Development of a Remote Monitoring System Using Meteor Burst Technology

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ABSTRACT

Monitoring the cleanup and closure of contaminated sites requires extensive data acquisition, processing, and storage. At remote sites, the task of monitoring often becomes problematical due to the lack of site infrastructure (i.e., electrical power lines, telephone lines, etc.). MSE Technology Applications, Inc. (MSE) has designed an economical and efficient remote monitoring system that will handle large amounts of data; process the data, if necessary; and transmit this data over long distances. Design criteria MSE considered during the development of the remote monitoring system included: the ability to handle multiple, remote sampling points with independent sampling frequencies; robust (i.e., less susceptible to moisture, heat, and cold extremes); independent of infrastructure; user friendly; economical; and easy to expand system capabilities.

MSE installed and tested a prototype system at the Mike Mansfield Advanced Technology Center (MMATC), Butte, Montana, in June 2005. The system MSE designed and installed consisted of a “master” control station and two remote “slave” stations. Data acquired at the two slave stations were transmitted to the master control station, which then transmits a complete data package to a ground station using meteor burst technology. The meteor burst technology has no need for hardwired landlines or man-made satellites. Instead, it uses ionized particles in the Earth’s atmosphere to propagate a radio signal. One major advantage of the system is that it can be configured to accept data from virtually any type of device, so long as the signal from the device can be read and recorded by a standard datalogger. In fact, MSE has designed and built an electrical resistivity monitoring system that will be powered and controlled by the meteor burst system components.

As sites move through the process of remediation and eventual closure, monitoring provides data vital to the successful long term management of the site. The remote monitoring system developed by MSE is cost effective, robust, and can easily be integrated into a site monitoring plan yet remains independent of other site activities/infrastructure and is expandable to meet future site monitoring requirements.

INTRODUCTION

Under the FY05 task TSF-Sensors & Monitoring, MSE Technologies, Inc. (MSE) is providing support to address the sensor and monitoring needs of the Department of Energy (DOE). With input from various closure sites, MSE has identified site monitoring needs and the status/availability of technologies to meet those needs. Site monitoring, especially post-closure monitoring, typically requires extensive data acquisition, processing, and storage. Monitoring is further hindered as site infrastructure (i.e., electrical power lines, telephone lines, etc.) is removed. MSE has designed an economical and efficient remote monitoring system with the ability to handle large amounts of data, process the data, if necessary, and transmit this data over long distances. This system is solar-powered and relies on meteor burst technology to transmit data from a remote field location. The meteor burst system does not require hardwired landlines or man-made satellites for data transmission. The initial, prototype system was installed at the Mike Mansfield Advanced Technology Center (MMATC), Butte, Montana, in June 2005. This document describes the prototype system that was installed.

METEOR BURST TECHNOLOGY BACKGROUND

Meteors passing through the upper atmosphere (80- to 120-km region) create trails of ionized particles in the Earth's atmosphere. In the 1950s, after it was discovered that the ionized trails were capable of reflecting radio waves transmitted from the Earth's surface, the military began communication experiments using the ionized trails. By 1975 the Natural Resources Conservation Service (NRCS) had incorporated a meteor burst communications system into the SNOTEL (SNOwpack TELemetry) system to monitor rain and snowfall levels at remote stations throughout the Rocky Mountains.

Meteor trails are typically tens of kilometers long and can reflect radio signals over distances of up to 2000-km (1200-miles) between a transmitter and receiver. Transmission time can vary since the ionized particle rapidly diffuse into the air, losing the ability to reflect radio waves. Most meteor trails last less than 1 second. However, a large meteor may create an ionized trail capable of reflecting radio waves for up to several minutes. Fig. 1 illustrates how the meteor burst technology works.

