GA-C22131(3Q/96)

E-SMART SYSTEM FOR IN-SITU DETECTION OF ENVIRONMENTAL CONTAMINANTS

QUARTERLY TECHNICAL PROGRESS REPORT

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GENERAL ATOMICS PROJECT 3719/4450
October 1996

GENERAL ATOMICS

DISCLAIMER

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Abstract

General Atomics (GA) leads a team of industrial, academic, and government organizations to develop the Environmental Systems Management, Analysis and Reporting neTwork (E-SMART) for the Defense Advanced Research Project Agency (DARPA), by way of this Technology Reinvestment Project (TRP). E-SMART defines a standard by which networks of smart sensing, sampling, and control devices can interoperate. E-SMART is intended to be an open standard, available to any equipment manufacturer. The user will be provided a standard platform on which a site-specific monitoring plan can be implemented using sensors and actuators from various manufacturers and upgraded as new monitoring devices become commercially available. GA's team members include Isco, Inc., Photonic Sensor Systems (PSS), Georgia Tech Research Institute (GTRI), Science & Engineering Analysis Corporation (SECOR), and the U.S. Air Force Armstrong Laboratory Environics Directorate at Tyndall AFB(AL).

This DARPA TRP project will further develop and advance the E-SMART standardized network protocol to include new sensors, sampling systems, and graphical user interfaces. Specifically, the E-SMART team will develop the following three system elements:

A new class of smart, highly sensitive, chemically-specific, in-situ, multichannel microsensors utilizing integrated optical interferometry technology,

A set of additional E-SMART-compatible sensors and samplers adapted from commercial off-the-shelf technologies, and

A Data Management and Analysis System (DMAS), including network management components and a user-friendly graphical user interface (GUI) for data evaluation and visualization.

In addition, the E-SMART TRP team has signed Articles of Collaboration with another DARPA TRP awardee, Sawtek, to develop an E-SMART-compatible Intelligent Modular Array System (IMAS) for monitoring volatile organic chemicals (VOC's) in the environment. This collaboration will simplify the network development required to field the IMAS sensor, and will encourage the adoption of the E-SMART standard by increasing the number of commercially available E-SMART sensors.

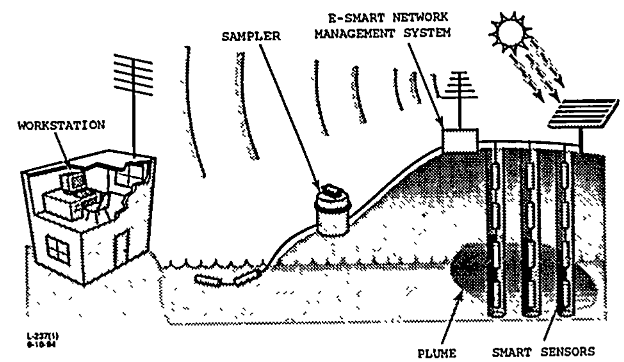
Figure 1 summarizes the vision and goals of the E-SMART TRP project.

E-SMART ARPA TRP

TEAM

General Atomics
Isco, Inc.
Photonic Sensor Systems, Inc.
Georgia Tech Research Institute
SECOR
Environics Directorate, Tyndall AFB

VISION



OBJECTIVES

Develop and promote E-SMART, an open standard for networking smart sensors at environmental sites. Prepare an initial set of E-SMART-compatible devices, including:

- A new class of smart, in situ, chemically-specific multichannel microsensors utilizing integrated optical interferometry technology.
- Sensors and field measurement equipment, based upon commercial off-the-shelf technology, and adapted for E-SMART networks.
- A data management and analysis system (DMAS), including a graphical user interface for data evaluation, data visualization, and network management.

SCHEDULE

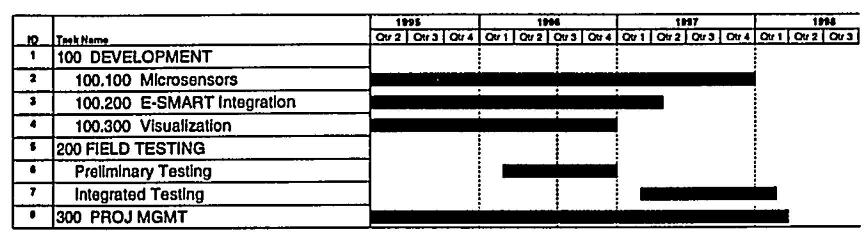


Fig. 1. Quad Chart Summarizing the E-SMART Project

Executive Summary

Program Management

- Isco, PSS/GTRI, and SECOR project management approved their subcontract modifications.
- A cost sharing issue has arisen for PSS/GTRI that needs to be resolved.

Multichannel Microsensor

- Microsensor development activities conducted by PSS/GTRI focused on improvements to the mechanical design and optimization of the integrated optic sensing chip, evaluation of polymer coatings for use with the interferometric sensor, development of the microsensor signal processing specification, and detailed design and start of fabrication of a preliminary E-SMART microsensor built in a cone penetrometer format.

