National Wildfire Coordinating Group

Fire Environment Working Team

RAWS/ROMAN STUDY REPORT

October 10, 2007

Table of Contents

Executive Summary 3
1.0 Background and Purpose 6
2.0 Methods 6
3.0 Results 8
3.1 External assessments and surveys 8
3.2 FENWT Review of Systems........ 11
3.3 What else have we learned along the way? 18
4.0 Analysis........ 30
4.1 RAWS........ 30
4.2 ROMAN 34
5.0 Conclusions 36
5.1 GENERAL 36
5.2 RAWS........ 37
5.3 ROMAN 38
6.0 Alternatives 41
6.1 RAWS........ 41
6.2 ROMAN 43
7.0 Recommendations........ 47
7.1 RAWS........ 47
7.2 ROMAN 47
7.3 OTHER........ 47
8.0 References:........ 49
Appendix A........ 50
Appendix B........ 54

Executive Summary

Purpose
The National Wildfire Coordinating Group (NWCG) tasked the Fire Environment Working Team (FENWT) in January 2006 to assess the needs/requirements of the fire community for fire weather in order to resolve two concerns:

- Unplanned growth in the size of the interagency Remote Automated Weather Station (RAWS) network while agency budgets are in decline;
- Should the agencies support the Real-time Observation Monitoring and Assessment Network (ROMAN) and if so how?

The purpose of the study was to develop recommendations for the RAWS network and the ROMAN system.

Methods
FENWT's study plan was to assess whether our needs for fire weather going forward are being and can continue to be met by the RAWS network and by our fire weather data systems, including ROMAN.

To identify and understand our needs for fire weather, FENWT worked closely with four assessments that occurred during the period of study:

- National Weather Service Customer Satisfaction survey;
- National Predictive Services Group's user needs ;
- National Wildland Fire Weather Needs Assessment of the Office of the Federal Coordinator for Meteorology (OFCM);
- National Wildland Fire Enterprise Architecture project (NWFEA).

FENWT also gathered information from program leads of these primary stakeholders:

- Remote Automated Weather Systems (RAWS)
- Automated Sorting Conversion and Distribution System (ASCADS)
- Wildland Fire Management Information System (WFMI)
- Weather Information Management System (WIMS)
- National Interagency Fire Management Integrated Database (NIFMID)
- FAMWEB Data Warehouse
- Wildland Fire Assessment System (WFAS)
- Western Regional Climate Center (WRCC)
- Real-time Observation Monitoring and Assessment Network (ROMAN)
- Meteorological Assimilation Data Ingest System (MADIS)

And FENWT incorporated other relevant information we encountered along the way including:

- Predictive Services RAWS-related workload
- Fire Planning Analysis (FPA)
- Wildland Fire Decision Support System (WFDSS)
- Oklahoma Mesonet
- Review of the Basis for the Remote Automated Weather Station Network
- Great Basin RAWS Network Analysis
- Review of the Forest Service Remote Automated Weather Station Network

The OFCM survey was instrumental in defining fire weather needs that RAWS and ROMAN should be supporting. Implementing our recommendations will help meet at least 15 data and decision support needs identified in their survey.

Recommendations of the NWFEA Core Blueprint Team, such as the Virtual Single Agency and master website concepts, were also influential in developing our recommendations.

Conclusions

The critical importance of fire weather data to many significant aspects of fire business can not be overstated. The original RAWS network was conceived to support the coarse-scale application of fire danger rating. Today, RAWS data are routinely used to support decisions impacting firefighter safety, whether or not to initiate a fuels treatment prescription, air quality, crew readiness, and strategic seasonal and multi-year resource allocations to name a few. Demand for these data happens every day. Last year the ROMAN website received 125 million hits in pursuit of fire weather data. The future use of RAWS data to support gridded, digital data products is already here and growing quickly.

The purpose of the RAWS network is to support point and gridded applications of fire weather for fire program analysis, fire danger rating, fire behavior prediction fire weather forecasting, and smoke management. We believe this purpose is both necessary and appropriate to meet the current and future needs identified by the fire community.

The size of the RAWS network to achieve this purpose is finite and can be determined through analysis beyond the resources for this study. This network size should be determined by

- leveraging other non-RAWS weather observation networks that can contribute to the needs of the fire community and by
- understanding the number and location of RAWS and non-RAWS observations required to support the gridded applications we need.

The functionality provided by ROMAN must be fully supported. It is a vital part of our fire weather data access infrastructure. As the implementation of NWFEA unfolds, we should find ways to link, combine, or merge our other data access systems while maintaining the functionality of ROMAN.

Recommendations

RAWS

<u>Low and high resolution grid emphasis, network size is finite and may increase or decrease.</u> Establish a primary core set of RAWS emphasizing gridded data applications while continuing to support point data needs. Support fire weather with a combination of RAWS and non-RAWS observations, as determined by specific research.

ROMAN

Short-term:

<u>Fully support / sanction ROMAN as an NWCG mission critical data access system.</u> Upgrade ROMAN software. Provide programmatic funding level to include project management, maintenance, and operations. Add enhancements such as fuel moistures and fire danger rating. Establish backup system to provide for Continuity of Operations. Maintain RAWS archive at WRCC.

Long-term:

<u>Advance to an Enhanced ROMAN</u>. Begin work fall 2007 to develop opportunities with MADIS for fire weather data access. Partner with NOAA for MADIS to be the future source of RAWS and other observation networks and gridded products. Pursue ways to link, combine, or merge our other data access systems and functionality with ROMAN.

1.0 Background and Purpose

The National Wildfire Coordinating Group (NWCG) tasked the Fire Environment Working Team (FENWT) to assess the needs/requirements of the fire community for fire weather in order to resolve two concerns: 1) growth in the size of the interagency Remote Automated Weather Station (RAWS) network is out-pacing the agencies' financial ability to maintain it; and 2) the fate of the Real-time Observation Monitoring and Assessment Network (ROMAN), a web-based system for accessing fire weather information, must be determined.

The purpose of the study is to develop recommendations for the RAWS network and the ROMAN system.

2.0 Methods

FENWT's approach to this study was to assess whether our fire weather requirements going forward are being and can continue to be met by the RAWS network (first deployed in the early 1980s) and by our fire weather data systems (some of which were implemented in the early 1990s). These data requirements include the type of data (sources, standards and quality, spatial and temporal scales); distribution; access; validation; storage; and integration with fuels, topography, occurrence and other data sets in use today.

Two methods were used to collect fire weather requirements information. First, FENWT participated in and leveraged results from four relevant assessments or surveys. These efforts are the:

- National Weather Service Customer Satisfaction survey (NWS, 2005)
- National Predictive Services Group's user needs survey (Winter et. al. 2007)
- National Wildland Fire Weather Needs Assessment of the Office of the Federal Coordinator for Meteorology (OFCM, 2007)
- National Wildland Fire Enterprise Architecture project (NWCG, 2007)

Second, FENWT received presentations from several data system program leads as part of a review of the current relevant fire weather data systems. These data systems are:

- Remote Automated Weather Systems (RAWS)
- Automated Sorting Conversion and Distribution System (ASCADS)
- Wildland Fire Management Information System (WFMI)
- Weather Information Management System (WIMS)
- National Interagency Fire Management Integrated Database (NIFMID)
- FAMWEB Data Warehouse

- Wildland Fire Assessment System (WFAS)
- Western Regional Climate Center (WRCC)
- Real-time Observation Monitoring and Assessment Network (ROMAN)
- Meteorological Assimilation Data Ingest System (MADIS)

We also incorporated other relevant information we encountered along the way, as explained in the results section 3.3, including:

- Predictive Services RAWS-related workload
- Fire Planning Analysis (FPA)
- Wildland Fire Decision Support System (WFDSS)
- Oklahoma Mesonet
- Review of the Basis for the Remote Automated Weather Station Network
- Great Basin RAWS Network Analysis (Brown et. al. 2001)
- Review of the Forest Service Remote Automated Weather Station (RAWS) Network (Zachariassen et. al. 2003);

Due to the nature of this material, many technical terms and acronyms will be found in this report. We have attempted to describe each of them in Appendix A: Glossary of Terms and Acronyms.

3.0 Results

3.1 External assessments and surveys

<u>3.1.1 National Weather Service 2005 Customer Satisfaction survey</u>

This was a current "Customer Satisfaction Survey" not a fire weather needs assessment. FENWT's NWS representative managed this survey effort. Survey results we found important to this study:

- NWS Fire Weather Program currently scoring well in customer satisfaction - a strong base from which to continue building a fire weather program.
- Fire Weather Planning Forecast (FWF) is used most frequently, and is the biggest driver of satisfaction for majority of respondents.
- Staff Interaction was the highest scoring and one of the biggest drivers of satisfaction.
- Red Flag Warning Program and Spot Forecasts are core strengths.
- Lightning Activity Level (LAL) is not currently a top priority for improvement, and is the lowest scoring product.
- User comments for additional insight. Key themes included:
    - Better consistency among areas/offices
    - Improved understanding of how needs differ based on geography
    - Overarching concern that funding will be cut and the quality of the service will suffer.
- Based on 1290 responses.

<u>3.1.2 National Predictive Services Group 2006 user needs survey</u>

This was an assessment of user needs of the Predictive Services program. This was not a fire weather network user needs assessment. FENWT's NPSG representative managed this survey effort. Assessment results we found important to this study:

- Basing decisions and taking action was more likely among those who had trust and confidence in the information, which points to a need for quality controlled, accurate, consistent and timely data and products.

- Technology related issues and password protection are barriers to use of data and products.

- Additional user comments:

    - Minimum standards are needed for data and products
    - Quality control, consistency, and accuracy of data and products is lacking
    - Better GIS capability and support is needed

- o Users want a One-Stop web portal to get to all fire weather and predictive service products
- o Confidence Levels would be very useful. Criteria needs to be developed to display confidence levels with products
- o Verification and validation of data and forecasts are needed. (e.g. lightning forecast vs. observed)
- o Improved access to historical data was requested
- o Product development needs to be targeted to specific user groups rather than top down development
- o Users want products and data to be supported year-round
- o NWS and mesonets (collections of multiple networks' data) were listed as key alternate sources for decision support information.

3.1.3 National Wildland Fire Weather Needs Assessment of the Office of the Federal Coordinator for Meteorology

In June 2005 the Western Governor's Association (WGA) recommended an assessment of user needs for fire weather be conducted by the National Oceanographic and Atmospheric Administration (NOAA) Office of the Federal Coordinator for Meteorology (OFCM).

OFCM had two goals for this assessment.

- Conduct a comprehensive review and assessment of weather and climate requirements of providers and users in their wildland fire and fuels management activities.
- Assess the capabilities of the provider agencies to ensure that needed weather and climate information is available to fire managers and other users.

A Joint Action Group for National Wildland Fire Weather Needs Assessment (JAG/NWFWNA) was formed – including several members of FENWT – in 2006 and tasked with assessing needs in nine functional areas:

1. Data collection, integrity, processing, and archival
2. Fire weather research and development
3. Forecast products and services
4. Modeling, prediction, and data assimilation
5. Information dissemination and technologies
6. Education, training, outreach, partnering, and collaboration
7. User response, decision support, and resulting user impacts
8. Funding and human resources (crosscutting)
9. Socioeconomic factors

During 2006–2007 a survey was developed and information gathered from 745 federal, state, tribal, and local fire weather users covering a wide range of stakeholders in the national wildland fire weather community.

OFCM delivered the results of its first goal – a review of fire weather user requirements – to the WGA in June 2007. Assessment results we found important to this study:

Functional Area 1: Data collection, integrity, processing, and archival.
Finding: Improvements in data management are needed to establish a comprehensive, nationally beneficial observing system to meet the needs of wildland fire weather users. Specific points:

- A complete, real-time, observationally based, gridded characterization of the current atmosphere is needed.
- A centralized means of reliably retrieving validated observation data is needed.
- A complete suite of deployable and non-deployable sensors must be well maintained and fully integrated into a national network for common data availability.
- All national weather station standards (to include those used by other agencies and NFDRS standards) should be reevaluated to ensure proper integration of all pertinent weather station data (to include portable weather stations) for use by the wildland fire community.

Functional Area 4: Modeling, prediction, and data assimilation.
Finding: Fire weather users and the meteorological community require the rapid transfer of fine-scale modeling, coupled fire-atmosphere modeling, and climate modeling advances into operations; emphasizing capabilities, limitations, and current improvement efforts. Specific points:

- Users overwhelmingly need higher resolution meteorological model fields in complex terrain and the tools and input data to understand fire behavior and smoke dispersion.
- Users need model accuracy and confidence information presented to them in an understandable format.
- Model output information needs to be made available in easy-to-use graphics and in high-bandwidth and low-bandwidth formats for use with workstations, PDAs, and text messaging. Products also need to be available in GIS format.

