# PORTABLE ROAD WEATHER INFORMATION SYSTEM:
Fabrication and Uses of Autonomous Weather Stations Deployed For Atmospheric Data Collection

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ABSTRACT: The collection of accurate real-time atmospheric data is of paramount importance when working in an operational setting. Both the current and historic state of the atmosphere greatly affect the decision making process of avalanche and weather forecasting, rescue operations, mining and construction projects, as well as addressing sighting concerns for future permanent weather station installations. In some areas, permanent weather stations exist and pertinent weather information can either be directly obtained or extrapolated to a given location. In other situations, cost, access and permitting issues can make having a permanent fixture prohibitive. With this in mind, four stand alone portable weather stations (PWS) were manufactured by Utah Department of Transportation's (UDOT) Weather Operations Group. These PWS can be transported to a sight specific location, produce their own power and come fully equipped with communication packages capable of broad band data dissemination. In addition, UDOT's PWS are designed to be set up quickly and with ease by one individual. This paper will outline the research, design and fabrication process of constructing these weather stations, a brief cost analysis, and the use and benefits of these systems in an operational capacity.

KEYWORDS: Avalanche Forecasting, Weather Forecasting, Decision Making, Portable Weather Station

## 1. INTRODUCTION

Operational decision making in the 21st century is centered on having the most accurate and up to date information available and on-hand in a timely fashion. When working in the mountain environment, a key piece of information that can affect the direction of the decision making process is atmospheric data. The inherent complex nature of mountain weather can dictate whether a project can continue or needs to be placed on standby.

Specifically, avalanche and weather forecasters, transportation engineers, rescue personnel, and project managers want to know: What is the wind doing, both the speed and direction? What is the ambient air temperature and relative humidity? Is precipitation occurring presently or has it occurred recently? How much water was there within the recent precipitation? What is the snow depth at the current location? Is the barometric pressure falling or rising? How intense is the solar radiation? What is the state and temperature of the road surface? What is the traffic flow below an avalanche path or through a construction project? Do we have a current visual image through the use of a video camera?

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The answers to some or all of these questions can greatly influence the operational decision to close a road for avalanche control or poor road conditions, to proceed with or discontinue a rescue mission, or whether a mining or construction project employing heavy equipment can continue. This information is also imperative when sighting locations for the installment of future permanent weather information systems. If the sight has anomalous winds, misrepresentative precipitation amounts, or bad communication, then appropriating resources to continue with an installation is ill advised.

The conduit for collecting this data is weather instrumentation such as anemometers, temperature and humidity probes, precipitation sensors, ultrasonic depth sensors, barometers, pyranometers, non-invasive road sensors, traffic counters, and pan tilt-zoom streaming camera equipment.

Historically, choosing a location to place these sensors in the mountain setting has been based on how representative and pertinent the collected information will be for an operation, the ease of access to the chosen site for maintenance, and the ability to erect a permanent structure in the area due to permitting and cost concerns. When some or all of these parameters preclude a permanent installation, the use of a portable weather station

(PWS) is ideal, assuming there is access suitable to the delivery and implementation of the system.

In the summer of 2007, a prototype portable roadway weather information system (RWIS) was manufactured by Peyton Parnegg of the UDOT Weather Operations Group. This station is still currently in service and is presently stationed in Big Cottonwood Canyon, Utah. It is slated to collect data for use with the PCAPS (Persistent Cold Air Pooling Study) project, a NSF funded collaboration between the University of Utah and Michigan State University with assistance from the Utah Department of Transportation. The study is focused on investigating “the processes leading to the formation, maintenance and destruction of persistent mid-winter temperature inversions (cold-air pools) that form in the Salt Lake basin.”

During the summer of 2010, the decision was made to take the original prototype version of this portable weather station, and streamline the design and fabrication process and produce four additional systems that can be deployed throughout the state of Utah. Some of these PWS will also be employed by the PCAPS project, while others will be dispersed throughout Utah to fill gaps in the RWIS network used for road weather forecasting, ongoing road construction projects and for long term sighting analysis for the installation of future permanent RWIS.

## 2. FABRICATION PROCESS

The initial design consideration for the four PWS that were manufactured during the summer of 2010 was to produce lightweight, streamlined and efficient trailers that housed a weather-tight box for battery and data logger storage, an appropriately sized photovoltaic array, and an extendable tower where instrumentation could be attached. The need existed for the trailers to be easily towed and managed by one individual.

Once on sight, the individual needed to be able to maneuver the PWS into place, erect the tower, attach the instrumentation, orient the photovoltaic array for optimal solar gain, and perform the necessary service to ensure that the whole system was functioning and communicating properly.

Four stock trailers measuring 1.5 meters by 3.1 meters (5ft X 10ft) with a straight tongue were selected. The UDOT welding shop attached a sheet of 3 gauge (.6 cm (1/4”)) steel to the frame of the trailer. They also affixed 4 trailer jacks on each corner and a wheeled trailer jack on the tongue.

These base models were transported back to the RWIS shop where the surface of the steel plate was painted white, increasing the albedo and thus reducing the amount of heat absorbed and radiated back towards the instrumentation, potentially affecting measurements. Once the paint dried, a steel job box was mounted to the plate, housing the battery, remote processing unit (RPU), and communication hardware. A pole mount for the photovoltaic array was also attached, as well as an extendable tower where the instrumentation would live and take measurements.

