Advanced Monitoring Systems Initiative Project Achievements for Environmental Restoration and Waste Management

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ABSTRACT

The Advanced Monitoring Systems Initiative (AMSI) project has been in existence since 2002. In this short time period, AMSI has successfully developed, tested and/or demonstrated over 30 advanced sensors and monitoring systems for applications in environmental restoration, waste management and other areas of national interest.

This presentation summarizes the AMSI project, and gives examples of recent successes. The purpose of the presentation is to make Symposium attendees aware of AMSI's capabilities and experience, for possible use in the future. Example successes include the following:

- Automated hexavalent chromium (Cr(VI)) monitoring in wells alongside the Columbia River
- Atmospheric chemical sensor array for remote, real-time plume tracking
- Wireless sensor platform for long-term monitoring of subsurface moisture
- Embedded piezoresistive microcantilever (EPM) units for carbon tetrachloride (CCl_4) and hydrogen cyanide (HCN) detection
- "iHistorian" for efficient, real-time data management of chemical releases.

INTRODUCTION

The AMSI project is located at the National Nuclear Security Administration Nevada Site Office (NNSA/NSO). It is managed by the NNSA/NSO Management and Operations Contractor, Bechtel Nevada (BN). The project began in 2002 as a NNSA/NSO funded proof of concept within the Environmental Management program. In subsequent years, funding has been received through Department of Energy (DOE) Headquarters.

AMSI's goal is to bridge the gap, often called the "valley of death", between end-users needing innovative solutions to sensing and monitoring problems, and technology developers who are working to address the needs. AMSI achieves its goals through one or more of the following activities:

- Working with end-users to define their sensing and monitoring system needs
- Facilitating interactions between end-users and system developers
- Providing engineering support in areas such as packaging, electronics and communications

- Testing and demonstration, both bench-scale and full-scale in the field at locations such as the Nevada Test Site (NTS) and Hanford
- Evaluation of results, including assisting users and developers in evaluating results
- Developing test data into information products for end-users.

RECENT SUCCESSES

Recent AMSI successes are presented in the poster presentation. Summarized below are examples of technologies that have been recently developed and demonstrated by AMSI and are operating in the field. The examples show the breadth of AMSI's involvement in innovative sensors and monitoring systems.

Automated Hexavalent Chromium Monitoring in the Columbia River

Burge Environmental, Inc. was contracted to design, fabricate and test a field-deployable Cr(VI) monitoring system for monitoring shallow groundwater wells along the Columbia River, Hanford Site, Washington. End-user concern is the impact of Cr(VI) from Hanford on salmon spawning beds. This Department of Energy contract was administered by the AMSI project.

Preliminary testing of the system was performed at the NTS prior to deployment at the Columbia River. The system was tested at the NTS in December 2003 and March 2004. Experiments were conducted with the system in the laboratory and in the field. Some experiments were conducted using water collected from shallow ground-water wells at the Hanford Site.

The Cr(VI) system was then deployed on the southern bank of the Columbia River in the salmon spawning beds adjacent to the N-Reactor at the Hanford site in July 2004. The system is located at Site 100D along the Columbia River. It is monitoring Cr(VI) concentrations from depths of 1.7 and 4.5 meters below the gravel surface of the Columbia River. The system was deployed in July 2004 and remains in operation (October 2005).

The system includes two detectors: Cr(VI) and conductivity. The analytical systems are designed to be "plug and play" components in the monitoring system. Hexavalent chromium is analyzed using a colorimetric method (diphenylcarbazide). The analytical system is fully automated and is capable of remotely analyzing the samples and standards.

A schematic of the monitoring system is shown in Figure 1. It incorporates the "plug and play" analytical systems. The monitoring system includes the sampling, standard preparation, control, power and communication components for supporting the analytical systems. The monitoring system is capable of sampling up to ten different locations, analyzing the samples, calibrating the analytical systems, and transmitting the data to a user by telemetry. The system is powered by solar cells. The system performs over 300 analyses before maintenance is required. The current system requires 20 minutes of maintenance every 5 to 6 months.