Functional Area 5: Information, Dissemination, and Technologies.
Finding: A coordinated, "one-stop" fire weather Internet presence is needed to facilitate fire weather user access to pertinent weather data and products for their region of interest.
Finding: A centralized means for collaboration on products and services is needed.
Finding: Consistent dissemination of timely products and services to model users is needed.

Finding: Wildland fire weather users and providers require robust, real-time access to weather data, to include increased continuity of operations planning. Specific points:

- Wildland fire weather users require a robust continuity of operations plan for the Geostationary Operational Environmental Satellite (GOES) Data Collection System (DCS), which serves as an integral mechanism for this flow of data.
- Wildland fire weather users require a robust continuity of operations plan for the Automated Sorting, Conversion, and Distribution System (ASCADS), which serves as a crucial node for weather data flow.

3.1.4 National Wildland Fire Enterprise Architecture project

One phase of this project was a Core Blueprint Team (CBT) assigned to create a description of the interagency fire business processes and recommend improvements. Two FENWT members participated in this effort. CBT results we found important to this study are:

- Fire agencies should operate like a Virtual Single Agency (VSA). This approach could structurally and culturally support the concept of one access point for all weather data and related applications.

- Establish a product management approach to reporting and other services. Some of the stated implications include consistency of data collection, improving data sharing, and improving data quality.

- Exercise centralized business-of-fire decision-making to make access to IT assets standard, consistent, and universal. This means ensuring security implementation does not inhibit wildland fire personnel from having access to all wildland fire information, and promoting the ability to share information seamlessly.

- Create collaborative abilities on master web sites.

3.2 FENWT Review of Systems

3.2.1 RAWS

Herb Arnold
http://www.fs.fed.us/raws/

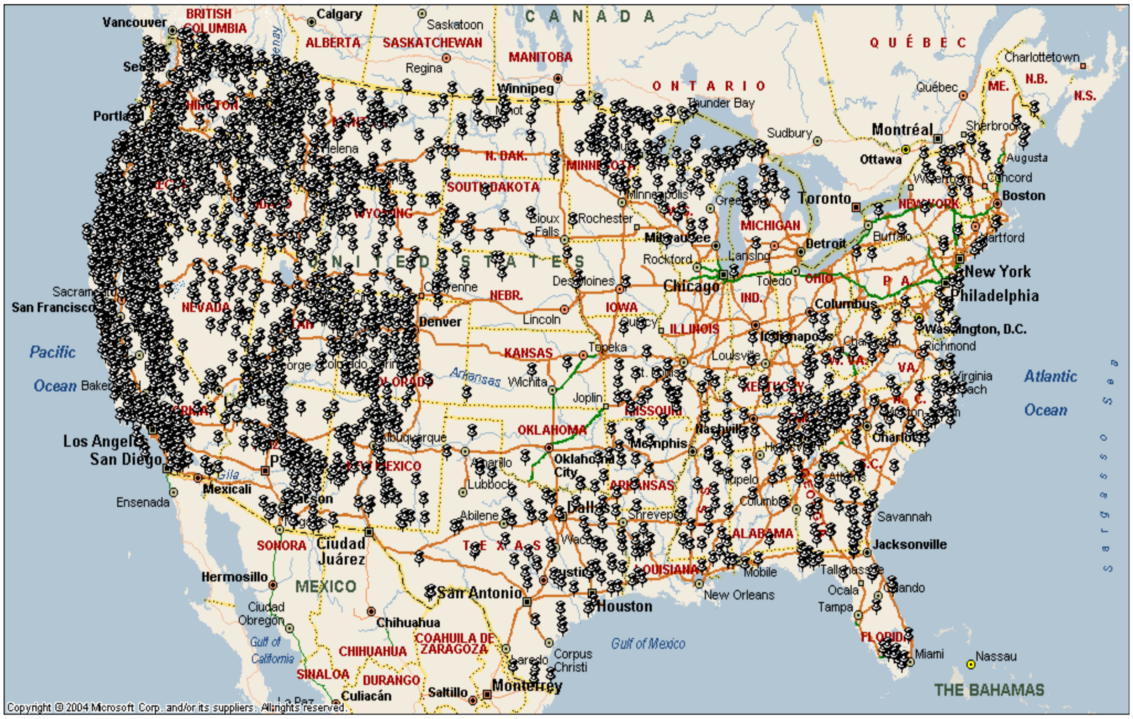

Figure 1. RAWS active in ASCADS in the continental United States

Remote Automated Weather Stations (RAWS) were first implemented in the 1980's. Prior to RAWS, fire weather stations were all manual-observation. Some of these stations remain, but automation has enabled observation locations to be more remote.

The RAWS network (figure 1) is the primary source of weather observations used for fire management applications. Stations meeting the NWCG NFDRS Fire Weather Station Standard are located in remote areas, generally at mid-slope, southwest aspect sites in order to record "near-worst case conditions."

There are 2400 stations registered in ASCADS, of which approximately 2000 are active. There are approximately 1600 stations that maintain NFDRS Standards; which implies an active maintenance program, not just having the equipment to measure the required parameters. In addition there are the Project RAWS and Fire RAWS which use radio alerts to pass information to the Incident Management Teams. In the future this information will pass digitally.

Stations meeting NFDRS standards measure wind speed and direction, air temperature, humidity, precipitation, and solar radiation.

BLM-NIFC provides:

- 95% Depot Service
- 25% Field Service - BLM and some BIA
- Dispatch Fire RAWS and Project RAWS
- BLM-IRM - 98% is Telecom Support and ASCADS Support
- Interagency RAWS Partners Group - Policy and Planning

RAWS data directly supports:

- Planning: Fire management plans; Fire Planning Analysis (FPA)
- Preparedness: Fire danger ratings
- Wildland Fire Operations: Fire behavior analysis
- All-Risk Management: Non-fire emergency support
- Resource Management: most programs

NIFC dispatches Fire RAWS to fire and all-risk incidents. There are 42 kits currently available with plans to increase that to 50 to meet demand for site specific fire weather observations. The standards are being developed by the FENWT Fire Weather Committee for these Fire RAWS. Additional sensors, such as air quality monitoring devices are being assessed for portable units like these.

The question of how many RAWS are needed was generated by budget/funding concerns. There was a perception that the RAWS Network growth was uncontrolled.

RAWS network growth is a mix of local control using local funding in the acquisition of RAWS to meet local needs and central funding for RAWS maintenance.
Costs:

- 2200 stations x $12,000/station = $24.6M
- Yearly (depot) maintenance costs
    - 2200 stations x $1,100/year = $2.42M/year
    - With field maintenance of $5-6M/year

3.2.2 ASCADS
Herb Arnold and Greg Jensen
http://www.fs.fed.us/raws/book/ascads/

The primary purpose of ASCADS is to make available near real-time weather observations from RAWS. It distributes these data to WFMI, WIMS, NWS, ROMAN, and WRCC. It stores station metadata primarily for maintenance tracking purposes. It is functional but is becoming obsolete and there are current plans to review the system and funding for a refresh/reengineer. Some functionality will be taken over by the Computerized Maintenance Management System (CMMS). CMMS will be a maintenance support system to track, by component, all maintenance performed on the interagency RAWS network.

Now is a good time to recommend new approaches to fire weather data systems, including ASCADS.

ASCADS was implemented in 1992. It is funded at $50K per year.

3.2.3 WFMI
Greg Jensen
http://www.nifc.blm.gov/index.html

WFMI is a suite of applications originally designed for dispatchers and is hosted on a BLM-sponsored website which includes the following program areas:

- Weather Data
    - Hourly weather observations
    - Display of where the stations are located
    - Metadata is available
    - Capable of grouping stations
- Lightning
- Fire Reporting

The site is password protected because of the restrictions on lightning data. There is a Change Management Board that manages the applications based on user requests.

WFMI was implemented in 1997 to replace the Incident Attack Management System (IAMS). It is funded at $230K per year. This does not include the years in which hardware refresh is due.

3.2.4 WIMS/NIFMID
Mike Barrowcliff and Larry Bradshaw
http://famweb.nwcg.gov/

WIMS is one of eight applications currently hosted on Forest Service Fire & Aviation Management's web portal, FAMWEB . WIMS is the primary national processor of RAWS observations for the National Fire Danger Rating System (NFDRS). It is password protected. WIMS handles hourly and daily data for 18 months. The user manually reviews daily data for quality and archives them into NIFMID for future NFDRS analysis (through the "change the "R" to an "O" procedure). WIMS is currently the only application where users can edit weather data and manage the NFDRS model.

NIFMID is the repository for daily NFDRS observations. It is accessed primarily through a query program, KCFAST, available on-line. Access is password protected. Archived files are retrieved through an ftp website.

WIMS is currently being evaluated for a reengineering; budget requests are proposed for 2009. This corresponds with the refresh/reengineer proposal study for ASCADS. There is potential for the two systems to be evaluated together.

Improved infrastructure for all systems that are hosted at Kansas City will allow the hardware platform to logically partition itself. An alternate "hotsite" will be located in Beltsville, Maryland to allow for more robust disaster recovery.

WIMS was implemented in 1993 to replace the Administrative Forest Fire Information Retrieval and Management System (AFFIRMS). Annual funding level was not provided.

3.2.5 FAMWEB Data Warehouse
Mike Barrowcliff and Larry Bradshaw
http://famweb.nwcg.gov/

KCFAST and NIFMID functionality soon will be replaced by the Data Warehouse. The warehouse will enable online user access to a copy of the actual archive and provide improved query opportunities. Access to weather and fire occurrence data in the warehouse will not be password protected; other parts will be. WIMS and the Data Warehouse are not able of providing ROMAN functionality in a password-free environment.

The Data Warehouse will also be incorporated into the alternate “hotsite” used by WIMS. COGNOS, a report writer/query tool that accesses data from multiple sources, will connect the Data Warehouse to other Forest Service data systems (fire reporting, fire statistics, aviation, etc.) at Kansas City.

The Data Warehouse will be implemented in 2007. Annual funding level was not provided.

3.2.6 WFAS
Larry Bradshaw
http://www.wfas.net/

WFAS is a website providing password-free access to multiple map displays of fire potential information. WFAS displays maps of NFDRS outputs computed in WIMS. It provides maps of satellite derived greenness and other products depicting fuel condition.

When WFAS was implemented in 1994 it provided a spatial display of fire potential not previously available. Since then, interactive map displays of fire related information has become common-place. WFAS has recently been re-chartered with emphasis on supporting regional spatial products and data mining from a graphical interface. It is funded at ~$80K per year which includes reimbursable agreements with the US Geological Survey, EROS Data Center for weekly processing of satellite-derived vegetation greenness data.

3.2.7 ROMAN
Ed Delgado
http://raws.wrh.noaa.gov/roman/

ROMAN is a website providing password-free access to real-time observations from RAWS and the observation networks of the MesoWest system presented in tabular and spatial formats. A color scheme is used to alert the user to quality issues with the data. Data quality alerts are not retained as the system is not a data archive.

The ROMAN project began in 2001. An important goal was to provide easy access to data and products from RAWS and other weather observation networks. The data from the other weather observation networks had to be consolidated into a fire-specific format.

In 2001, the system had 8 million hits. In 2006, there were 125 million hits. Because of its high user traffic it has become the ‘face’ of the RAWS network.

It is an interagency-supported system. Initially it was funded by the BLM-Utah. Forest Service has provided funding in FY 2006 and 2007. Funds have been paid through a BLM cooperative agreement that ended FY 2007. The total cost of development and support has been about ~$600K. FY 2007 funding was $60K. These funds are for operations and maintenance (O&M) to keep the system running only (programmer support from the University of Utah (UU), MesoWest program). The ‘system’ hardware resides at the NWS Western Region Headquarters in Salt Lake City. The NWS contribution is cost-share IT-support (server housing, communications). Back up databases reside in several places. MesoWest is a research-grade, developmental program; it is not managed to support systems like ROMAN operationally.

Current funding level supports:

- Continuous coordination with NIFC Remote Sensing Support Unit (metadata issues, mainly with FIRE RAWS names and locations)
- Monitoring of data flow
- Bug fixes to core software
- Email support
- UU MesoWest programmer (2/3 FTE)
- Some of the user support workload previously directed at the Remote Sensing Support Unit (by being the ‘face’ of RAWS).

Current funding level does not support:

- Functional enhancements
- Software documentation
- Independence from Mesowest – sustainable operations
- Adequate QA/QC

ROMAN is an operational system. Development that would be appropriate for ROMAN is occurring within MesoWest. A user who wishes to use these features accesses them through the companion MesoWest website. These features include:

- Creating and saving profiles for start up preferences.
- Multiple data layer options, including GEOMAC layer overlays, NOAA/NESDIS radar and satellite overlays, smoke plume tracking, and others.

