed to the user along with the associated data quality descriptors, when he or she accesses the weather data from the *reporting stations* section. For each weather station, the logged-in user will be able to view its historical data as well as QC report.

5. WeatherShare integrates the quality controlled data from various sources into one standardized format and stores the data in a central database.

6. Through the graphical user interface (GUI), an interactive map display, client machines (including Caltrans District 2 staff, CDF/CHP/SHASCOM/EMS dispatch staff, general public, etc.) send their requests to the WeatherShare Server. In the proof-of-concept phase of WeatherShare, the default GUI is the same for users from different agencies and the user is allowed to define his or her profile in terms of data layers and alert thresholds.

7. Server identifies the client and his/her privilege level.

8. Server responds to the client's request by searching the database for information needed by its business logic and sends the result back to the client machine. Information is restricted based on the client's privilege level. Only authorized users can access the confidential information such as the Caltrans RWIS pavement temperature data.

9. WeatherShare automatically pushes road weather information to the user every 5 minutes so that the user can monitor the changing conditions without refreshing the webpage.

5.3.2. Prototype/Storyboard

The WeatherShare system will serve a variety of agency users ranging from Caltrans District 2, EMS Providers, SHASCOM, CHP and CDF to the general public. To the users, the WeatherShare system is deployed as a web browser based system that will present different layers of weather and road information according to privilege level and needs. On the server side, the system runs the scripts in the background, fetching data of different formats from different sources, and puts them into the WeatherShare database in a standard format for further analysis and quality control. The system outputs weather and road information as well as maps and additional information based on the request from the user (client).

The primary means of interface to the WeatherShare system will be a W3-standard-compliant web browser. All user side requests will go through the web-based client architecture that uses HTTP as the primary means for interacting with the WeatherShare system server. A secured FTP push/pull technique may be used for users exchanging data with the server. For example, CDEC (and possibly Caltrans District 1) can feed their real-time road and weather information to

WeatherShare using a push mode with an account on the server host and the path information for the drop-off directory.

A common user interface will be presented to all the users when they first access the system. Users, except the general public, can log into the WeatherShare system with their user ID and password to set their profile and define what they need and how they prefer to see the information. Once the user is logged in, the customized user interface is implemented according to their predefined settings and various layers of road and weather information options will be available. The graphic user interface (GUI) is the vehicle to return processed output to the end users. A snapshot of the proof-of-concept WeatherShare GUI is shown in Figure 11.

