Watershed, Soil, and Air

Tech Tips

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Remote Telemetry System for Particulate Monitoring

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Over the past several years, the Missoula Technology and Development Center (MTDC) evaluated commercial real-time particulate instruments used to monitor smoke particulate concentrations from prescribed burns and wildland fires. The results of these evaluations are documented in three reports (figure 1): *Laboratory Evaluation of Two Optical Instruments for Real-Time Particulate Monitoring of Smoke* (9925–2806–MTDC), *Evaluation of Optical Instruments for Real-Time Continuous Monitoring of Smoke Particulates* (0025–2860–MTDC), and *Real-Time Smoke Particulate Sampling: Fire Storm 2000* (0125–2832–MTDC).

The U.S. Department of Agriculture, Forest Service, and the U.S. Department of the Interior, Bureau of Land Management have purchased several DataRams manufactured by Thermo-Andersen, Inc., to monitor real-time smoke particulate during prescribed and wildland fires. The Data-Rams have been deployed during a number of prescribed burns and wildland fires across the country. The first few deployments revealed problems in efficiently obtaining the real-time information. Although the instruments are designed to provide real-time information, someone had to personally view the instrument's display panel to learn the particulate concentrations or had to download stored information from the instrument to a personal computer or laptop for viewing later. This required someone to download the instruments on a regular basis (once a day, for example) or to periodically look at the DataRam screen to determine the reading. These methods had several problems, including:
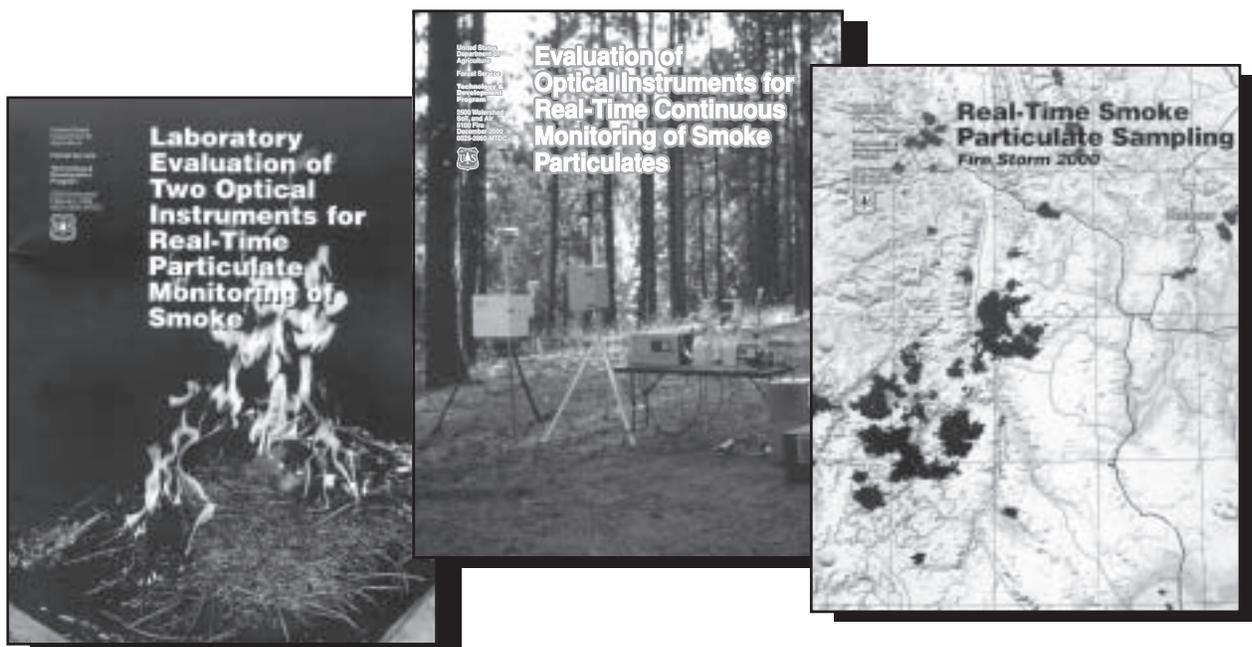

Figure 1—These reports document the evaluation of commercial instruments to measure smoke particulate in real time.

- Persons had to be trained to set up, monitor, and download the instruments.

- Laptop computers were required and had to be configured.

- Data were either a day old or were an instantaneous reading that may not have indicated the overall situation or trend.

- Downloading took time that could be used more productively for other purposes.

- Information was not easily accessible to other local, county, or State offices.

MTDC was asked to develop a system to remotely access the information from the DataRams, eliminating the need to physically download or access the data. Criteria for the remote telemetry system included:

- Telemetry equipment should be easy to set up and operate.

- The telemetry system should operate in all locations, including remote areas.

- The system should operate on line power or on a battery for at least as long as the DataRam operates on a battery (about 24 hours).

- The system should be relatively inexpensive.

- Data from the instrument should be accessible in real time.