The ROMAN program requests an annual funding level of $150K/year.

ROMAN is included on the Forest Service Fire and Aviation Management Information Technology Portfolio and has a 300 "Lite" documentation prepared.

3.2.8 WRCC
Kelly Redmond
http://www.raws.dri.edu/index.html

WRCC is the official archive of hourly RAWS observations. BLM supports the development and maintenance of web access to value-added products based on these data, such as daily lists, summaries, time series, frequencies, etc. This site is not password protected. WRCC provides a table for users to check the quality (completeness) of an individual RAWS archive. It does not track the ROMAN data quality flags for the data RAWS data archived.

There is nothing inherent to WRCC that makes it unable to perform the functionality of ROMAN. ROMAN caters to weather and WRCC caters to climate. If all the data was at one place, both those purposes could be provided at one place.

RAWS are deployed more often to meet locally defined needs rather than from centrally perceived and defined needs. The incremental value of a station to a system is hard to quantify. The biggest issue is how to appropriate the costs when benefits are distributed. There may also be value in including RAWS as a contributor to a network of other networks. The totality of the issue needs to be addressed. The Oklahoma Mesonet is an excellent example of a fine scale centrally developed network.

NOAA has determined that it is more economical to produce high quality data at the start, rather than to correct the data later.

3.2.9 MADIS
Jim O'Sullivan
http://madis.noaa.gov/

MADIS is a consortium of observation networks including data, metadata, quality assurance designed to meet the needs of stakeholders. This NOAA initiative began in 2005. Development continues toward going operational in the very near future. The opportunity exists to work with MADIS to meet our needs during this formative stage.

Data sources include surface, upper air, satellite, grids, and metadata. The surface-observing networks have requirements for accuracy, density and reporting interval. MADIS collects these data and provides them to the user in quality controlled and integrated datasets. Metadata informs the user about how observations are taken.

Maintaining and enhancing NOAA's observing systems as well as leveraging existing and emerging partner and citizen platforms are necessary to address all requirements NOAA has for observations.

Meteorologists with the National Weather Service have access to MADIS via the Advanced Weather Interactive Processing System (AWIPS) for NOAA. It is a technologically advanced information processing, display, and telecommunications system that integrates meteorological, hydrological, satellite and radar data. Predictive Services meteorologists use a similar system called FX-Net which is an extension of AWIPS that addresses bandwidth limitations using advanced data compression techniques.

3.3 What else have we learned along the way?

3.3.1 GACC Predictive Services fire weather role

Tom Wordell
http://www.nifc.gov/nicc/predictive/predictive.htm

In 2006, NPSG asked FENWT to support additional positions to handle the workload they have encountered in order to provide quality weather data and NFDRS outputs from RAWS in each geographic area. FENWT conducted an analysis to assess the impact of the role Predictive Services has played for RAWS data since they were first on-scene in 2000.

A marked improvement in both data completeness within the fire season, and the accuracy of the elements being entered in WIMS (e.g. state of the weather, herbaceous stage) is evident. Each agency and every geographic area has seen significant improvement in the WIMS data record from 1995-99 to 2000-04. However, even with these results in RAWS data and NFDRS output quality, there is still much room for improvement. Due to time constraints of Predictive Services personnel and lack of a formal, national declaration as to the role of Predictive Services in the RAWS program, much of RAWS data continue to be of poor quality. This remains an issued that needs to be addressed.

3.3.2 FPA

Howard Roose
http://fpa.nifc.gov

The Fire Program Analysis system will provide local fire planners and national managers with analysis tools to support strategic fire planning and budgeting for a comprehensive, interagency fire management program. FPA will evaluate the effectiveness of alternative fire management strategies for meeting fire and land management goals and objectives using fire behavior modeling. This new application system will replace the current legacy budget analysis systems for wildland fire programs: NFMAS, FirePro and FireBase.

System build and operational testing is scheduled for June 2008.

A significant challenge to the process is acquiring reliable weather data to support the analysis. The analysis is based on Fire Planning Units (FPU); each FPU requires a defined weather station that is representative of the unit. For every day with a fire in the FPU records, there must also be specific weather observations at the representative weather station. The NIFMID archive has the specific weather observation format, but daily data is incomplete or unreliable, especially on days with fire activity. The WRCC archive is complete, but does not have the specific format. This has led to FPA building a new complete dataset using original and estimated data (www.wrc.dri.edu/fpa).

FPA asked FENWT to recommend how to manage this dataset.

3.3.3 Risk Informed Decisions (e.g. Wildland Fire Decision Support System (WFDSS)
John Szymoniak
http://wfdss.nwcg.gov/

WFDSS is a web-based decision support system. The current application within WFDSS for fire behavior is FSPro (fire spread probability). This application spatially calculates and displays the probabilities of wildland fire spread for a specific fire location over a multiple-day period. It was used during the 2007 fire season on 146 incidents as of 9/9/07. It is currently under development as a decision support system which will replace the Wildland Fire Situation Analysis (WFSA) process.

Weather and climate data from RAWS are a major component of the analysis. Current and historical observations (wind) and computed indexes (ERC) from RAWS are used. Given the site-specific nature of the application, there are never enough RAWS. Weather data is derived from various sources some of which are in digital gridded formats. Other fire behavior applications are planned to be included in future developments, including FARSITE, FLAMMAP, BEHAVE. Additional modules will include an impacts module (economics and burned area rehabilitation), decision support process, and documentation framework. The entire web system is based upon access to large databases of information that can be effectively projected in an online mapping system.

3.3.4 Oklahoma Mesonet and OK-FIRE
Drs. JD Carlson and Renee McPherson
www.mesonet.org
okfire.mesonet.org

The Oklahoma Mesonet was built to meet the state's need for weather information for agriculture, water resources management, scientific research, emergency management, drought mitigation, and education. The network consists of at least one weather station in every county (119 stations, 3300 sensors). It is managed by the University of Oklahoma and Oklahoma State University. The staff includes a field manager, five field technicians, a lab technician, three meteorologists and several programmers and outreach personnel. The Mesonet is a primary weather data source for all weather data users within the state including transportation, law enforcement, severe weather, and fire.

The Mesonet receives data through the state law enforcement communications network. It uses automated quality assurance (QA) and a review from a QA Meteorologist. Original data is flagged for any errors. No estimate is made to replace errors or missing values. Data is distributed via the web, FTP, and publications.

OK-FIRE is a JFSP-funded program to provide fire applications to the OK Mesonet observations. Program partners include the US Forest Service, Bureau of Indian Affairs, US Army Corps of Engineers, US Fish and Wildlife Service, National Park Service, Oklahoma Forestry Services, and the Nature Conservancy.

The OK-FIRE website is a good example of providing a display of data for many different applications in one place. The website offers products for fire weather, fire danger and smoke dispersion using animated, zoomable maps, and site-specific charts and tables. Weather products are from the Oklahoma Mesonet. Gridded fire danger products use satellite-derived "relative greenness" to inform the live fuel moisture calculations in the National Fire Danger Rating System.

3.3.5 Review of the Basis for the Remote Automated Weather Station Network
Dr. Wade Smith, Mitretek Systems

Dr. Smith conducted a brief assessment of the interagency RAWS network to inform the BLM of their potential workload as their RAWS program entered into a competitive sourcing analysis in 2005. The assessment provided good historical documentation but, with a limited budget, did not answer the questions it generated.

Highlights of the assessment:

"RAWS network is not a requirement it is a solution to meet requirements."

- Basis for original RAWS network
  - Support the National Fire Danger Rating System
    - Establish a 75-mile grid for intermountain west
      - Based on professional consensus of fire managers and meteorologists
      - BLM adopted grid approach with top-down decisions
      - Forest Service adopted local approach with bottom-up decisions
      - Class 1 stations
        - Permanent
        - Year-round operation
    - Augment basic grid in certain areas

        - Determine number of additional stations for an area at national level based on set of criteria
        - Let local unit select station locations
        - Class 2 stations
            - Fewer sensors
            - Could be moved

- Large systematic increase in network size is unlikely – most growth will occur at the local (state and county) level. This local growth will be significant.

- Networks are now supporting fire behavior and many other fire and resource programs (e.g. fire planning, recreation, wildlife, NWS, etc.). Need to coordinate and identify general needs and the value of other non-fire users of RAWS data.

- Predictive Services is analyzing the RAWS network data at regional scales. They are finding many stations are correlated for single parameters and are moving toward focusing a subset of available stations.

- Regional and site-specific requirements are different and require different strategic approaches. This affects needs for permanent and portable units

- Investigate ways to use data from other networks to supplement or rationalize current network.
    - State and other Mesonet integration efforts
    - NWS Integrated Surface Observing System (ISOS)
    - NOAA's Environmental Real-Time Observing Network (NERON)
    - Use a partner approach to achieve network

<u>3.3.6 Great Basin RAWS Network Analysis</u>
Dr. Tim Brown
http://cefa.dri.edu/Publications/gbreport.pdf

Dr. Brown recommended the International Network Standards. These standards consider:

- Effect of station change must be known in advance
- Processing algorithms must be well documented
- Station history essential for data interpretation and use
- Observations with long uninterrupted record should be maintained
- Sufficient calibration, validation and maintenance facilities
- Backup observing systems
- Data poor, sensitive to change, inadequate spatial and temporal resolution regions should be given highest priority
- Design network for long-term monitoring
- Commitment to long-term research networks
- Data management systems that facilitate access, use and interpretation are essential

He conducted an analysis of station density in the Great Basin. The appropriate spacing for stations is 50 miles. The existing density for most of the West is greater than this. Figure 2 below shows station densities (color) and location (dot) on a 50 by 50 mile (2,500 sq. miles) grid.

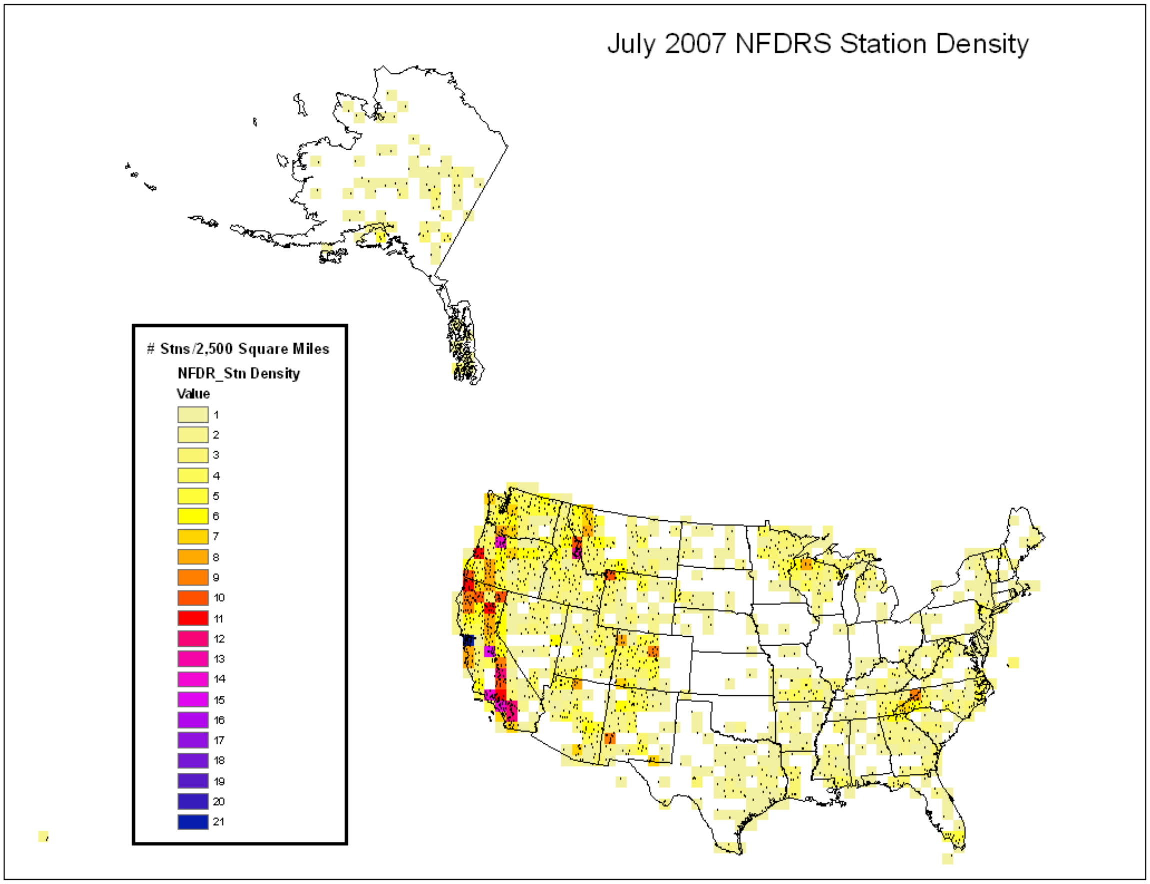

Figure 2. NFDRS RAWS Station Density

Dr. Brown described the North American Regional Reanalysis (NARR) datasets, a 32-km gridded three dimensional dataset that covers all of North America, which he has been using to provide data quality checks and enhancements to various climatological datasets in WIMS and at WRCC (figure 3). They are getting correlations of 0.95 for temperature fields, 0.90 for relative humidity and solar radiation. Correlations of about 0.5 to 0.6 are being obtained for wind speed and precipitation due to their non-uniform nature.