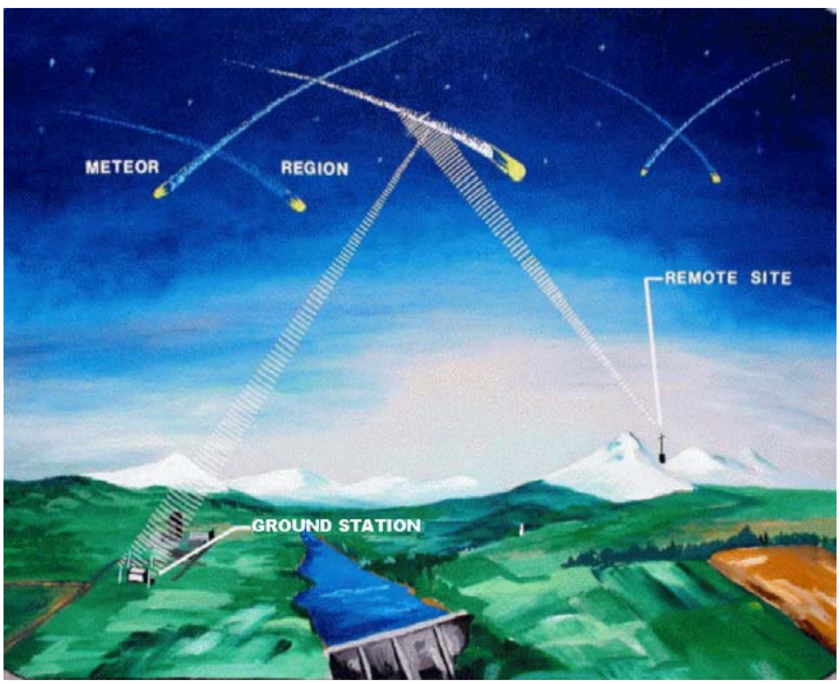

Fig. 1. Illustration of Meteor Burst technology operation

Standard operation of a system is as follows: (1) a ground station transmits a continuous, coded signal, in the Low Band VHF region (40- to 50-Mhz); (2) when an ionized trail appears in the desired location, the signal is propagated via reflection or refraction to a remote site; (3) the remote site decodes the signal, turns on its transmitter and transmits a signal back along the same path to the ground station. Because the ionized trails typically exist for only a few milliseconds to a few seconds, communication is intermittent, and high-speed digital transmission techniques must be used. Hence, “bursts” of data are transmitted and received. Depending on the time of day, time of year, and system design factors the wait-time between finding suitable, ionized trails can range from a few seconds to minutes.

ADVANTAGES OF METEOR BURST TECHNOLOGY

The meteor burst technology is an alternative to standard, man-made satellite data transmission and has several advantages. There is a two-way communication between the ground station and the remote site, which greatly reduces the chance of data loss. Data can consist of short messages (i.e., sensor data), coded messages of up to several hundred characters, text messages of a few words, or long messages transmitted in successive “bursts.” The data “burst” feature makes it possible for multiple links to share a common frequency. The meteor burst system does not require equipment to be placed in orbit. Operation costs can be reduced because expensive satellite time rental can be avoided. Finally, meteor burst data transmission it is not susceptible to many natural and man-made atmospheric disturbances (e.g., aurora borealis and fouling due to nuclear explosions), which often render other satellite systems inoperable.

MSE REMOTE MONITORING SYSTEM

The characteristics MSE identified as being key to designing/ building an effective remote monitoring system include:

- Ability to handle multiple, remote sampling points with independent sampling frequencies;
- Robust (i.e., less susceptible to moisture, heat, and cold extremes);
- Independent of infrastructure;
- User friendly;
- Economical; and
- Easy to expand system capabilities.

The prototype remote monitoring system MSE designed and installed at the MMATC consisted of a “master” control station, two remote “slave” stations, and an electrical resistivity monitoring system. Data acquired at the two slave stations are transmitted to the master control station using radio telemetry. Data from the electrical resistivity is stored directly to the datalogger in the master control station. The master control station then transmits a complete data package to a ground station via the meteor burst technology. The components of the prototype remote monitoring system are described in more detail in the following sections.

Master Control Station

The master control station, shown in Fig. 2, is made up of 6 major components: a meteor burst antenna; a meteor burst panel; a 900 MHz radio antenna; a solar panel; a battery charge controller; and batteries.