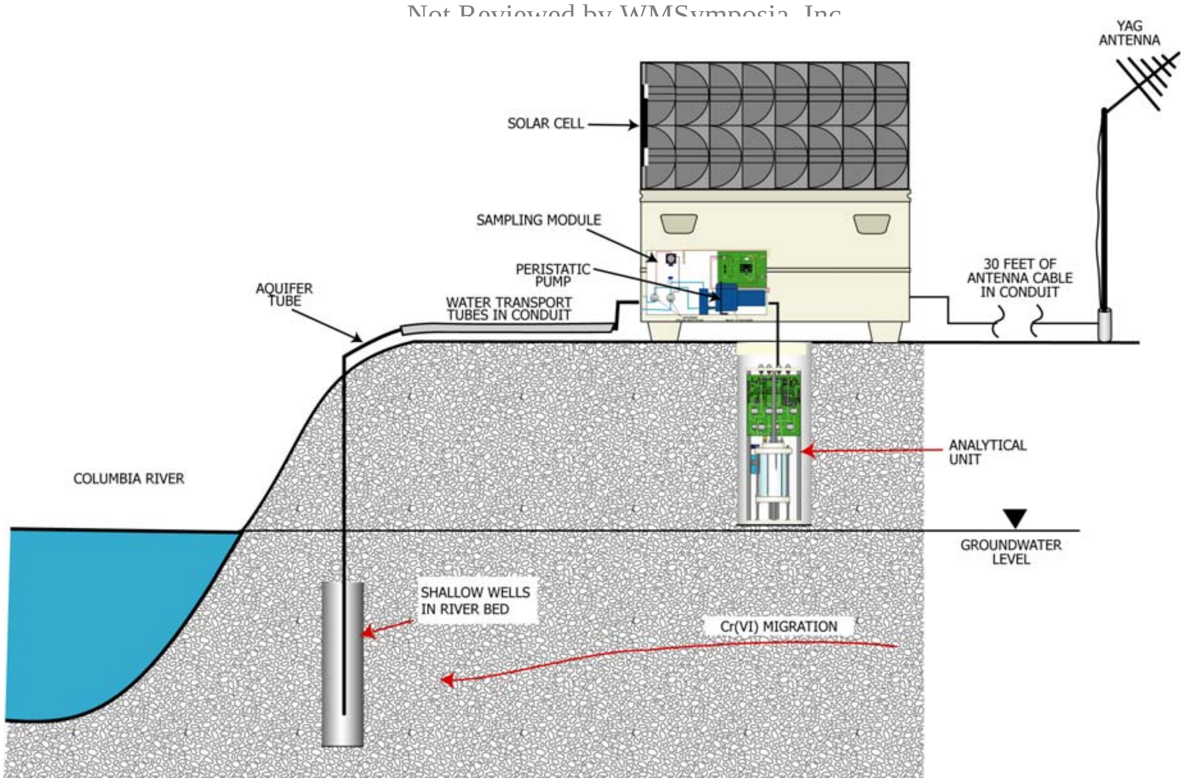

Fig. 1. Schematic of monitoring system

The monitoring system is capable of preparing standards for a continuing quality control check. A mid-calibration check standard (60 ppb) is analyzed with each batch of samples.

The current Cr(VI) monitoring system may be interfaced with several "plug and play" analytical systems including carbon tetrachloride, trichloroethene, and trinitrotoluene (TNT). Future directions include the development of "plug and play" radiological detectors for monitoring 90Sr and 99Tc.[1]

Atmospheric Chemical Sensor Array

This project, funded by AMSI and other governmental sources, developed chemical sensor array systems, and implemented them as new mobile field diagnostic and support capabilities at the NTS for Test & Evaluation campaigns. The system enhances ground truth diagnostic capabilities for customers at NTS, and also serves as a platform to expedite fielding and rapid prototyping of new sensor technologies (e.g., microcantilevers).

Real-time chemical monitoring field-deployable system development is continually required to maintain the United States' technological advantage in national security operations, as well as for efficiently monitoring and remediating DOE sites. Development and expansion of chemical monitoring capabilities at NTS supports and attracts customers.

1 Burge Environmental, *Automated Monitoring of Hexavalent Chromium along the River Corridor, Hanford Site, Washington, 2005*

The initial AMSI activity leveraged funding from other governmental programs, and resulted in the development and implementation of new mobile diagnostics capabilities for the Chemical Biological Test and Evaluation Program at NTS. This project modified existing BN-developed data telemetry and control software to support an array of field-deployed real-time photoionization detector (PID) chemical sensors for plume diagnostics (Fig. 2).