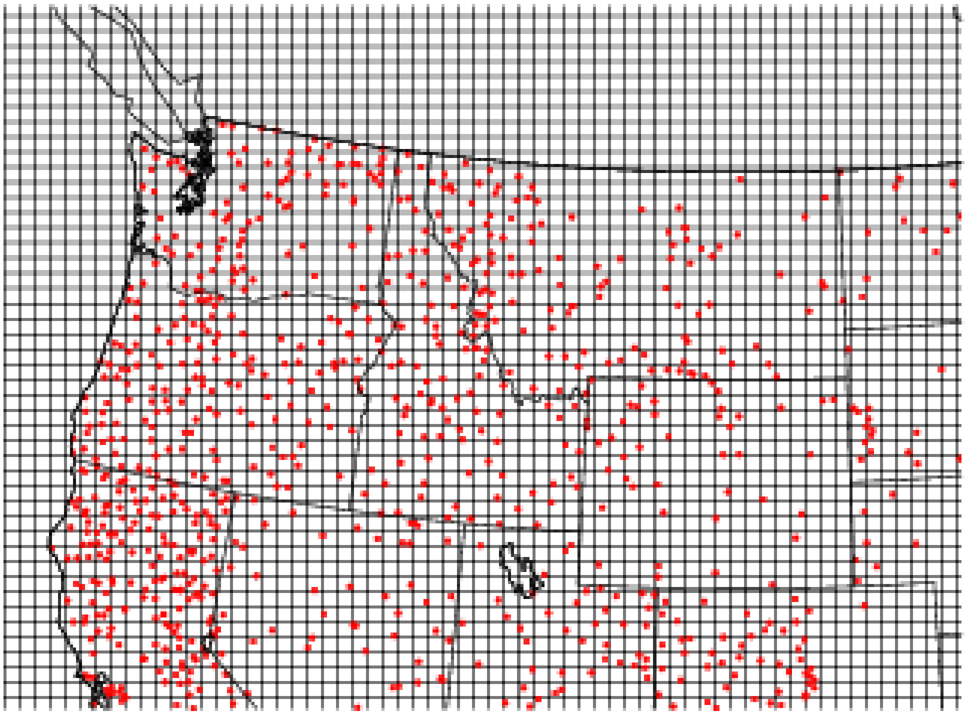

Figure 3. The NARR grid and RAWS locations in the northwest United States

The following maps (figure 4) of Alaska and the continental US (CONUS) display the distribution of the RAWS network (red dots, ~1900 stations) over the distribution of 53 non-RAWS networks (blue dots, ~15,400 stations), all available from MADIS. The non-RAWS networks include MesoWest, the Oklahoma Mesonet, the NWS Cooperative Station Network, state transportation networks, and various other weather networks.

The RAWS network overlaps in many places with other surface observing networks. However, its strength is the non-urban locations of its stations, which tend not to be occupied by other networks. See regions of southeast Georgia southeast Oregon and northern Michigan in the CONUS map. The distribution of other observation networks, for example those in Florida and Oklahoma, should be part of any discussion to consider a final size of the RAWS network.

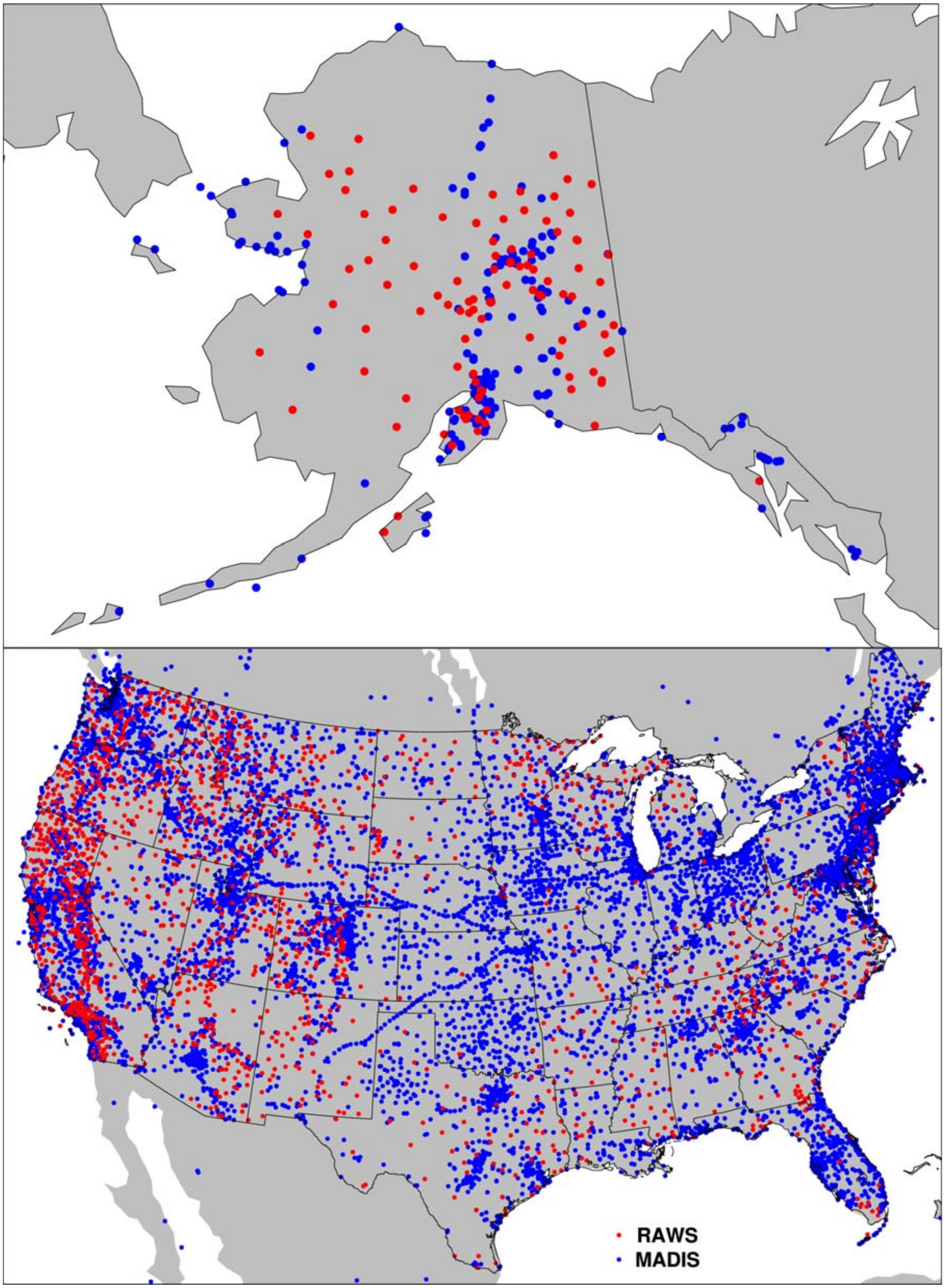

Figure 4. RAWS locations (red) compared to other station networks (blue) available in MADIS for Alaska (top) and the continental United States (bottom).

Consider sharing costs of stations with resource programs that all use the data.

Considerations for fire severity stations

- The station should operate year-round
- Station location, sensor complement, and maintenance schedules must meet NFDRS standards
- The station needs to be representative of the broad scale landscape
- The station should have 20 years of consistent, quality, year-round data
- Annual maintenance should be accomplished early in the season
- The WIMS station catalog receives proper “care and feeding”

Questions FENWT should be addressing:

- What is the purpose of RAWS?
  - Does it need to be formally redefined?
    - Fire vs. resources
    - Analysis vs. forecasting
    - Climatology vs. weather
    - Danger vs. behavior
    - All fire needs vs. specific fire needs
- Can other networks be used for fire business?
  - If so, how are they officially sanctioned?
- Should there be studies to assess other networks for fire business?
- How much density to inform grid products?
- Should there be a reference network within the network?

Potential projects:

- Comparison of RAWS to other networks
  - Determine if other networks suitable for fire danger and other fire business
- Grid sensitivity analysis
  - Determine how much RAWS improved gridded weather fields
- Regional RAWS comparisons
  - Analysis of network density & determine number of stations for a specific purpose (e.g., fire danger)

3.3.7. Review of the Forest Service RAWS Network

The following is the abstract, verbatim from the RAWS Report (2003).

> *“The RAWS network and RAWS data-use systems are closely reviewed and summarized in this report. RAWS is an active program created by the many land-management agencies that share a common need for accurate and timely weather data from remote locations for vital operational and program decisions specific to wildland and prescribed fires. A RAWS measures basic observable weather parameters such as temperature, relative humidity, wind speed, wind direction, and*

precipitation as well as "fuel stick" temperature. Data from almost 1,900 stations deployed across the conterminous United States, Alaska, and Hawaii are now routinely used to calculate and forecast daily fire danger indices, components, and adjective ratings. Fire business applications include the National Fire Danger Rating System (NFDRS), fire behavior, and fire use. Findings point to the fact that although the RAWS program works and provides needed weather data in support of fire operations, there are inefficiencies and significant problem areas that require leadership attention at the National level."

Also, a key finding was in regards to roles and responsibilities (page 13):

"RAWS or WIMS-related administration and operational responsibilities are seldom explicitly stated in an individual's position description. The informal and vague language in these position descriptions contains phrases such as weather-related duties or additional duties or collateral duties. Often personnel directly involved in RAWS-related operations interpret lack of specific duties in these position descriptions as an indication of lack of interest in the RAWS program by upper management. Thus, parts of the network are managed and function well while others that are not as well-managed function poorly. The result is a lack of or questionable quality in critically needed fire weather data (personal observations; D. Clements, F. Hesselbarth, T. Mathewson, and M. Nelson, personal communication 2002)."

3.3.8 Summary of Data Flow between Systems

Figure 5 depicts the flow of data from a RAWS to ASCADS and from ASCADS to its primary clients for user access. Data from GOES are also available to other users through similar pathways.

Figure 6 shows the distribution of RAWS data through ASCADS to four access systems. The user interface of each system is described. While multi-agency users have access to these systems, data flow is almost entirely stove-piped and agency-centric. Also, there is not a systematic use of spatial data.