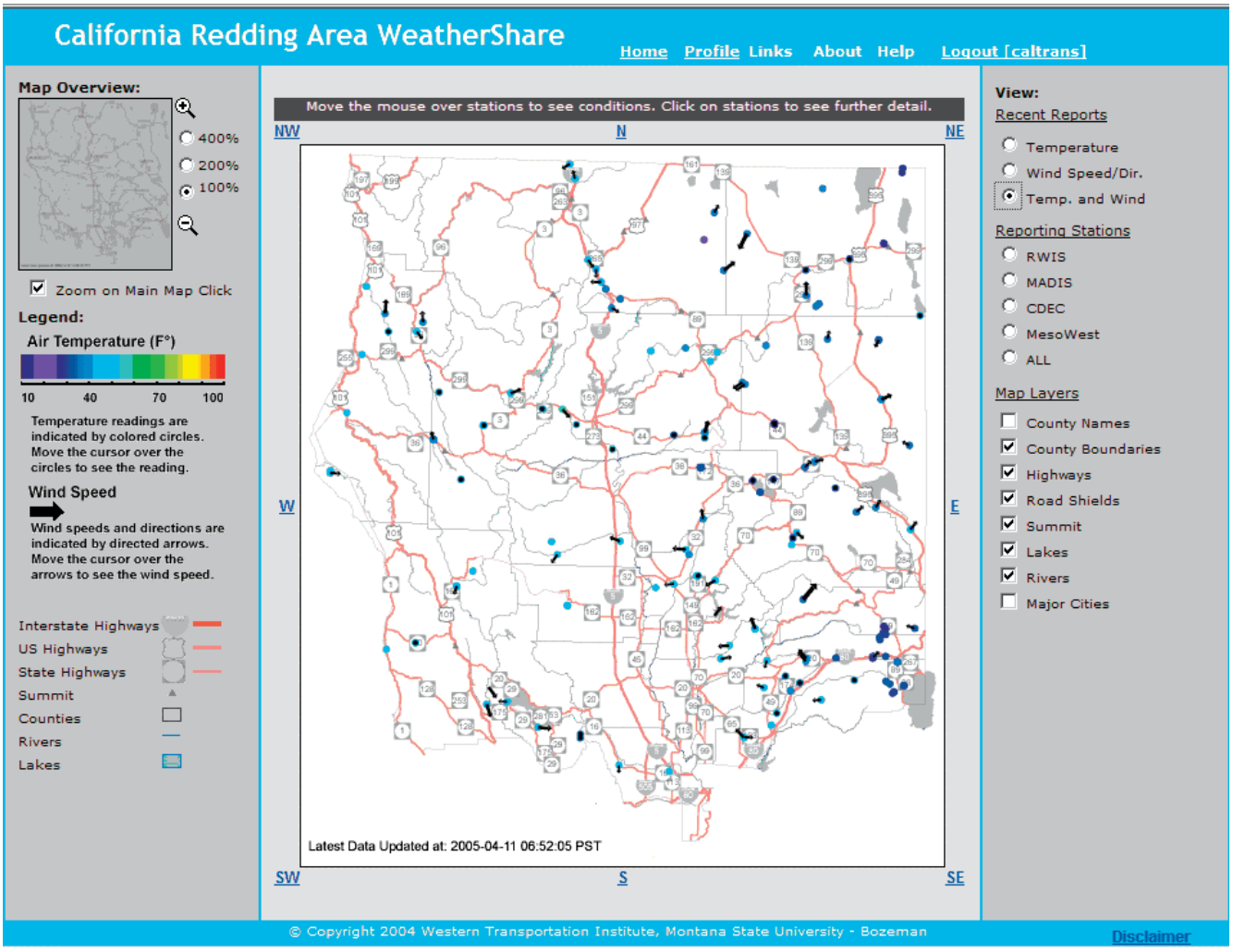


Figure 11: A Snapshot of the Proof-of-Concept WeatherShare Interface

5.4. Affected Personnel (Users)

5.4.1. Organizational Structure

The stakeholders analyzed in the current system include Caltrans District 2, CHP, CDF, NorCal EMS, EMS Providers, SHASCOM, Caltrans Division of Research & Innovation, WeatherShare, and Traveling Public. Their roles and weather data uses are listed in Table 2.

Table 3: Organizational Roles in the New System

	Roles					Data Uses				Data Provider	
Stakeholder	**Road Maintenance**	**Traffic Management**	**Incident Responder**	**Dispatch**	**Travel During Poor Wx**	**RWIS Wx Measurements**	**RWIS Roadway Measurements**	**RWIS Forecasts**	**Other Weather Service w/ Cost**	**Operates Wx Stations**	**Other Roles**
Caltrans District 2	X	X	X	X	X	X	X	X	X	X	
CHP		X	X	X	X	X	X				
CDF			X			X	X			X	
NorCal EMS							X				Supports Emergency Responders
EMS			X	X	X	some	X				
SHASCOM				X		X	X		X		
Caltrans Division of Research & Innovation											Oversees research in District 2
WeatherShare						X	X				Integrates / streamlines available road and weather data
Traveling Public					X	X					

5.4.2. User Class/Actor Profiles

The user classes evaluated in the new system include those analyzed in section 3.4.2, i.e., three *human actors* consisting of Agency User, RWIS Monitor, and Traveler, and one *system actor*, the Weather Station Network. Instead of obtaining road and weather information from separate sources represented by the actor of Weather Station Network, these three human actors will obtain information from the WeatherShare system.

There will be one more *human actor* to be evaluated in the new system: the system administrator for WeatherShare. In addition, there will be two more *system actors* to be evaluated in the new system: the classes of Other System and Other Data Source. The Other System user class describes the systems that will obtain road and weather information from the WeatherShare system. The Other Data Source user class describes the data sources other than those included in the user class of Weather Station Network, as they will provide other data for the WeatherShare system.

We can use the Use Case Model to describe the WeatherShare system from the viewpoint of various user classes/actors interacting with the system, as later shown in Figure 12.

5.4.3. Other Involved Personnel

The Division of Research & Innovation and other management staff at Caltrans will not use the system but are interested in the success of the system.