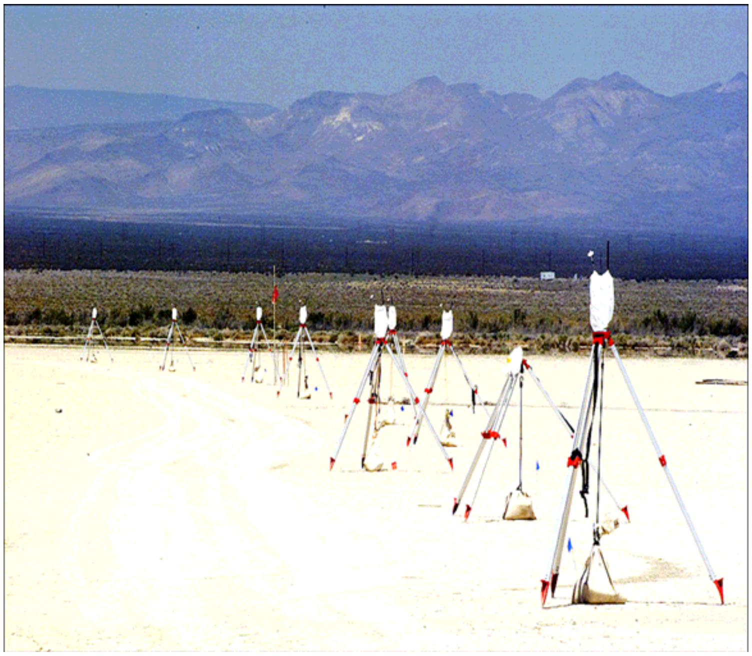

Fig. 2. Portion of PID array located downwind from stack at the NTS

The mobile, field deployable array of PIDs measures atmospheric chemicals down to the parts-per-billion volume range (ppbv). During test campaigns, the operations platform controlled the commercial PID chemical sensors in remotely deployed arrays containing up to 22 sensors.

The test campaign successfully demonstrated the ability to provide sensitive, accurate diagnostics in remote areas without supporting infrastructure. These capabilities can be used both on and off the NTS and provide an important new capability to the nonproliferation and other communities. Chemical sensors were successfully deployed remotely, up to two miles from the command trailer. These sensors were successfully operated and monitored using the operations software from a mobile trailer. Data from the PID point sensors were used to estimate plume dilution factors and plume diameters.

The project recently improved remote operations capabilities of the PID array; enhanced real-time data displays; increased the number of array units to >50; utilized the solar enclosures for deployments; and incorporated global positioning system units. Remote operation from the Special Technologies Laboratory (STL) in Santa Barbara, California was demonstrated numerous times throughout the 2005 testing. Remote operation capability significantly reduces labor and travel costs.

The Situational Operations Management software platform used on this project can be used in other monitoring applications, including groundwater or vadose zone monitoring by installing appropriate sensors.

Wireless Sensor Platform

AMSI is providing supplemental funding to the development, at the Idaho National Laboratory (INL), of a wireless, battery-less sensor platform. The platform is a passive system that requires no onboard power, but instead relies on energy storage in a capacitor, an induction system for charging the capacitor and wireless communication for sensor operation, data collection and data transmittal.

The platform is initially configured for long-term subsurface moisture monitoring applied to waste landfill covers. A wireless system has the advantages that there are no penetrations of the cover, there are no wires to be damaged by equipment, and there are no wires that can break because of landfill subsidence.

The initial platform configuration was tested at the NTS, and is being upgraded to add more sensors. Recent activities also include the assembly and use of a pressure plate extractor system to calibrate the new heat dissipation water potential sensors that have been integrated into the wireless sensor platform

The sensor packages being calibrated are pictured in Fig. 3. Each package contains temperature, volumetric water, and matrix water potential sensors.

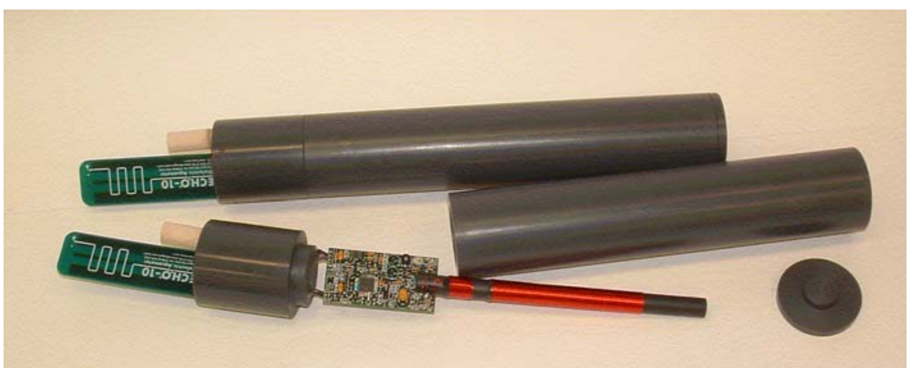

Fig. 3**.** Sensor Packages with INL platform and integrated volumetric water, water potential, and temperature sensors

Several sets of sensor packages have been run through the calibration process and the data is now being compiled to generate a calibration curve. The sensor packages and corresponding calibration data will be sent to Nevada Test Site personnel for field- testing.