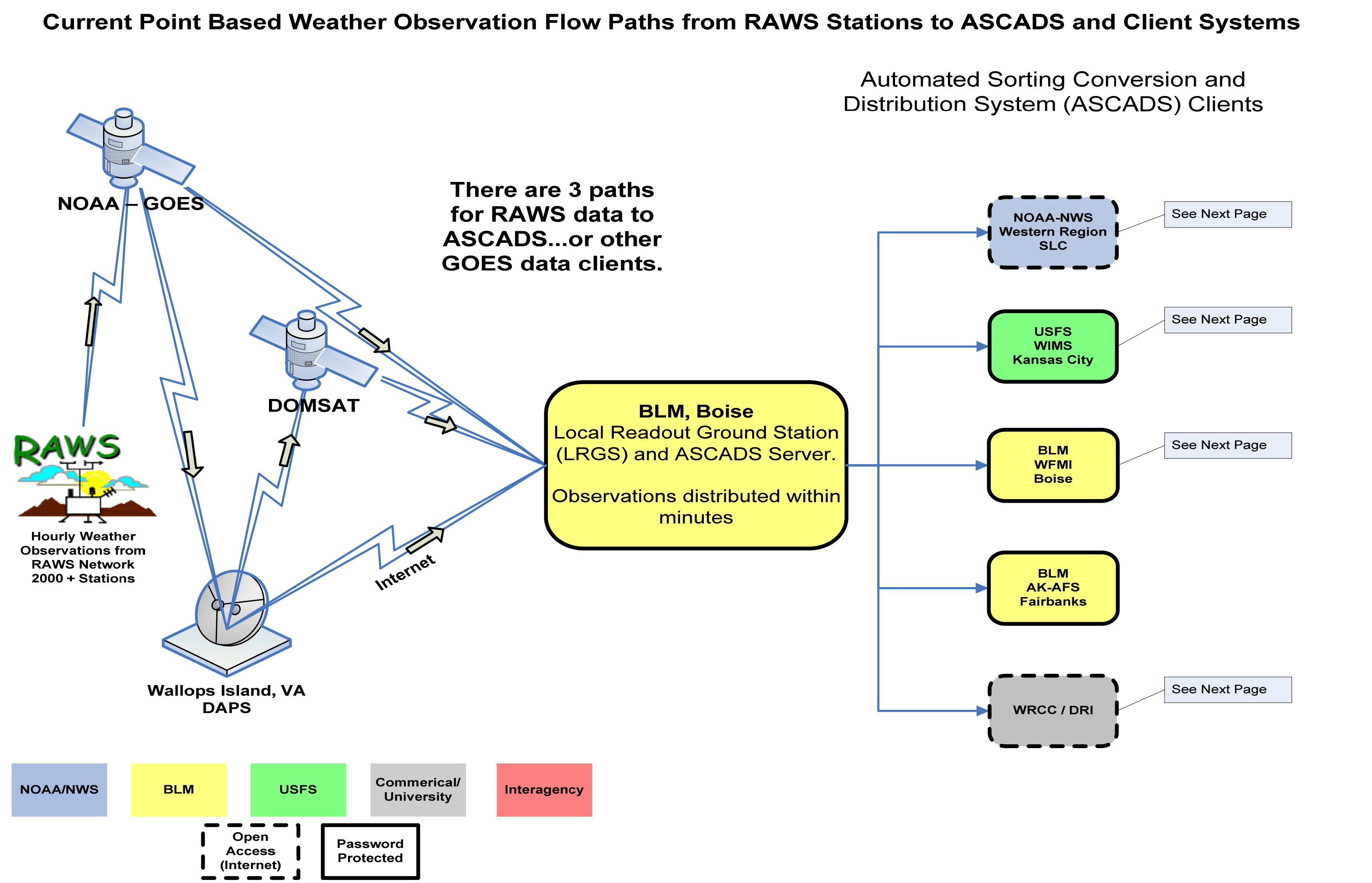

Figure 5. Existing Data RAWS Data Flow

Current General Distribution of RAWS Data from ASCADS through Four Clients (Plus Some Ancillary Data)

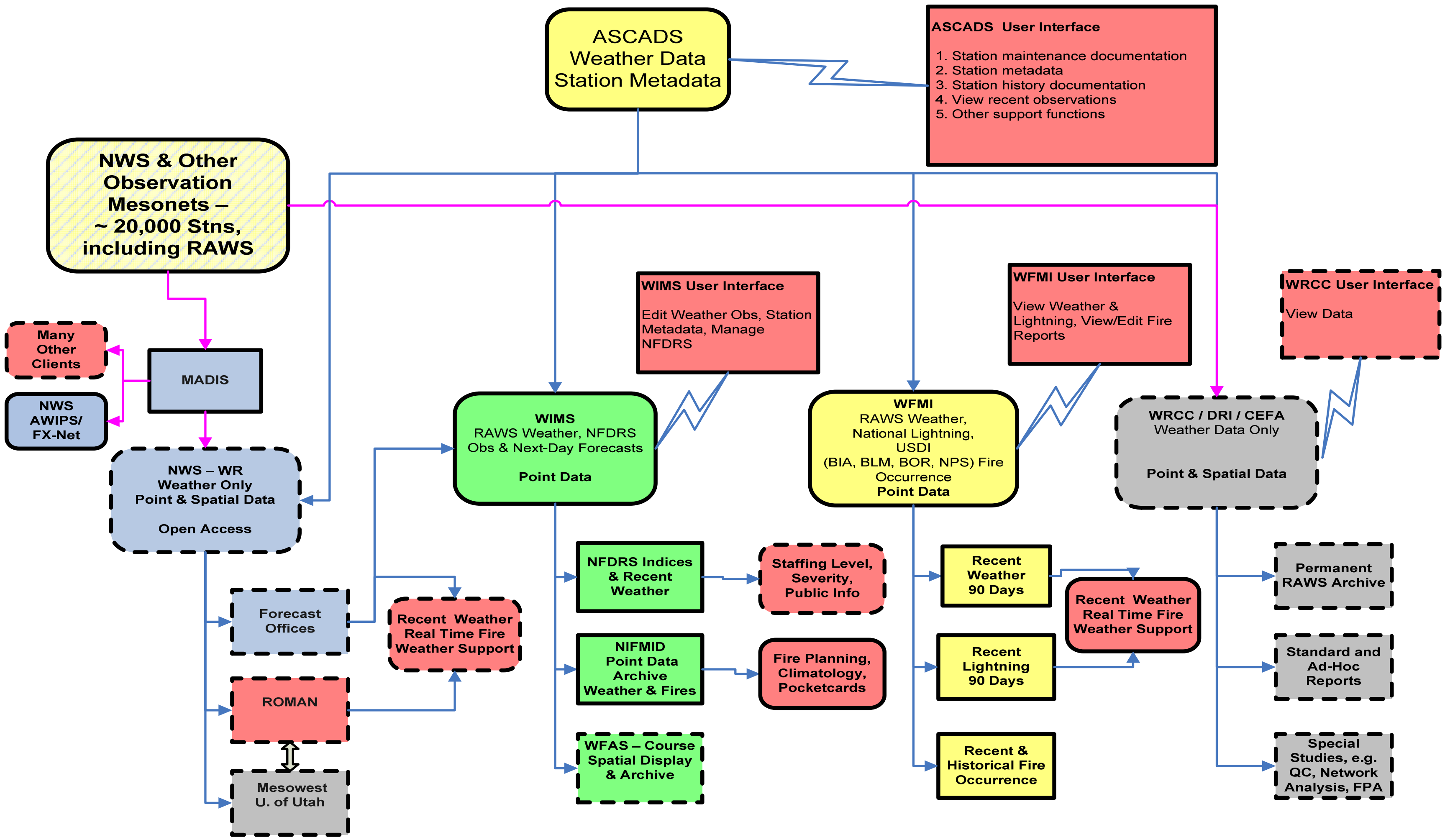

Figure 6. More Detailed RAWS Data within clients.

4.0 Analysis

4.1 RAWS

<u>4.1.1 Purpose</u>:

Initially the purpose of the RAWS network was to support fire danger rating. Today, the network remains sited to meet standards for fire danger rating but its purpose has evolved to support the weather needs of many programs that use and rely upon its data. These programs are primarily fire business-related – fire program analysis, fire danger rating, fire behavior prediction, fire weather forecasting, and smoke management – but also resource-related – hydrology, climatology, restoration and rehabilitation, to name a few.

In general, we have a large enough network for low resolution applications such as fire danger rating and fire planning. On the other hand, it seems there may never be enough stations to satisfy high resolution, site specific applications such as fire behavior. There will always be a need for another station located "over on the other side of the mountain." Thus a key question about the size of the network becomes: can we meet this high resolution need for observations with a low-density RAWS station network?

Four options are available to answer this question. The first is local human observation, particularly on the fireline. In an effort to improve on this option, portable weather stations (portable RAWS and FIRERAWS) were developed to provide round the clock observations in these situations. As a second option portable stations will continue to be maintained and deployed for special needs, such as prescribed burn decision-making and to support air quality monitoring. Further, they are likely tools to provide validation of other weather data. However, this resource is limited in number and, frequently, in timely execution for emergency applications.

Many RAWS data users (who need only real-time observations) have turned to the third option - other observation networks - to meet their needs for supplemental data. These networks provide data in locations not typically sited by RAWS, including north aspects (SNOTEL), roadways (DOT) and urban areas (NWS). The ROMAN system provides the fire community with access to many of these networks.

We need to understand if these other networks' data are meeting the needs of our high-resolution users or if they are a "best-data-available" substitute for more RAWS observations.

Actual observations are surely preferred whenever they are available. However, fire activity rarely occurs within the enclosure of a RAWS site. Data from NFDRS RAWS are widely used in fire behavior analysis. Usually the RAWS is not at the location of the fire but the data may still be useful if it is at or near the elevation of the fire and in the general vicinity of the fire. The farther away and less similar the RAWS site is from the location of our analysis, the more we must extrapolate these point data across the terrain. The observations become estimates.

Today, technology brings to us estimates of observations (weather, fuels, etc.) in the form of gridded data. The NWS uses our RAWS data and other observation networks to initialize and validate the National Digital Forecast Database. The North American Regional Reanalysis (NARR) is a gridded observation dataset. These and other digital datasets provide us an alternative to mentally extrapolating estimates across mountainous topography. Current and developing fire applications are already using digital data files to describe fuels (LANDFIRE) and weather (Wind Wizard, FSPro, FARSITE) parameters in complex terrain. More is coming: the OFCM survey captured a need for a complete gridded characterization of the current atmosphere. Thus, digital gridded data offers a fourth option to collecting weather observations, one that has both low- and high-resolution applications.

We recall Dr. Smith stated, "**The RAWS network is not a requirement, it is a solution to meet requirements**." Thus, an important question is: **What does embracing the digital data world mean to the size of the RAWS network? The future RAWS network should be designed to support our use of gridded applications**.

How many stations are necessary to inform digital data models **and** supply a meaningful observation network to the field? In the West, the station density appears to be generally at or above the 50-mile "meaningful network" spacing mentioned by Dr. Brown. This reflects the growth in the network since its initial 75-mile spacing.

We need to consider the strategy of RAWS as one network in a "network of networks", leveraging the wealth of other data sources to meet our demand for more observations. Access to other networks will be increasingly routine through portals like MesoWest and MADIS.

4.1.2 Scale and growth:

Applications of RAWS data vary with local, regional and national scale. Each scale needs to be part of the solution.

The use of digital, gridded observations requires point observations like RAWS data for initialization and validation. It also presents an objective solution to defining the ultimate size of the RAWS network. Further analysis will be necessary to determine the appropriate grid size to support the fire weather applications and number of point observations needed per grid to support this digital dataset. Yet, the result will be a finite network size and general station location requirements.

Local growth of the network for fire weather purposes would need to be coordinated with this resulting network size and shape. Any further growth of the RAWS network should come with its own funding.

4.1.3 QA/QC:

According to results from the NPSG and OFCM surveys, users are asking for improvements to data quality. Data quality improvements would also address NWFEA recommendations. We see three solutions to improving data quality.

It is cheaper to collect quality observations the first time than to go back later and correct them. We have been doing the latter for fire planning (NFMAS, then FPA) for several years now. Successful QA/QC techniques (that include automated and manual processes) exist for networks similar to RAWS (e.g. OK Mesonet). We are moving toward fully automating all the RAWS observations and need to get there soon.

Existing standards for data entry need to be enforced. Without accurate observations, reliable forecasts can not be made. Management of WIMS data entry is a local responsibility, but it can have regional and national downstream impacts.

Currently, WRCC is the archive for hourly data; NIFMID for once-daily NFDRS-related data. A “System of Record” protocol should be established for these RAWS observations. Such a process for making corrections to these records needs to be established so that edits become part of the record for the benefit of future users of the data.

There are also data quality issues with station metadata. There are at least three systems of record for station metadata: ASCADS, WIMS, and WRCC. Each one has its own station identification scheme (number and often name). A common station identification system and system of record should be employed for cross system (i.e. location, name) station metadata.

4.1.4 NFDRS standards:

Use of observations from stations other than RAWS raises the question of standards. To what standards are these other networks measuring observations? Are these standards acceptable to fire management? What impact do they have to fire spread and fire danger rating calculations? Should guidance be developed for use of non-RAWS data? How does a fire danger rating computed from non-RAWS or gridded data compare to one computed from RAWS data for the same location? We did not have the resources to answer these questions for this study. We need to examine whether the unique set of observation standards for RAWS is still appropriate and efficient compared to a universal set of standards.

4.1.5 ASCADS:

The users have described their need for weather data as all-access, all the time. It is always fire season somewhere in the US. Disruption of access to the RAWS weather observation network must be minimized with redundancy and back-up. The mechanism for collecting and distributing RAWS data to archives and user-access locations must be stable and dependable. ASCADS has set a high bar for efficiency. The next generation process needs to be designed to meet these needs.

However, we found that ASCADS does not meet every agency's needs. Some collect their RAWS data transmissions before the data even get to ASCADS.

ASCADS is about to be re-engineered. This is the perfect opportunity to fashion the new "ASCADS" to meet the needs identified here and in the OFCM survey.

If RAWS is managed as one weather network among many, and if other networks are judged to meet our needs, then these other networks could be part of the "back-up" necessary to support continuity of operations.

4.1.6 FPA dataset:

One key objective of our weather network should be: the RAWS observations we routinely, automatically collect and archive are the dataset needed by fire planners (e.g. FPA). This would eliminate the costly work to rebuild a quality archive for this and other applications. To meet this objective, we must meet the needs for data quality in section 4.1.3.