5.5. Support Environment

WTI will continue to maintain the existing WeatherShare server till the project completion. As a result of the facilities study, WTI will continue to administer and maintain the system after the completion of this phase (December 2005), possibly for another three years.

For the administration and maintenance, responsibilities include but not limited to:

- Maintaining server in proper operational state,
- Administering/Managing user accounts and privileges,
- Checking data sources periodically to make sure they are still interacting properly,
- Backing up the database and the server on a daily basis, and
- Responding to email requests (assuming a 5-year operational existence).

6. OPERATIONAL SCENARIOS

In this chapter, we provide several fictional scenarios that illustrate how the WeatherShare system could be used by different end users. Before describing the operational scenarios, we need to first identify the use cases in the new system. Use cases provided here may be expanded during phases subsequent to this proof-of-concept phase of WeatherShare.

6.1.1. Use Case Diagram

The use case diagram allows for the specification of high-level user goals that the system must carry out. These goals are not necessarily tasks or actions, but can be more general, required functionality of the system.

Typically, use case diagrams depict:

- **Use cases.** A use case describes a sequence of actions that provide something of measurable value to an actor. The use case should be read in such a way that Actor conducts action describing use case, e.g., Traveler accesses WeatherShare.
- **Actors.** An actor is a person, organization, or external system that plays a role in one or more interactions with your system.
- **Associations.** Associations between actors and use cases are indicated in use case diagrams by solid lines. An association exists whenever an actor is involved with an interaction described by a use case. Associations are modeled as lines connecting use cases and actors to one another, with an optional arrowhead on one end of the line.

As shown in Figure 12, the use case diagram can be used to describe the WeatherShare system from the point of view of various actors interacting with the system.