INL also incorporated commercial off the shelf (COTS) LabView® programming into the system to: periodically activate the platforms via an external reader; power different sensors; and collect data.[2]

2 Idaho National Laboratory, Dennis Kunerth, *INL Wireless Sensor Platform, 2005*

Embedded Piezoresistive Microcantilever Sensors

The AMSI project is funding development of EPM units at Northern Arizona University (NAU). A unit configured for measuring CCl_4 in water and including temperature compensation was recently tested at the NTS.[3] After immersing the test unit in water, CCl_4 was introduced into the water. The EPM detected the CCl_4 after a few seconds, and reached equilibrium in a minute or so. Data were easily acquired via a laptop computer. This technology has potential application at the Hanford Site in their Underground Water Monitoring project.

Another AMSI project with NAU involves developing EMP units for HCN gas measurements in the atmosphere.

iHistorian for Efficient, Real-time Data Management

This AMSI data management project is a combination of current analytic processes, COTS software and on-site developed Visual Studio .net (VS .net) software. iHistorian transforms a labor and time intensive process into a automatic system to deliver analyzed data to the customer on an almost real-time basis.

Figure 4 shows a diagram of the iHistorian process as applied at the NTS Nonproliferation Test and Evaluation Complex (NPTEC) for testing STL Fourier Transform Infrared (FTIR) sensors.

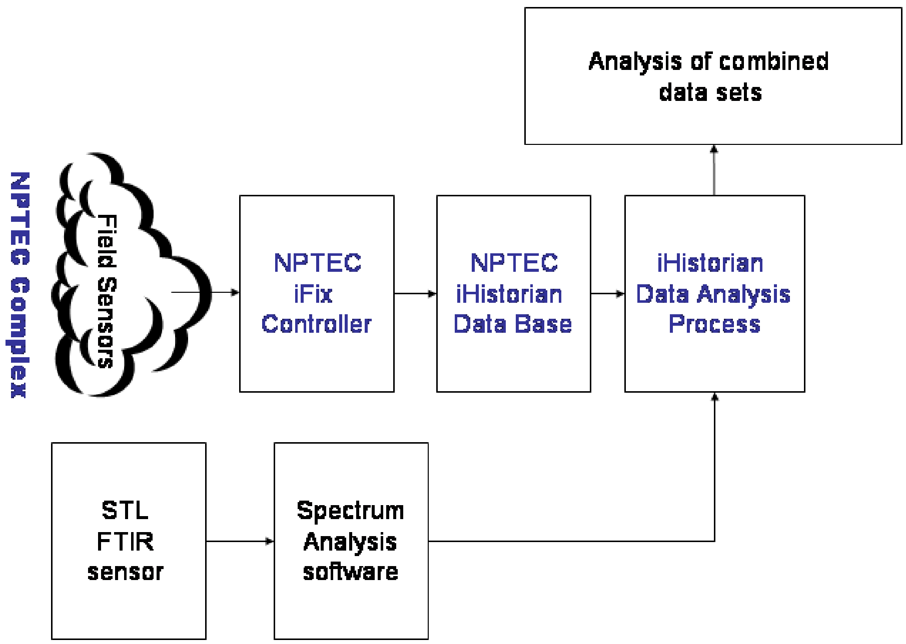

Fig. 4. iHistorian system schematic

The initial use of iHistorian at NPTEC demonstrated that the criteria of delivering analysis of combined data sets timely, through an automated process, with common data repository and reusable code, and with remote access and remote processing were accomplished.

3 Northern Arizona University, *Embedded Pierzoresistive Microcantilever Sensor, Carbon Tetrachloride, 2005*

CONCLUSION

Since the project began in 2002, the AMSI project has demonstrated the ability and capability to quickly and efficiently develop and deploy advanced sensors and monitoring systems to meet complex-wide end-user needs. The project continues to seek new systems and technologies through cooperation with other Department of Energy Sites, contractors, Universities, and Programs. All new technologies developed and sponsored by AMSI are available to other end-users.