4.1.7 Predictive Services workload:

While it has traditionally been the role of the local fire manager to "manage the model" of RAWS and fuel inputs in WIMS, it is clear that the regional presence of the Predictive Services program has improved the quality of RAWS data collection and application (e.g. timely and appropriate state of the weather and herbaceous stage entries in WIMS) in most parts of the country. However, this RAWS quality enforcement role is not part of the current workload defined for Predictive Services. A solution to this situation is needed. **Local managers need to be held accountable for managing RAWS observations and NFDRS model inputs in WIMS. Predictive Services should be given the ability to do so when local management does not meet its obligations.**

4.2 ROMAN

4.2.1 General

ROMAN was far and away the system users supported the most in the OFCM survey. At 5 years old, ROMAN is the newest weather data access system used by the fire community. The functionality it provides is generally not available in the legacy systems: password-free access, real-time observations from RAWS and other networks in MesoWest, displayed in interactive map, tabular, trend and other formats. This functionality primarily serves the FBAN and IMET community. WFMI is also real-time, but was designed for dispatchers and therefore is less readily accessible and does not include other station networks' data. Applications of fire danger rating are traditionally performed with data from RAWS on daily rather than hourly timescales, thus the absence of the ROMAN functionality in WIMS/NIFMID. Neither ROMAN nor WFMI perform the fire danger computations of WIMS. WRCC is focused on fire-relevant displays of the RAWS network climatology and in this way it is complementary to ROMAN. The functionalities performed by at least one of these systems that must be carried forward are:

- real-time, password-free access to hourly observations and associated products from RAWS and other networks,
- fire danger rating computations,
- climatology applications from RAWS and other networks

4.2.2 A FENWT interpretation of the existing systems

An analogy might be helpful to describe our understanding of the relationships of some of these systems.

ROMAN is like the service counter at the local electrical supply store. MesoWest is the warehouse in the back. MesoWest carries a wide assortment of goods made from both generic and specialized manufacturers. ROMAN has no member's fee.

MADIS is a home improvement warehouse across the street. Currently, it has a service counter called AWIPS available to member employees of the National Weather Service. However, the ROMAN service counter approach could be moved to the front of the MADIS warehouse.

WIMS is the service counter to an electrical supply store across town that specializes only in light fixtures. It has a member's-only clientele. NIFMID is its warehouse. It has the same kind of widgets as ROMAN, but it only carries the select high-end brand (RAWS) and it offers unique accessories (related to fire danger rating) not found in ROMAN, MesoWest or MADIS. Some members have merchandise approval (data edit) privileges. The FAMWEB Data Warehouse is opening fall 2007. Then, member and non-member customers will be able to bypass the WIMS service counter to access copies of NIFMID merchandise. WFAS distributes specific bundles of NIFMID products to anyone who wishes to use them.

WFMI is another member's only service counter for the same high-end (RAWS) widgets available at ROMAN and WIMS. Its "warehouse" – WRCC – is not in the back, but located in a nearby city. WFMI does not carry the same unique accessories (fire danger rating) as WIMS. Instead, they offer their own accessories (lightning and fire report data). WRCC offers open access to products that describe groups of RAWS widgets (climatology) and restricted access to all of the widgets that have ever been made (the data archive).

ASCADS is the only shipping company that supplies these warehouses with RAWS-brand merchandise. ASCADS also tracks how well the manufacturers (each RAWS station) of these widgets comply with standards (maintenance and metadata).

Ideally we would have universal (no password), anytime, anywhere access to a copy of the data in real-time or other desired timescale from one warehouse through one service counter. Those who need access to the original data (e.g. to edit) can do so through tighter security pathways. (The FAMWEB data warehouse has been designed this way.) The warehouse would be on the home improvement center scale – it would have it or access to it all. (MADIS is being designed this way.)

5.0 Conclusions

5.1 GENERAL

The critical importance of fire weather data to many significant aspects of fire business can not be overstated. The original RAWS network was conceived to support the coarse-scale application of fire danger rating. Today, RAWS data are routinely used to support decisions impacting firefighter safety, whether or not to initiate a fuels treatment prescription, air quality, crew readiness, and strategic seasonal and multi-year resource allocations to name a few. Demand for these data happens every day. Last year the ROMAN website received 125 million hits in pursuit of fire weather data. The future use of RAWS data to support gridded, digital data products is already here and growing quickly.

Responses to the external user surveys and our own efforts to gather information defined the following general needs for our fire weather data infrastructure.

5.1.1 Minimum Standards

The cornerstone for many user needs is minimum standards for these data and products based upon them. Standards provide a basis to judge quality and performance.

Standards also clarify how our data compares to that of other observation networks. The more unique our observations are, the fewer opportunities we will have to use data from other networks. More investigation is needed than we conducted here to consider the possibility of adopting more widely accepted standards.

Upholding standards, especially those we currently have in place, is the key to improving data quality.

5.1.2 Data quality

We need to collect fire weather data in the highest quality manner possible. Improvements are needed in the completeness of data entered into NIFMID through WIMS. Station metadata should be scrutinized for errors. Demand for quality data is high. Some of our most influential applications require it (for example, fire planning). It is very expensive, and not always possible, to reconstruct historical datasets, and we are paying the price.

Also we need to communicate to the user the quality status of the data available to them. The user needs to know about completeness of the record and about accuracy or suspect values.

5.1.3 Robust Continuity of Operations

The fire community relies on RAWS data and other observations every day. There is no down-time during the year in the demand for fire weather data somewhere in the country. Data should be available every day. Backup systems that ensure reliable information flow (e.g. ASCADS, GOES) are needed to provide for continuity of operations.

5.1.4 Spatial applications

RAWS observations will continue to be used to support digital, gridded, spatial applications. These applications cross the spectrum from low (fire danger rating) to high (fire behavior) temporal and spatial resolutions.

A spatial display of observations, both point-based and gridded, is now common practice; users expect this from their data access websites. Supporting the fire community's growing use of spatial applications for fire business analysis will be a key role for the future RAWS network.

5.2 RAWS

There are three issues to address with respect to the size of the RAWS network:

- Purpose of the RAWS network
- The use of non-RAWS observations and digital data in fire business
- The RAWS network local purchase and national maintenance model

5.2.1 Purpose

The purpose of the RAWS network is to support point and gridded applications of fire weather for fire program analysis, fire danger rating, fire behavior prediction fire weather forecasting, and smoke management. We believe this purpose is both necessary and appropriate to meet the current and future needs identified by the fire community.

Improvements are needed in how we manage our RAWS data if the network is to achieve its purpose into the future. Gridded applications will be only as useful as the quality of the data supporting them.

5.2.2 Non-RAWS observations and digital data

More work will be necessary to objectively determine the size and location of the RAWS network needed to achieve its purpose. We believe the growth of gridded applications to be significant to this determination. The answer to the finite size of the network should result from the number of stations needed to support gridded applications. Support for higher resolution grids will require more station locations than would be necessary for low resolution grids. Station density also may depend on the complexity of terrain. This is where use of other observation networks may be invaluable. Further analysis is also necessary to determine which of these networks' observations are applicable to fire weather applications.

Though there will probably never be enough Portable RAWS to play a major role in supporting the grid emphasis we are recommending, there will likely be continuing need for the information it can provide. Its strategic role needs further assessment.

Once we settle on a core network of nationally supported RAWS, all other needs for fire weather data would be served by these options:

- Other (non-RAWS non-fire-supported) observation networks,
- Nationally supported portable RAWS and FIRERAWS,
- Digital data products.

5.2.3 Local purchase/National maintenance

A significant obstacle to finding a solution to the cost of maintaining the RAWS network is the decentralized purchasing authority of the agencies involved. Contributing to this situation is the federal grant funding received by states to purchase weather stations they may not be prepared to maintain. Policy may need to be developed to maintain the planned network size.

To arrive at the appropriate size and distribution of the RAWS network, evaluating them in the context of other available observation networks such as ASOS, DOT, Agricultural Weather, and SNOTEL would encourage better efficiency. Using the Oklahoma MESONET as an example, very few RAWS may be needed if other networks are available to provide the needed data. Any policy developed should encourage the evaluation of all available networks as a part of determining the RAWS complement needed. This evaluation could be shepherded by the GACC's, though analyses may be best conducted over smaller sized areas.

Our conclusion is that the size of the RAWS network is finite and it can be determined based on a clearly defined purpose to support point and gridded applications of fire weather.

5.3 ROMAN

ROMAN exists as a user-conceived remedy for problems fire weather users were having with the legacy systems. People needed solutions to issues they had with limited and bureaucratic access, uncertainty over data quality, a limited supply of observations spatially, and slow response time to system upgrade requests.

The “skunk works” existence that sustains ROMAN is both an asset and a liability. The blend of applied research and operations enables rapid implementation of innovation. The cost of freedom from red-tape has been a lack of investment planning, enterprise support, project management oversight, and programmatic stability.

Users have asked for a one-stop web portal to access fire weather-related information and data. ROMAN is just one of several possible access points but it is currently the most popular according to surveys of fire weather users.

The functionality provided by ROMAN must be fully supported. It is a vital part of our fire weather data access infrastructure. ROMAN needs to be recognized and sustained as an NWCG Project similar to IQCS.

MesoWest and MADIS are NWS-supported databases of weather observations. MesoWest is operational and has been supporting the nationwide application of ROMAN for five years. Adequate funding for MesoWest to support growth and innovation for ROMAN has not happened since ROMAN was put on “life-support” funding in 2005.

MADIS is a new, larger database sponsored primarily by NWS that is now under development. We believe it will provide even more opportunity for access to observation networks. Understanding how to leverage what MADIS will become is an important part of supporting ROMAN in the long-term. NWS has invited our participation in a development group beginning fall 2007. NWCG should get involved in MADIS development to see how it can support our needs through ROMAN in the long-term.

In the long-term, we should look for ways to link, combine, or merge the other data access systems with ROMAN, including WIMS, WFAS, WFMI, WRCC, and ASCADS. These systems either duplicate or compliment the features of ROMAN. The users have asked for fewer access points, preferably one.

Our vision of a future fire weather data access system is shown in Figure 7. ASCADS delivers RAWS data to MADIS for real-time use and WRCC for archival purposes. MADIS provides high quality point and spatial data to the field through a ROMAN interface, in the structural context of the NWFEA project. These data support the breadth of fire weather applications needed by the field user.

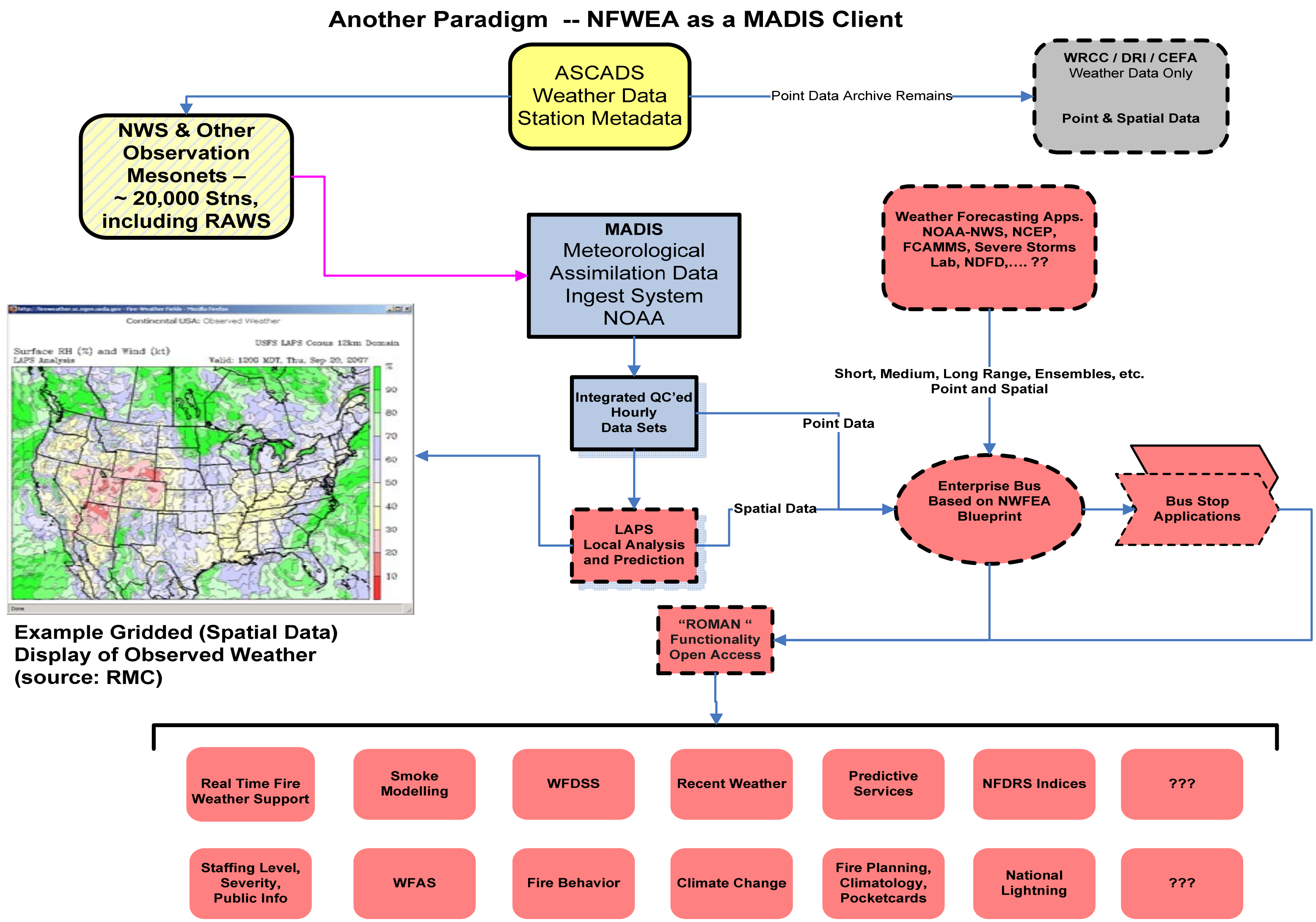

Figure 7. Weather in a NWFEA Framework.