After drilling through the steel and mounting these 3 components of the PWS, three 12 volt 200amp/hr batteries were dropped into the box, wired in parallel and into three circuit breakers and then into a solar charge controller. Next, two 90-watt solar panels were affixed to the pole mount, wired in parallel and into the solar charge controller. A 3m (10ft) UT10 tower was placed on one side of the job box, the appropriate sensors attached and the sensor wire was run into the box and into the RPU. Lastly, The RPU was configured with the appropriate IP address, the communications were enabled and verification was gained that a connection could be made to the station from the weather operations server located at the UDOT Traffic Operations Center (TOC).

## 3. COST ANALYSIS

The Little Cottonwood Canyon SR-210 Transportation Study conducted by the consultant team of Fehr & Peers Associates in 2005 estimated that “a road closure during the 1991-1992 ski season meant the loss of $1,410,370 per day in revenue for the resorts.” This figure represents the loss to two ski areas located near the end of a 10 mile stretch of highway, and would be significantly higher adjusted for today’s dollars. The cost of placing a PWS on the roadway containing road sensors and weather instrumentation that can monitor the condition of a highway is minimal compared to the prospect of having to shut down the corridor due to accidents or snow on the road from avalanches. Gathering real time data that indicates a need to service the roads and keep vehicles moving through areas affected by avalanche paths is priceless.

| QUANTITY | ITEM | TOTAL COST |
|---|---|---|
| 1 | Trailer w/trailer jacks | $700.00 |
| 1 | 3 gauge Steel Sheet | $375.00 |
| 1 | Job Box | $250.00 |
| 1 | Solar Panel Pole Mount Kit | $150.00 |
| 1 | Galvanized Steel Threaded Pipe | $30.00 |
| 1 | UT10 Tower | $565.00 |
| 2 | 90-watt Solar Panel | $800.00 |
| 3 | 200 amp/hr Sealed Batteries | $1,000.00 |
| 1 | Morning Star Solar Controller | $140.00 |
| 3 | Circuit Breakers | $150.00 |
| 2 | Terminal Blocks | $10.00 |
| 1 | Wire | $20.00 |
| 1 | Campbell Scientific CR1000 Datalogger | $1,440.00 |
| 1 | Campbell Scientific NL115 Ethernet/Compact Flash Module | $350.00 |
| 1 | Campbell Scientific MD485 Multi Drop Interface | $265.00 |
| 1 | Bluetree Wireless Communicatin Device | $800.00 |
| 1 | Yaegi Antenae | $125.00 |
| 1 | RM Young Anemometer | $930.00 |
| 1 | Vaisala HMP45C Temperature/Humidity Probe/Radiation Shield | $780.00 |
| 1 | Vaisala Precipitation Sensor | $1,000.00 |
| 1 | LI200X Pyranometer | $360.00 |
| 2 | Campbell Scientific SR50 Sonic Ranging Sensor | $2,010.00 |
| 1 | Wavetronix Traffic Counter | $5,500.00 |
| 1 | Axis PTZ215 Pan-tilt Camera | $1,259.00 |
| 1 | Spray Paint | $200.00 |
| 1 | Miscelaneous Parts | $250.00 |
| | **TOTAL:** | **$19,459.00** |

Table 1: Estimated quantity and cost of materials to produce one PWS by UDOT's Weather Operations Group

The PWS that was manufactured by UDOT's Weather Operations Group and is on display for ISSW 2010 at Squaw Valley, CA, is loaded with a full suite of sensors and the appropriately sized photovoltaic array and battery bank. Table 1 outlines each piece of equipment attached to the model and the corresponding quantity and price. Customization of one of these units to collect only the data that is of interest to an operation is easily accomplished. The reduction in the number of sensors and size of the power system would reduce the overall cost of a PWS.

## 4. CONCLUSIONS

The collection of reliable atmospheric data greatly reduces the uncertainty that can accompany operational decision-making. Information provided by weather instrumentation that accurately depicts the state of the atmosphere can reduce the ardor of deciding whether or not to commit resources to continue with a given project. A PWS that can quickly and efficiently be moved into position and collect data is an indispensible tool when confronted with tough choices in a mountain environment.

The UDOT Weather Operations Group was able to design, fabricate, and outfit a PWS with a suite of sensors for $19,459.00 per unit. Four of these systems were produced during the summer of 2010 and will be deployed into the field and begin collecting data for various purposes and projects.

The range of uses for these PWS varies, from temporarily assessing the viability of a location for the future installment of a permanent weather information system, to construction projects where traffic flow and on the ground weather conditions will dictate how to proceed with a given project. PWS can be utilized for sight specific measurements so that taking data from a proximal permanent weather station doesn't have to be extrapolated to make a "best guess" about the atmospheric conditions for the project location. Having precise information can dictate whether it's possible to move rescuers into position to continue with a mission or abort. It can dictate whether conditions are appropriate for flying a helicopter into difficult terrain. PWS can be used to monitor the road conditions and traffic flow below the run-outs of avalanche paths during periods of peak congestion on mountain corridors through the use of traffic counters and camera equipment. This can help avalanche forecasters decide how to proceed with road closures and subsequent control work. In short, the implementation of portable weather stations into an operation that conducts work in the mountain environment is a cost effective tool that can aid in the decision making process by increasing accuracy and reducing uncertainty.

## 5. REFERENCES

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