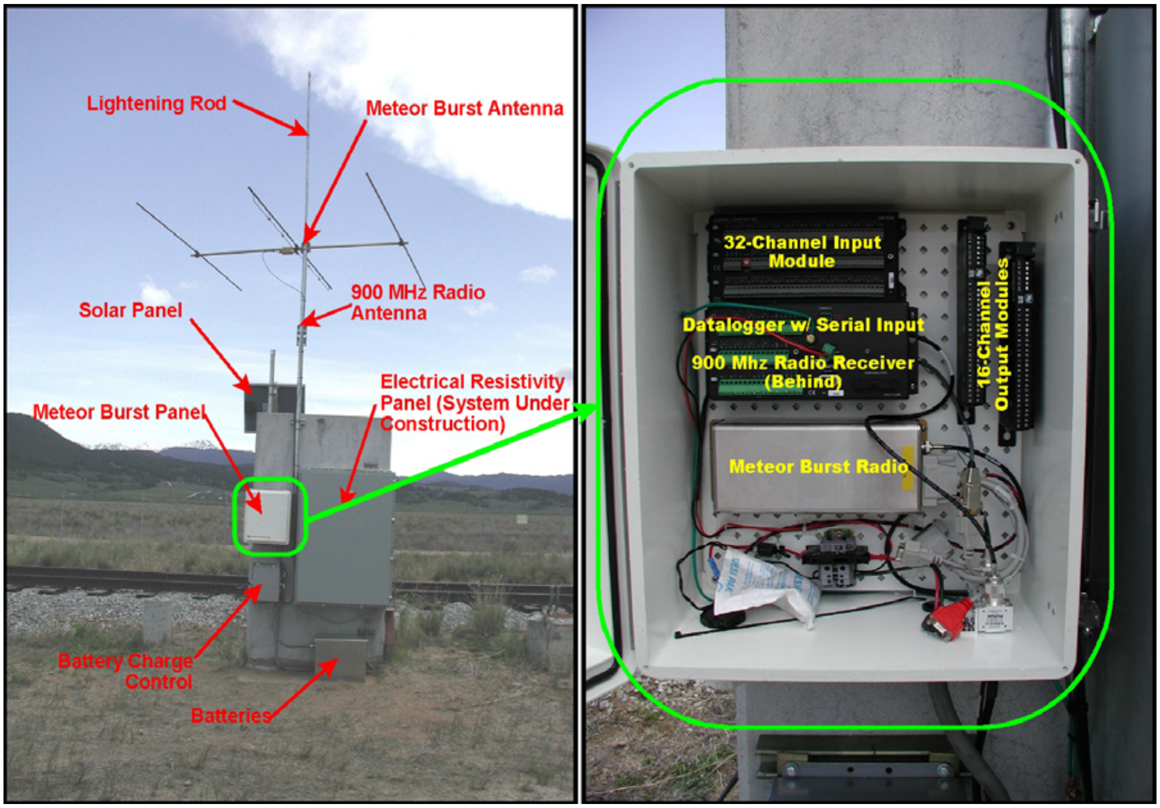

Fig. 2. Photo of master control station and Meteor Burst panel components

This equipment provides the primary datalogging and transmitting functions. The electrical resistivity panel is for an electrical resistivity system that MSE is currently designing for use with the meteor burst system. A close–up view of the meteor burst panel components is shown in Fig. 2.

Data from the sampling units are transmitted to the meteor burst panel via a 900-MHz telemetry system. Additional input and output channels were included in the design to accommodate the electrical resistivity system.

Remote Slave Units

Two remote slave units were installed as part of the initial remote monitoring system. A pressure transducer placed down a site monitoring well provided a data source for the slave units. Fig. 3 shows the setup for each of the slave units.