6.0 Alternatives

The plan for this study was based on understanding the current and future needs the fire community has for fire weather data. The OFCM survey provided much of this information. These alternatives were developed with an objective of incrementally meeting more of these needs. The degree to which each alternative meets the OFCM needs related to fire weather data is provided in Appendix B.

6.1 RAWS

1. ***Unplanned growth, increasing network size.*** Status Quo: Few limits, no planning, no coordinated funding between all users of RAWS data
    a. **Pros**: No change.
    b. **Cons**:
        i. Does not address issue of supporting the network in this uncertain or declining budget climate.
        ii. Provides no plan for how RAWS network with unlimited unplanned growth will achieve its purpose.
    c. **Costs**: Short-term costs:
        i. current network maintenance costs $7.5-8.5M/yr;
        ii. relatively low cost of doing nothing – no funded study, no cost of change;
        iii. High and ever increasing long-term cost of increased network infrastructure and maintenance (a primary reason for this study).

2. ***Point emphasis, network size likely to decrease.*** Establish a primary core subset of RAWS emphasizing point data applications. Adjust the number of RAWS in the network based on primary stations for fire planning and Predictive Services.
    a. Select the 1000-1500 primary RAWS identified for each Fire Planning Unit in the FPA analysis and for each GACC Predictive Service Area as the "core" fixed RAWS network.
    b. Provide multi-agency fire program support to maintain this RAWS network foundation.
    c. Emphasize existing standards and high data quality at time of collection
    d. Any other weather stations would be purchased (if new), maintained, and managed through an alternative multi-program/multi-user funding approach (yet to be determined).
    e. Informal use of other station networks to support other fire weather applications continues, such as the current use of ROMAN.
    f. **Pros**:

            i. Takes advantage of existing analyses by FPA and PS to quickly determine a fixed, core network without lengthy analysis.

   g. **Cons**:
      i. **Does not meet the purpose of RAWS network to support fire weather and fire behavior applications**.
      ii. Spatial representation will be weak in areas where few RAWS currently exist.
      iii. Eliminates climatology and current observations of many existing stations
      iv. Risk of agency non-compliance to meet needs for weather data
      v. Does not leverage existing grid data for fire weather applications to assess network size.
   h. **Costs**:
      i. ~$5-7 M/yr network maintenance

3. ***Low and high resolution grid emphasis, network size is finite and may increase or decrease.*** Establish a primary core set of RAWS emphasizing gridded data applications while continuing to support point data needs. Support fire weather with a combination of RAWS, Fire RAWS, and non-RAWS observations, as determined by specific research.
   a. Conduct a well-funded analysis to determine which other networks' observations can be used for specific fire weather applications.
      i. Part of this research examines the merits of adopting more widely accepted observation standards for the RAWS network (wind sensor height in particular is at issue).
   b. Conduct a well-funded analysis to determine the number of RAWS, in combination with other networks, needed to achieve the network purpose.
   c. Analysis will be as a function of gridded weather products at scales necessary to support both fire danger rating (low resolution) and fire behavior (high resolution) applications.
   d. Multi-agency fire program support to maintain this RAWS network foundation.
   e. Implement steps toward improving data quality
      i. Emphasize high data quality at time of collection
      ii. Accountability for existing data standards
      iii. System of Record
      iv. Continuity of Operations
   f. Define finite network. Any other weather stations would be purchased (if new), maintained, and managed through an alternative multi-program/multi-user funding approach (yet to be determined).

g. Formal use of other station networks to support fire weather applications based on the above analysis of their merits to meet our needs.
h. Become part of the network of networks; possibly convert to international standards of measure.
i. **Pros**:
    i. Meets the purpose of the network
    ii. Accomplishes or directly contributes to meeting eight OFCM-identified fire weather data needs
    iii. Aligns with draft NWFEA Blueprint
    iv. Positions RAWS network to meet current and future needs (e.g. spatial/digital, climate change)
    v. Embraces those other networks that may apply to fire applications, thereby reducing unnecessary overlap and reducing the final network size
    vi. Final size is determined objectively to accomplish network purpose
    vii. Due to relationships of other networks and gridded models, final network size may not need to increase
j. **Cons**:
    i. Analysis to determine final network size requires substantial funding.
    ii. Final network size will not be determined in the timeframe of Alternative 2. Analysis is likely a multi-year project.
    iii. Project management may be needed to reach conclusion without scope creep.
k. **Costs**:
    i. ~$300-400K for analysis
    ii. ~$6-10 M/yr network maintenance

6.2 ROMAN

Alternatives that involve system engineering (new design or merging of existing systems) will take time to implement. Therefore, short- and long-term alternatives have been prepared.

<u>Short-term</u>:

1. ***<u>Maintain ROMAN as is.</u>*** Status Quo. Continue current “life-support” funding.
    a. **Pros**:
        i. Sustains current functionality. Provides minimal software and database maintenance, but no enhancements or growth.
        ii. Leverages on-going support from NWS to host servers and provide communication linkages.

   b. **Cons**:
      i. Source of current level of funding is unreliable and discretionary, not guaranteed.
      ii. Does not leverage skills available at University of Utah (UU) for growth and enhancements.
      iii. Lack of long-term planning. Risk of system shut-down from equipment failure.
   c. **Costs**: $60,000 per year.

2. ***<u>Fully support / sanction ROMAN as an NWCG mission critical data access system.</u>*** Upgrade ROMAN software. Provide programmatic funding level to include project management, maintenance, and operations. Add enhancements such as fuel moistures and fire danger rating. Establish backup system to provide for Continuity of Operations. Maintain RAWS archive at WRCC.
   a. **Pros**:
      i. Supports critical functionality of password-free real-time access to many observation networks.
      ii. Enables growth of applications and service. Leverages UU meteorology/programming skill set. Provides for continuity of operations and backup.
   b. **Cons**:
      i. Perpetuates stove-pipe approach to our weather data access points by not creating linkages to legacy systems
   c. **Costs**:
      i. ~$150,000 per year

<u>Long-term</u>:

1. ***<u>Develop a Portal to link existing data access systems</u>*** (ROMAN, WIMS, Data Warehouse, WFMI, WRCC, and WFAS) ***<u>to one new access point.</u>*** Retains the functionality of ROMAN as a separate system.
   a. **Pros**:
      i. Provides one point of access without elimination of existing systems.
   b. **Cons**:
      i. Agencies IT constraints may put this out of reach.
      ii. Doesn't eliminate or merge any existing systems
   c. **Costs**:
      i. All current legacy system O&M costs.
      ii. ~$150K to develop Portal.
      iii. ~$50K/yr O&M costs.

2. ***<u>Reengineer ROMAN into one or more of the legacy systems</u>***, specifically WIMS and ASCADS. Leverage current reengineering efforts for ASCADS and WIMS to incorporate the functionality of ROMAN. This

includes password-free real-time access and access to other weather station networks. Coordinate with Data Warehouse, WRCC, and WFMI for further consolidation opportunities or seamlessness.

a. **Pros**: Combines ROMAN features into an existing system, reducing stove piping and potentially improving efficiency of user access.
b. **Pros**: Leverages re-engineering opportunity of WIMS and ASCADS. Could merge critical information between WIMS, ASCADS, and ROMAN (including data quality, station catalog, and seasonal fuel moisture inputs). Could enable access to WIMS from ROMAN and vice versa.
c. **Cons**: Risk of loss of software development skills at UU.
d. **Cons**: Agencies IT constraints may prohibit password-free real-time access.
e. **Costs**:
    i. ~$200-400K development cost
    ii. ~$50-100K/yr additional O&M costs for legacy system

3. ***Advance to an Enhanced ROMAN***. Begin work fall 2007 to develop opportunities with MADIS for fire weather data access. Partner with NOAA for MADIS (rather than MesoWest) to be the future source of RAWS and other observation networks and gridded products. Pursue ways to link, combine, or merge the other data access systems and functionality with ROMAN, including WIMS, WFAS, WFMI, WRCC, and ASCADS.
    a. **Pros**:
        i. Leverages success and concept of ROMAN into the more complete network database and support staff skill of MADIS, providing more data options and efficiency to the end user.
        ii. Reduces stove-piped systems. Reduces duplicative data access options.
        iii. Provides for long-term growth in data access.
        iv. Emphasizes functionality of legacy systems.
        v. Meets goals of NWFEA and the OFCM survey.
        vi. Provides seamless interface with all systems.
        vii. Can be implemented incrementally.
    b. **Cons**:
        i. Interagency / interdepartmental IT complications of potential system redesign, merging, linkages.
        ii. Agency reluctance to potential IT system elimination.
        iii. Requires new system design.
        iv. Cost
    c. **Costs**:
        i. ~$200-400K development cost
        ii. ~$100-150K/yr O&M costs associated with current ROMAN functionality in MADIS.

iii. Development and maintenance costs of combining the other systems with ROMAN and MADIS are roughly off-set by current system costs

7.0 Recommendations

7.1 RAWS

Alternative 3:
Low and high resolution grid emphasis, network size may increase or decrease. Establish a primary core set of RAWS emphasizing gridded data applications while continuing to support point data needs. Support fire weather with a combination of RAWS and non-RAWS observations, as determined by specific research.

7.2 ROMAN

Short-term:
Alternative 2:
Fully support / sanction ROMAN as an NWCG mission critical data access system. Upgrade ROMAN software. Provide programmatic funding level to include project management, maintenance, and operations. Add enhancements such as fuel moistures and fire danger rating. Establish backup system to provide for Continuity of Operations. Maintain RAWS archive at WRCC.

Long-term:
Alternative 3:
Advance to an Enhanced ROMAN. Begin work fall 2007 to develop opportunities with MADIS for fire weather data access. Partner with NOAA for MADIS (rather than MesoWest) to be the future source of RAWS and other observation networks and gridded products. Pursue ways to link, combine, or merge the other data access systems and functionality with ROMAN, including WIMS, WFAS, WFMI, WRCC, and ASCADS.

7.3 OTHER

7.3.1 Data Quality

Concerted effort is needed to improve data quality for RAWS and NFDRS elements in WIMS:

- Adherence to standards
- Training and local accountability for NFDRS management in WIMS
- Additional positions in predictive services to handle data quality related workload
- Increase flexibility of data management in WIMS to enable quality processes
- Continuity of Operations for GOES and ASCADS

- System of Record data management

7.3.2 FPA fire weather dataset

As explained in section 3.3.2, FPA has requested direction from FENWT for the management of the dataset they have developed for their analysis process. As noted in 4.1.6, the ideal solution is to have in place a process in which the point data FPA needs is the same point data that is collected from our RAWS network into NIFMID in the first place. For at least the foreseeable future, until such a system is in place, a separate point dataset will continue to evolve for FPA purposes. FPA has also been building a gridded weather dataset for its analysis purposes. Both of these datasets reside at CEFA/DRI. Our recommendation is to keep both datasets separate from the hourly archive in WRCC, the daily archive in NIFMID, and any other systems of record, and to continue to archive these datasets at CEFA/DRI.

8.0 References:

2001. Brown, T.J., B.L. Hall, K.T. Redmond, and G.D. McCurdy. Great Basin RAWS Network Analysis. Program for Climate, Ecosystem and Fire Applications, CEFA Report 01-01.