- Data should be accessible to other agencies.
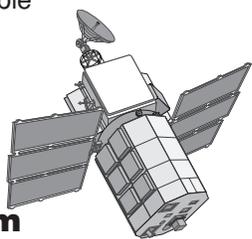
Telemetry System

MTDC investigated several different methods to remotely access the smoke monitoring information. These methods included using modems with standard phone lines, cellular phone modems, and satellite modems. Each of these methods has advantages and drawbacks. Modems using phone lines are the least expensive method, but limit the deployment sites to areas where a phone line is

present. This would prohibit locating the DataRam in areas away from buildings or phone lines. Cellular modems would eliminate the need for phone lines, but coverage is still limited to larger populated areas and may not exist in areas where the instruments will be located. Also, data transmission can be easily interrupted or lost. Satellite modems are more expensive than phone line equipment, but provide the best coverage. A DataRam could be located almost anywhere as long as the modem antenna has a relatively unobstructed view of the sky. Depending on the frequency and amount of data being sent, satellite transmission costs can be comparable to cellular phone costs.

Because the characteristics of the satellite modem best matched the established criteria, MTDC began working with Applied Digital Security, Inc. (ADSI), to develop a remote telemetry system for the DataRam. ADSI is a communications business located in Chula Vista, CA, that specializes in providing unique telemetry systems. They work with satellite, radio, and cellular services across the country to provide cost-effective solutions to individuals, businesses, and agencies.

ADSI, with the guidance of MTDC, has developed a self-contained telemetry system using the ORBCOMM satellite data transmission service to effectively transmit data from the DataRam. ADSI programmed the satellite modem to retrieve all the collected internal data from the DataRam (particulate concentration, time-weighted average concentration, internal temperature, relative humidity, and mean particle size). The data are averaged every 5 minutes and sent hourly from the modem to ADSI's Web server. A global positioning system (GPS) receiver relays the exact location of the instrument.

The AQD4-2000 Telemetry System

The original satellite telemetry system, model AQD4-2000, is housed in an environmentally protected briefcase (figure 2). All cables and the antenna are mounted in the briefcase for shipping. The AQD4-2000 uses a 3-foot-long antenna that is mounted on a magnetic base. An RS-232 cable serves as the interface between the Data-Ram and the AQD4-2000. The satellite modem, batteries, a battery charger, LED (light-emitting diode) indicator lights, and the GPS unit are mounted permanently inside the case.

Figure 2—A DataRam particulate monitor and the AQD4-2000 remote telemetry system.

Figure 3—The AQD4-2000 MK II telemetry system.

The AQD4-2000 is simple to operate. Connect the RS-232 cable to the back of the DataRam and to the connector mounted on the briefcase. Screw the antenna into its magnetic base and attach the antenna cable to the connector on the briefcase. Attach the power cord to 110-volt power. Start a run on the DataRam and turn on the telemetry unit by pressing the on/off switch.

Three LEDs inside the system serve as status indicators and help troubleshoot problems. The top LED indicates power is supplied to the modem. This LED illuminates shortly after the unit has been turned on. The middle LED indicates that the unit is communicating with the DataRam. The bottom LED indicates that the unit is communicating with the satellites. It should illuminate within a few minutes after the unit has been turned on—if it does not, move the antenna.

The AQD4-2000 MK II Telemetry System

The original AQD4-2000 system was upgraded to the MK II system (figure 3), which has several enhancements. The size of the case has been reduced from 18.5 by 14 by 6.5 inches to 13.5 by 12 by 6 inches. The weight has been reduced by nearly 10 pounds, to about 16 pounds. The antenna was replaced with a multipiece unit that screws together (figure 4). A faceplate was installed to

protect the internal components. The on/off switch and LEDs are mounted on the faceplate (figure 5). An RS-232 connector for troubleshooting the modem is also mounted on the faceplate. The MK II system operates similarly to the AQD4-2000 that it replaces. The AQD4-2000 MK II costs about $2,000.
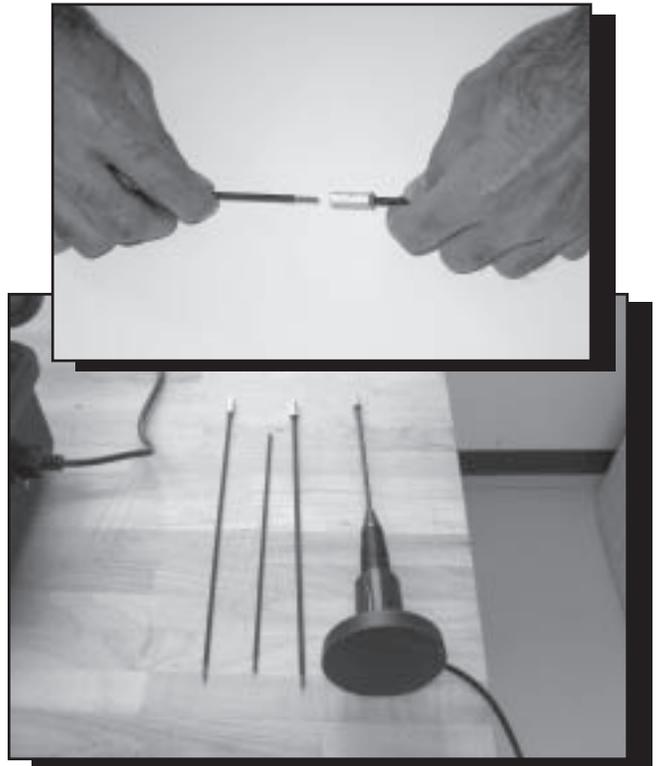
Figure 4—Assembling the AQD4-2000 MK II antenna.