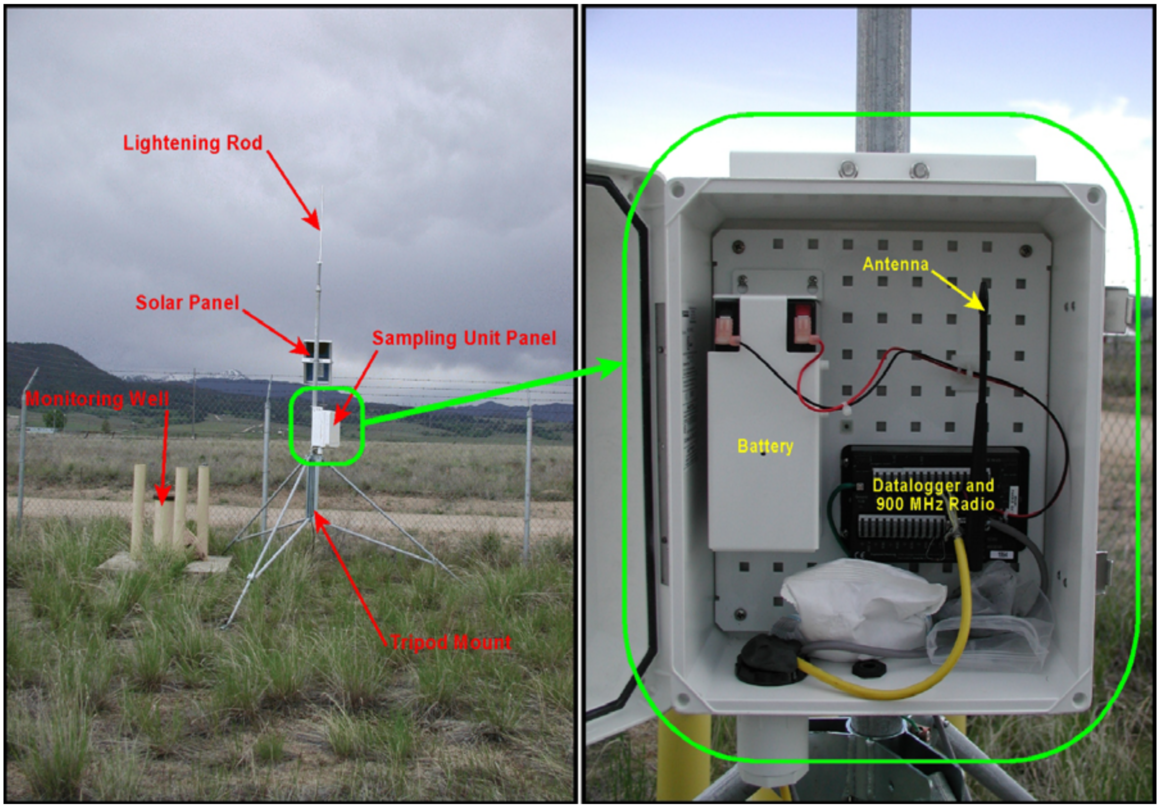

Fig. 3. Photo of remote slave unit and sampling unit panel components

The major components of the remote slave units included: a sampling unit panel; a solar panel; and a tripod mount. A close–up view of the sampling unit panel components is shown in Fig. 3. Data from the pressure transducers are acquired at the top of every hour and transmitted to the main control unit.

Electrical Resistivity Monitoring System

Electrical resistivity has been frequently used for characterization and monitoring of the subsurface. These methods can be an effective tool for long term monitoring of installations such as landfills and subsurface barriers because electrical resistivity methods can provide an early warning system; require a much lower sensor density than conventional methods assuming same level of coverage and information returned to users; and can be automated and results correlated with other types of monitoring data such as water levels. Electrical resistivity methods can provide spatially integrated measurements and be scaled to meet the monitoring objectives of most sites. However, existing electrical resistivity systems have several limitations, including: requiring large amounts of power to make measurements; expensive; automation requiring a computer that must be protected from adverse weather; and data transfer requiring infrastructure.

MSE designed a relatively simple resistivity system that works in conjunction with the meteor burst system. The system can be used to acquire both self-potential data and low frequency electrical resistivity data. This system is totally self-contained and does not rely on external supporting infrastructure at the site. It is solar/battery powered and has a 100-volt, 2-amp power supply. To reduce costs the resistivity system does not include extra features that are found in most commercially available electrical geophysical measurement systems. While these features are important for many applications; they are not necessary for a monitoring system. The MSE system is currently setup for 11 electrodes. With additional hardware costs, the system could be easily expanded to allow the desired number of electrodes. Additional meteor burst transmission costs may also be required depending on the number of additional channels.

DATA MANAGEMENT

Data acquired from the remote sampling locations and electrical resistivity system can be stored in the datalogger in the main control unit panel. The datalogger has some data processing capabilities. Multiple processing routines can be uploaded directly to the datalogger. The two-way communication between the ground station and the master control station allows for switching between these routines, if necessary. Data is stored at the main control unit the pre-defined transmission time is reached. At this time the system will search for a suitable, ionized trail(s) so that it can transmit the data to the ground station. Once received, data are then posted to the Internet. The data formatting is simple and can be accessed for further processing with little difficulty.

ACKNOWLEDGEMENTS

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