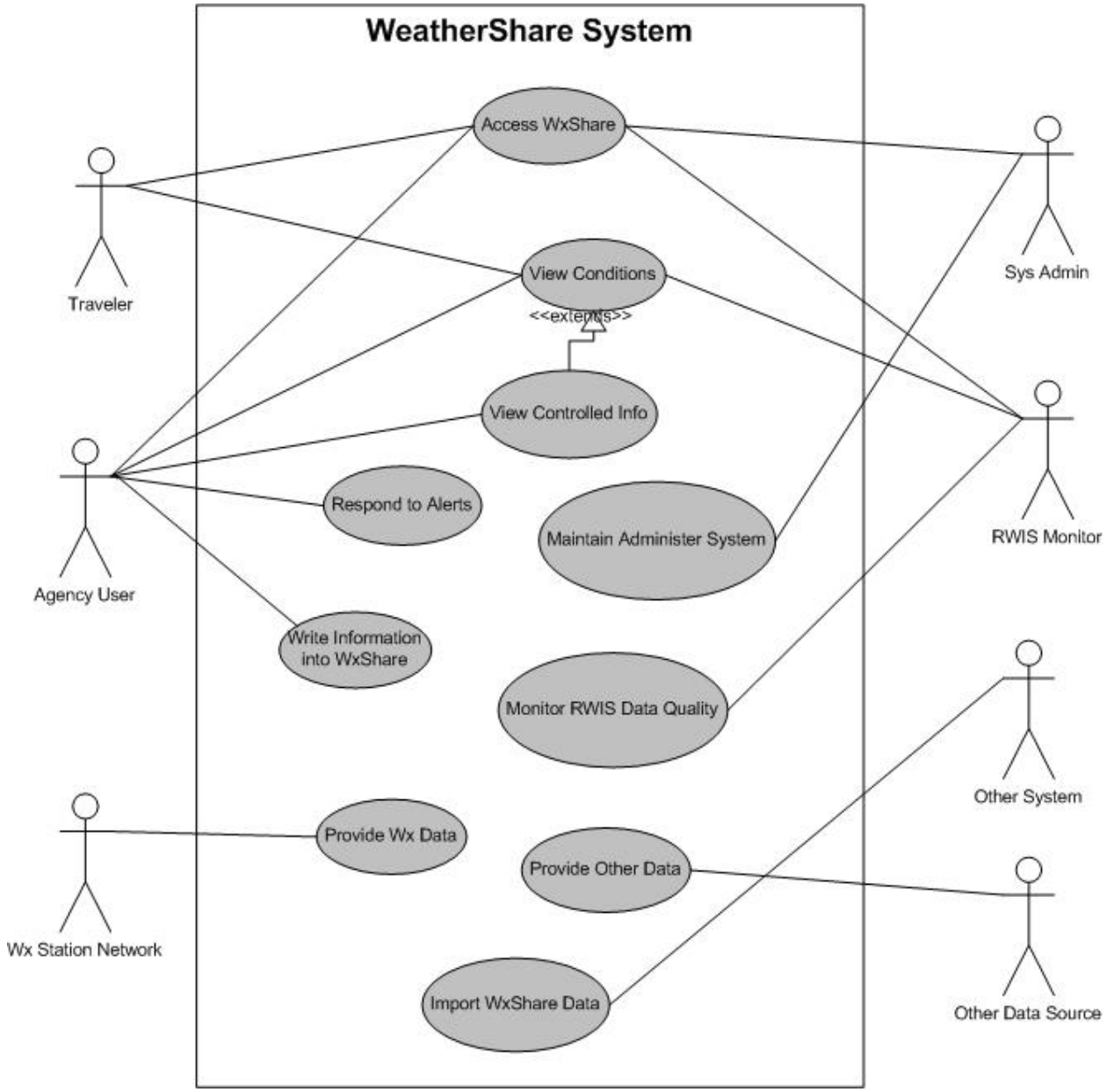


Figure 12: Use Case Diagram for the Proposed WeatherShare System

The use cases of the WeatherShare system are listed and described as follows.

Use Case 1: Access WeatherShare

Primary Actor: Traveler, System Administrator, Agency User, RWIS Monitor
Goal: User gets access to the WeatherShare system to obtain their privilege.
Preconditions:

1. User account exists on the system (except Traveler Users)
2. User profiles are accessible by the system.

Trigger: User enters username and password in login fields.
Success End Condition: User logs in with privilege assigned according to account type and profile.
Failed End Condition: User cannot login with correct username and password.
Main Success Scenario:

1. Travel User logs into the system without username and password and is only allowed access to uncontrolled weather and road information.
2. System Administrator gets access to the WeatherShare system with administrator password and receives the root privilege.
3. Caltrans District 2 TMC and maintenance staff login with username and password and the system allows them access to all road and weather information.
4. Other RIME agency users login with username and password and the system allows them access to all road and weather information.

Use Case 2: View Conditions

Primary Actor: Traveler, Agency User, RWIS Monitor
Goal: User accesses uncontrolled road and weather information from the WeatherShare system.
Preconditions: User (except Traveler User) is assigned the right to access the system.
Trigger:
Success End Condition: User gets the information.
Failed End Condition: User request cannot be fulfilled by the server and data cannot be displayed.
Main Success Scenario:

1. Traveler gets the road and weather info before trip. No pavement data from RWIS.
2. Caltrans District 2 TMC operator zooms map to area of incident and retrieves the air temperature, represented by color dots in the WeatherShare map display.
3. Any RIME agency user zooms map to area of interest, click on a station icon, and retrieves the real-time weather data and historical weather data back to up to one year, both with data quality descriptors.

Use Case 3: View Controlled Information

Primary Actor: Agency User
Goal: User accesses controlled information – information that can only be accessed with proper privilege, such as pavement temperature and condition.
Preconditions: User is assigned the right to access the controlled information.
Trigger:
Success End Condition: User obtains the controlled information.
Failed End Condition: User request cannot be fulfilled by the server and data can not be displayed.
Main Success Scenario:

1. Caltrans District 2 Field Maintenance staff zooms map to area of incident and retrieves the road pavement temperature represented by color dots in the WeatherShare map display.

Use Case 4: Respond to Alerts

Primary Actor: Agency User
Goal: User accesses controlled information – information that can only be accessed with proper privilege.
Preconditions: User is assigned the right to accept the alert information and alert condition exists, e.g. air temperature is below 10°F.
Trigger: User gets the alert icon adjacent to the weather parameter once clicking on the weather station icon and views the detailed weather information for the station.
Success End Condition: User notices the alert icon and makes appropriate decisions.
Failed End Condition: User does not notice the alert icon.
Main Success Scenario:

1. Caltrans District 2 Field Maintenance staff notices the alert icon from a station where wind speed exceeds 40 mph or air temperature drops to below -15°F. This affects their decision of applying anti-icing chemicals for winter highway maintenance.