2003. Zachariassen, John; Zeller, Karl F.; Nikolov, Ned; and McClelland, Tom. A Review of the Forest Service Remote Automated Weather Station (RAWS) network. Gen. Tech.Rep. RMRS-GTR-119. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 153 p + CD

2005. Claes Fornell International Group. NOAA National Weather Service Customer Satisfaction survey, National Fire Weather Program

2005. Mitretek Systems. Review of the Basis for the Remote Automated Weather Station Network. Presentation/report to BLM Remote Sensing Support Unit.

2007. Andrus, Lt. Col. David, National Wildland Fire Weather: A summary of User Needs and Issues. Department of Commerce, Office of the Federal Coordinator for Meteorological Services and Supporting Research. 63. p.

2007. National Wildfire Coordinating Group. Draft National Wildland Fire Enterprise Architecture Business Blueprint.

2007. Winter, Patricia L.; Bigler-Cole, Heidi. The National Predictive Services User Needs Assessment: Final Report. In press. 63 p + appendixes.

Appendix A

Glossary of Terms and Acronyms
Adapted from Zachariassen et. al. 2003

AFFIRMS: Administrative and Forest Fire Information Retrieval and Management System; weather information management system replaced by WIMS in 1993.
ASCADS: Automated Sorting Conversion and Distribution System, BLM-administered (interagency) database/ system used as a primary method of retrieving data from the GOES satellite and forwarding to client systems. It is used for metadata storage maintenance documentation, and produces watchdog alerts. ASCADS is a single source for all RAWS data such as maintenance history, sensor suite, location, route, and raw weather data; but it is not a long-term storage archive.
ASOS: Automated Surface Observing System; sponsored by the NWS, DOD, and the FAA.
AWIPS: Advanced Interactive Processing System; a NWS application used for interactive processing, display of hydrometeorological data, and the rapid disseminations of warnings and forecasts in a highly reliable manner.
BIA: Bureau of Indian Affairs.
BLM: Bureau of Land Management; part of the USDI (see below).
CEFA: Climate, Ecosystem, and Fire Applications; a research group that is part of the DRI Division of Atmospheric Sciences, Reno, NV, that is concentrating on fire weather applications. Has carried out numerous climatological and QA/QC studies using RAWS data.
DAPS: Data Collection System (DCS) Automated Processing System; all simply known as DAPS.
DOMSAT: Domestic satellite transmits RAWS data from Wallops GOES ground station to ASCADS.
DRI: Desert Research Institute is a part of the University and Community College System of Nevada. DRI pursues a full-time program of basic and applied environmental research on a local, national, and international scale. Areas include water resources and air quality, global climate change and the physics of the earth's atmosphere.
F&AM: Fire and Aviation Management, Forest Service, Washington Office responsible for national RAWS systems.
FENWT: Fire Environment Working Team of the NWCG.
FCAMMS: Fire consortia for advance modeling of meteorology and smoke, mesoscale weather forecasting centers.
FFP: Fire Family Plus; a desktop computer application used widely for fire weather and occurrence analysis.
FPA: Fire Program Analysis System. Effort to provide managers with a common interagency process for fire management planning and budgeting to evaluate the

effectiveness of alternative fire management strategies through time, to meet land management goals and objectives.

FRWS: Fire RAWS; portable weather stations deployed during an incident or prescribed burn.

FS: Forest Service.

FTP: File Transfer Protocol, process used to transfer files between different types of systems (such as internet, pc to pc, servers, and so forth).

GACC: Geographic Area Coordination Center; regional level fire business coordination center.

GOES: Geostationary Operational Environmental Satellite, the satellite used for data relay from NFDRS weather stations to ASCADS. Also handles almost all weather related DCP data that is transmitted via satellite.

GPS: Geo-Positioning System.

IAMS: Initial Attack Management System; no longer in use, replaced by the BLM/NIFC Wildland Fire Management Information system in the late 1990s.

KCFAST: Kansas City Fire Access Software; long term RAWS data archive; part of NIFMID.

MADIS: Meteorological Assimilation Data Ingest System. System designed to assimilate and to quality control on weather observations from a wide range of data collection platforms and networks, including both surface and upper air.

Metadata: information about information; usually nonnumeric. For example as this relates to RAWS the station catalog is a metadata file containing general information about the station/site (station ID, site description, State and county codes, lat/long, station type and name, station owner, conversion codes, access control, site physical description, and so forth) and NFDRS parameters (fuel model(s), live fuel type, climate class, annual precipitation, lat/long, and so forth).

Mesonet: A regional network of surface observing stations designed to diagnose mesoscale weather features and their associated processes.

NASF: National Association of State Foresters.

NESDIS: National Environmental Satellite Data Information Service; provides access to global environmental data from satellites and other sources. Formed in 1980 by combining the National Environmental Satellite Service (NESS) and the Environmental Data Service (EDS) two line offices of NOAA, NESDIS acquires and manages the United States operational environmental satellites, provides data and information services, and conducts related research.

NFDRS: National Fire Danger Rating System; a computer model that calculates fire danger rating indices and components, used for fire business decision making and as a management decision tool. The NFDRS allows land management agencies to estimate the current day's and the following day's fire danger at multiple scales and areas. NFDRS characterizes fire danger by evaluating the approximate upper limit of fire behavior in a fire danger rating area during a 24-hour period. NFDRS output gives relative ratings of the potential growth and behavior of any wildfire. Fire danger ratings are guides for initiating presuppression activities and selecting the appropriate level of initial response to a reported wildfire rather than detailed real time site-specific information. NFDRS computations are based on once daily, mid-afternoon observations (2 p.m. LST) from the Fire Weather Network comprising some 1,900 weather stations throughout the conterminous United States and Alaska. Many of the stations are seasonal and do not report during the non-fire season.

NIFMID: National Interagency Fire Management Integrated Database, database/warehouse for archiving fire business/management information; includes RAWS weather observations.

NITC: National Information Technology Center (USDA), located in Kansas City, MO; the NIFMID/WIMS/KCFAST host.

NOAA: National Oceanographic and Atmospheric Administration, Department of Commerce.

NPS: National Park Service, Department of Interior.

NPSG: National Predictive Services Group. Interagency group representing predictive services functions at the National Geographic Coordination areas.

NWS: National Weather Service.

NWCG: National Wildfire Coordinating Group, an interagency group established to coordinate programs of the participating wildfire management agencies. Interagency fire weather and fire danger working teams within this group make recommendations for network and individual station life-cycle management, network standards, better planning, and technology transfer.

NWFEA: National Wildland Fire Enterprise Architecture project. An effort to create a master “blueprint” of interagency fire business processes and related data.

OFCM: Office of the Federal Coordinator for Meteorology. Established by the Department of Commerce to facilitate full coordination of federal meteorological activities.

Pocket Card: The Fire Danger Pocket Card is a method of communicating information on fire danger to firefighters. The objective is to lead to greater awareness of fire danger and increased firefighter safety. The Pocket Card provides a description of seasonal changes in fire danger in a local area using graphics and short text. It is used by both local and out-of-area firefighters.

Predictive Service Meteorologist: A meteorologist who works for Federal land management agencies in GACCs. They provide “predictive” services for fire business purposes as opposed to forecast services provided by NWS. The distinction is a matter of semantics and forecast authority.

RAWS: Remote Automatic Weather Station, fire weather station network.

ROMAN: Real-time Observation Monitoring and Assessment Network. Internet application housed at Western Region, NWS that provides access to a variety of weather observation networks.

RSFWSU: Remote Sensing Fire Weather Support Unit (also known as the Boise Depot); operated by the BLM as an interagency weather station repair and maintenance facility located in Boise, ID.

SNOTEL: SNOwpack TELemetry; sponsored by the Natural Resources Conservation Service (NRCS); collects and transmits snow pack and related climatic data.

WFAS: Wildland Fire Assessment System; Web-based interface providing weather and NFDRS products, primarily maps. WFAS-MAPS generates national maps of selected fire weather and fire danger components (ignition, energy release, and spread components) of the NFDRS. To generate these maps, WFAS queries WIMS each afternoon for the daily weather observations.

WFDSS: Wildland Fire Decision Support System. The current application within WFDSS for fire behavior is FSPro (fire spread probability). This application spatially calculates and displays the probabilities of wildland fire spread for a specific fire location over a multiple-day period.

WFMI: Wildland Fire Management Information; a BLM managed fire weather database it replaced the BLM Initial Attack Management System (IAMS) in the late 1990s.

WFO: Weather Forecast Office; part of the National Weather Service (NWS).

WIMS: Weather Information Management System; weather information database; also the host for the NFDRS model. WIMS archives (short term) and manages all RAWS data (GOES and non-GOES). The 13:00-hour data points are permanently archived, but the 24 hourly points are kept for 18 months. WIMS, which was implemented in 1993, replaced AFFIRMS.

WRCC: Western Regional Climate Center is one of six regional climate centers in the United States, is administered by NOAA and specifically by the National Climate Data Center and NESDIS. The mission of the WRCC is to archive and distribute climate data and information; promote better use of this information in decision making, conduct applied research related to climate; and improve coordination of climate-related activities ranging from local to national scales.

Appendix B

Comparison of Alternatives and Applicable OFCM Fire Weather Needs

Key:
- +++ Will directly accomplish or contribute to meeting this need
- ++ Likely to support meeting this need with others
- \+ Could contribute indirectly to meeting this need
- [Blank] No contribution expected
- **Bold** Recommended Alternatives

OFCM Need Ref #	OFCM Wildland Fire Weather Need	RAWS 1: Unplanned growth, increasing network size	RAWS 2: Point Emphasis, network size likely to decrease	**RAWS 3: Low and High Res. Grid emphasis, finite network size up or down**	ROMAN Short-term 1: Maintain ROMAN as is	**ROMAN Short-term 2: Support ROMAN as NWCG mission critical system**	ROMAN Long-term 1: Develop a Portal to link existing data access systems	ROMAN Long-term 2: Reengineer ROMAN into one or more of the legacy systems	**ROMAN Long-term 3: Advance to an enhanced ROMAN**	Other Recommendations Data Quality – System of Record – Continuity of Operations
1.1.a	A strategy for a complete, real-time, observationally based, gridded characterization of the current atmosphere needs to be developed and implemented based on an integrated set of all available in situ and remotely sensed environmental data.	++	+	+++						
1.1.b	A centralized means of reliably retrieving validated					+	++	+	+++	

	observation data is needed.									
1.1.c	A complete suite of deployable and non-deployable sensors must be well maintained and fully integrated into a national network for common data availability.	+	+	+++		+++	++	++	+++	+++
1.1.d	The comprehensive, prioritized list of needed observed and predictive fire weather data elements developed from this assessment should be refined and validated.			+++						
1.2	All national weather station standards (to include those used by other agencies and NFDRS standards) should be reevaluated to ensure proper integration of all pertinent weather station data (to include portable weather stations) for use by the wildland fire community.	+	+	+++						++
2.1.b	A better understanding of wildland fire smoke is needed, and smoke prediction tools need to be refined and perfected.	++	+	++						
2.1.c	Wildland fire and climate change/climate variability is an issue of high concern, for which more scientific understanding is a priority.	++	+	++						

3.1.a	Managers at each level of government need tailored products and tools for their unique duties and responsibilities; these products need to be made available to the entire community for greater use and awareness.					+	++	+	+++	
3.1.b	Information on forecast product accuracy should be made available to users.									+
3.1.c	Users need more detailed information regarding long-term forecasts and climate outlooks.									+
3.3.e	Users need NFDRS forecasts for more locations.	++		+++		++	+	+	+++	
4.1.a	Users overwhelmingly need higher resolution meteorological model fields in complex terrain and the tools and input data to understand fire behavior and smoke dispersion.	++		+++		+	+		++	
4.1.b	Users need model accuracy and confidence information presented to them in an understandable format.			+++		+	+		+++	
4.1.c	The fire community needs better modeling of fire potential, threat, and impacts associated with climate and climate change.	++		++						
4.1.d	Model output information									

	needs to be made available in easy-to-use graphics and in high-bandwidth and low-bandwidth formats for use with workstations, PDAs, and text messaging. Products also need to be available in GIS format.			+++	+	+	+	+	++	
5.1	A coordinated, "one-stop" fire weather Internet presence is needed to facilitate fire weather user access to pertinent weather data and products for their region of interest.				+	+	++		+++	+
5.3	Consistent dissemination of timely products and services to model users is needed.				+	+	+	+	+++	++
5.5.a	Wildland fire weather users require a robust continuity of operations plan for the Geostationary Operational Environmental Satellite (GOES) Data Collection System (DCS), which serves as an integral mechanism for this flow of data.									+++
5.5b	Wildland fire weather users require a robust continuity of operations plan for the Automated Sorting, Conversion, and Distribution System (ASCADS), which serves as a crucial node for weather data flow.									+++