Figure 5—Faceplate of the AQD4-2000 MKII system.

Web Site

All data sent from the units through the satellite telemetry units are posted (figure 6) on the Internet at the address: *http://www.satguard.com/usfs/*. The home page shows a map of the United States with green or red dots. The dots indicate the last reporting location of a unit. Green means the units are operating. Red means they are not. The map can be expanded (zoomed) twice by clicking on the approximate area of the map for finer details. All the units are listed in a frame to the left of the map. Specific information may be viewed by selecting individual unit numbers either on the map or the list. This information includes:

• Current and past particulate concentrations, internal temperatures, and internal relative humidities in tabular and graphical formats (figure 7). Data in the tables can be easily copied and pasted into a spreadsheet application for analysis.

• Graphical and tabular representations of the 1-, 8-, and 24-hour running averages for the most recent day (figure 8).

• An application and a chart for converting times from Greenwich Mean Time to United States time zones.

• Chart showing the telemetry system voltage (for troubleshooting).

• Location using the GPS location and an Internet mapping site to show the precise location of each unit.

Figure 6—Main home page of the telemetry Web site for Forest Service DataRams. The DataRam units are listed on the left while the deployment location is shown on the map.

Concentration (ug/m3)   **Unit: USFS 24**

Figure 7—Graphs show the current particulate concentration, temperature, and relative humidity. The data are also available in tabular form.

Concentration (µg/m³)
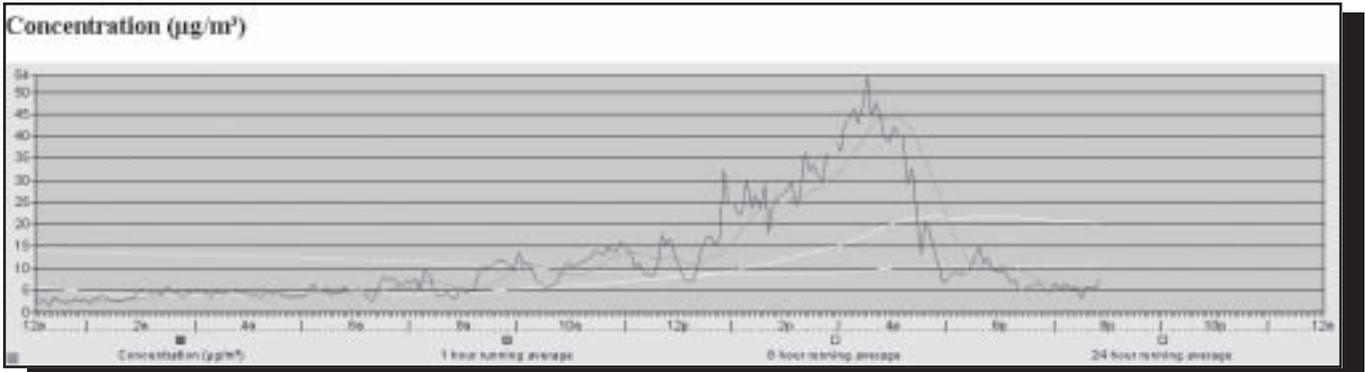
Figure 8—Running averages are shown in graphical form.

Conclusions

The AQD4-2000 MK II remote telemetry system is a compact package that allows convenient, real-time access to particulate concentrations estimated by the DataRam. The system is easy to set up and sends data by satellite transmission to a Web server. Here, the data can be viewed and accessed in tabular and graphical form. A GPS device is used to relay the precise location of the instrument. A mapping feature is used on the Web site to graphically show the location. The Web site also shows running averages of particulate concentrations as well as the current voltage of the telemetry system. The AQD4-2000 MK II hardware package includes all the cables, the antenna, and the batteries needed to operate the DataRam. All the electronics are housed in a briefcase that protects them from water and dust. LEDs indicate the modem has power, satellites are in view, and that the DataRam and the telemetry system are communicating.

About the Author

Andy Trent is a Project Engineer at MTDC. He received his bachelor's degree in mechanical engineering from Montana State University in 1989. Before coming to MTDC in 1996, Andy worked as a civilian engineer for the Department of the Navy. Andy works on projects in the nurseries and reforestation; forest health protection; and watershed, soil, and air programs.

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