Use Case 5: Maintain and Administer System

Primary Actor: System Administrator
Goal: Monitor the system running, backup data, and control the privilege and access area of different users.
Preconditions: System Administrator accesses the system with the administrator privilege.
Trigger: System Administrator logs into the system.
Success End Condition: System Administrator logs out of the system.
Failed End Condition: System Administrator fails to log into the system.
Main Success Scenario:

1. System Administrator creates a Caltrans District 2 Field Maintenance staff user account according to a request and sets certain privileges for the account.
2. System Administrator backs-up the data.
3. System Administrator deletes an expired account.

Use Case 6: Monitor RWIS Data Quality

Primary Actor: RWIS Monitor
Goal: Check the questionable RWIS sensors/stations and correct the wrong data reported by WeatherShare.
Preconditions: RWIS Monitor user logs on and is assigned the right to check the RWIS sensor/station information.
Trigger:
Success End Condition: User gets the RWIS sensors/stations information.
Failed End Condition: User request cannot be fulfilled by the server and data cannot be displayed.
Main Success Scenario:

1. RWIS Monitor staff gets the RWIS sensors/stations information.
2. RWIS Monitor staff finds the data error in some stations and checks the sensor error.

Use Case 7: Import WeatherShare Data

Primary Actor: Other System
Goal: Import WeatherShare Data into another system.
Preconditions: Other system is assigned the right to access the WeatherShare System for download.
Trigger:
Success End Condition: User gets the data from the WeatherShare system.
Failed End Condition: User request cannot be fulfilled by the server and data cannot be accessed.
Main Success Scenario:

1. Other website fetches the data from WeatherShare.

Use Case 8: Provide Weather Data

Primary Actor: Weather Station Network
Goal: Provide weather information that is needed for the WeatherShare system.
Preconditions: WeatherShare is assigned the right to access the Weather Station Network to fetch data in a real-time manner.
Trigger:
Success End Condition: WeatherShare obtains data from the Weather Station Network.
Failed End Condition: WeatherShare cannot get data from the Weather Station Network or the data are errors.
Main Success Scenario:

1. CDEC (possibly Caltrans District 1 RWIS) provides their real-time weather information to WeatherShare using a push mode.
2. WeatherShare accesses the Caltrans District 2 RWIS data online using a pull mode.
3. WeatherShare accesses the CDEC data online using a pull mode.
4. WeatherShare accesses the MesoWest data online using a pull mode.
5. WeatherShare accesses the MADIS data online using a pull mode.

Use Case 9: Provide Other Data

Primary Actor: Other System
Goal: Provide other available data that may be useful to the WeatherShare system.
Preconditions:
Trigger:
Success End Condition:
Failed End Condition: User request cannot be fulfilled by the server and data cannot be provided.
Main Success Scenario:

1. WeatherShare may provide some useful information gathered from another system.

Use Case 10: Write Information into WeatherShare

Primary Actor: Agency User
Goal: Certain agency users to update the information in the WeatherShare system
Preconditions: User is assigned the right to update the information.
Trigger:
Success End Condition: User successfully updates the information.
Failed End Condition: User request cannot be fulfilled by the server and data cannot be updated.
Main Success Scenario:

1. Caltrans District 2 employee logs in and updates his or her profile and defines weather alert thresholds.

Some scenarios are described below to create a better understanding of the WeatherShare system.

1. Register for a password - involves agency user or traveler and system administrator.

2. Respond to incident – use by agency user, such as TMC operator.

    1) At beginning of shift, operator logs onto WeatherShare, views new forecasts for the region. It is running on the same computer as ATMS.

    2) Operator monitors the CHP computer-aided dispatch (CAD) system and identifies an incident.

    3) Operator retrieves incident details. Incident requires dispatch of traffic management team (TMT).

    4) Operator switches computer to WeatherShare and zooms map to the area of incident, obtaining air temperature information (indicated by color dots on the WeatherShare map). In the area of the incident (with mountainous setting), all air temperatures are between 25-35°.

    5) Operator selects each weather station. He finds that one station is a Caltrans RWIS and the air temp is 35°C and pavement temp is 29°C. The coldest site is off the road, on a mountain.

    6) Operator determines that it is snowing since the data indicate freezing conditions. Operator checks the RWIS forecast that says temperatures fluctuated below freezing all morning.

    7) Operator dispatches and informs someone at TMT that they will need chains.

    8) Operator posts messages on CMS, via ATMS warning, of incident ahead.

    9) Upon clearance of incident, operator posts messages warning of icy conditions ahead.

7. SUMMARY OF IMPACTS

Overall, this WeatherShare system is expected to significantly increase the sharing of road and weather information among RIME organizations and improves the quality and accessibility of weather information provided to transportation decision-makers and incident responders in the region.

In terms of operational impacts, all the RIME agency users will need training in order to fully utilize the WeatherShare system. Other anticipated operational impacts may include change in interfaces with TMC or dispatch centers, change in Internet access policies, change in RWIS historical data request procedures, etc.

In terms of organizational impacts, there is none identified at this stage. Anticipated organizational impacts, however, may include modification of staff responsibilities, need for training, etc.

Impacts during the development stage of WeatherShare may include meeting/discussions regarding the new system, development or modification of databases, training, parallel operation of the new and existing systems, impacts during testing of the new system, and other activities needed to aid or monitor development. During development of the system, WTI follows the National Transportation Communications for ITS Protocol (NTCIP) ESS standard to define the variable names and database structures. This facilitates data sharing and greatly improves the data exchangeability for future system enhancement and maintenance.

Detailed analysis of impacts resulted from the WeatherShare system will require continued evaluation for multiple seasons and multiple years.

8. ANALYSIS OF THE NEW SYSTEM

8.1. Summary of Advantages

With the deployment of the WeatherShare system, the following improvements can be expected.

- As a component of the RIME program, public safety in Caltrans District 2 will be improved.
- Allows users to view all available road and weather information from various sources by one user-friendly interface, greatly increasing the efficiency of situation assessments for a wide array of purposes, including roadway maintenance, incident management, homeland security applications, emergency medical services, traveler safety, fire suppression, flood management, etc.
- The automated alert capabilities of WeatherShare will shorten the response time to incidents, saving lives.
- The integrated, easily accessible road and weather information could benefit homeland security by aiding emergency response and law enforcement personnel.
- WeatherShare would also help improve the traveling public's safety by enabling easy and efficient access to localized road and weather information for the areas in which they live and the routes by which they travel.
- A single interface WeatherShare system provides District 2 staff with an easier, more efficient tool for collecting road and weather information. Additionally, the system allows for quick and easy training of new staff.
- Data quality control techniques will be implemented in the WeatherShare system to provide more accurate weather and road information.

8.2. Summary of Disadvantages/Limitations

Caltrans servers are not conducive to implementation of the WeatherShare system because of firewall management regulations at Caltrans.

8.3. Alternatives and Trade-offs Considered

To enhance the WeatherShare system, an accurate forecast weather information source is desirable. However, considering funding limitations, it is not incorporated into the WeatherShare system at this stage.

ACRONYMS

APRSWXNET	Automatic Position Reporting System Weather Network
ATMS	Automated Traffic Management System
BLM	U.S. Bureau of Land Management
CAD	Computer-Aided Dispatch
CARB	California Air Resources Board
CCTV	Close Circuit Television Camera
CDEC	California Data Exchange Center
CDF	California Department of Forestry & Fire Protection
CDWR	California Department of Water Resources
CHP	California Highway Patrol
CIMIS	California Irrigation Management Information System
CMS	Changeable Message Sign
CNRFC	California Nevada River Forecast Center
DRI	Desert Research Institute
EMS	Emergency Medical Service
ESS	Environmental Sensor Station
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FSL	Forecast Systems Laboratory
GIS	Geographic Information Systems
GUI	Graphical User Interface
ID	Identifier
IEEE	Institute for Electrical and Electronic Engineering
ITS	Intelligent Transportation Systems
QC	Quality Control
MADIS	Meteorological Assimilation Data Ingest System
NIFC	National Interagency Fire Center
NOAA	National Oceanic and Atmospheric Association
NTCIP	National Transportation Communications for ITS Protocol
NWS	National Weather Service
RAWS	Remote Activated Weather Stations
RIME	Redding Incident Management Enhancement
RWIS	Road Weather Information Systems
SHASCOM	SHasta Area Safety Communications agency
SHASAVAL	Mt. Shasta Avalanche Center
SNOTEL	Snowpack Telemetry
SSI	Surface Systems International
TMC	Transportation Management Center
TMT	Traffic Management Team
UHF	Ultra High Frequency
WTI	Western Transportation Institute