Sawtek Integrated Modular Array Sensor (IMAS)

- Perkin-Elmer has been added to the IMAS TRP team as a commercialization partner upon the recommendation of Sawtek. Sawtek was invited to the E-SMART TRP Team Node Specification Review Meeting. Sawtek was also invited to the E-SMART Field Test Demonstration Site Meeting at Tinker AFB.

Other Sensors and Actuators

- Temperature, pressure, and gas calibration facilities were prepared for the E-SMART development laboratory at GA.
- Testing continued and calibration started of off-the-shelf liquid level/barometric pressure, oxygen, and hydrocarbon sensors this quarter, for the Tinker AFB demonstration.
- Eleven E-SMART sensor nodes were constructed for the initial Tinker AFB.
- Six liquid level/barometric pressure and two oxygen sensors were calibrated, along with characterization of one hydrocarbon/MOS sensor for the field demonstration.
- The initial set of nine sensors was installed at the Tinker AFB demonstration test site the week of 9/9/96.
- Twelve sensors (8 liquid level/barometric pressure, 2 oxygen, and 2 hydrocarbon/MOS) were fabricated for the second installation at the field site.

E-SMART Network Management

- Development was performed on the next version of Network Management Software that will be deployed at Tinker AFB, October 1996.
- Development of the E-SMART graphical user interface (GUI) continued. Efforts focused on construction of software objects that comprise the GUI screens.
- Incorporation of an object-oriented approach to networking continued. Thus far, the *Network Services Server* (NSS) has been successfully implemented, allowing E-SMART nodes to be installed on and to communicate data across the network.
- A browser technology was identified to access E-SMART data on the World Wide Web. Options were evaluated to determine the best approach for providing remote access to E-SMART data generated from testing at environmental sites, such as Tinker AFB.
- Alternatives for E-SMART Internet connections are continuing to be evaluated.

- Instrumentation & Control Systems, September 1996 issue, featured an article written by Echelon Corporation describing the E-SMART, Environmental Systems Management, Analysis, and Reporting neTwork.

E-SMART Field Testing

- The draft test plan for the E-SMART prototype environmental monitoring system at Tinker Air Force Base was issued and distributed to OC/ALC for review.
- All formal contracting and subcontracting for the Tinker AFB demonstration project was completed.
- The program plan for the E-SMART prototype environmental monitoring system at Tinker AFB was completed.
- A mobile office trailer was installed at Tinker AFB to serve as the environmentally-controlled portable structure for the E-SMART Data Management and Analysis System.
- A formal project kick-off meeting for the Tinker AFB field test was held on September 9th at the OC-ALC/EMR office.
- The Phase I E-SMART network at the SWTA at Tinker AFB was installed.
- Preliminary E-SMART barometric pressure, hydrocarbon, and oxygen sensor data was obtained from the Tinker AFB field test.

Dual Use and Commercialization

- Interactions with Biode, Inc. continued for development of an E-SMART compatible Hg sensor.
- The Naval Surface Warfare Center (NSWC) provided interest in applying E-SMART systems in their Smart Ship Program and other programs.
- PSS/GTRI received an award for a Phase II STTR proposal for development of an E-SMART-compatible Integrated Optic Sensor for Cone Penetrometers. The scope of this work is consistent with the TRP Project.

1. Work Conducted July - September, 1996

1.1 Multichannel Microsensor (PSS/GTRI)

During the quarter, microsensor development activities conducted by PSS/GTRI focused on (a) improvements to the mechanical design and optimization of the integrated optic sensing chip, (b) evaluation of polymer coatings for use with the interferometric sensor, (c) development of the microsensor signal processing specification, and (d) detailed design and start of fabrication of a preliminary E-SMART microsensor built in a cone penetrometer format.

1.1.1 Integrated Sensor Chip Fabrication

The preliminary design of an optical head configuration suitable for incorporation into a 1.5 inch diameter or smaller housing has been completed. The mechanical design simplifies previous designs and permits inclusion of all elements including diode laser and detector electronics. Optimization of the integrated optic sensing chip is continuing in three areas: 1) development of a more reproducible fabrication procedure for the Fresnel beam splitter, 2) development of blazed gratings for higher input/output coupling efficiency, and 3) development of alternatives to the "lift-off" etch used to create the sensing region.

1.1.2 Polymeric Coatings for BTEX Compound Detection

The screening and evaluation of selected polymeric coatings for use with the integrated optic interferometric sensor continued during this reporting period. The screening process is based on a list of approximately 60 polymers identified in the previous quarterly report. The initial screening consists of a quick evaluation of both response and discrimination capability when exposed to BTEX and selected interferant species. A standard interferant species list developed by the E-SMART team was also reported in the previous quarterly report. Those polymers showing good sensitivity or discrimination ability are being subjected to more rigorous characterization using this list. For all screening and testing a standard waveguide test bed based on a fused silica (SiO_2) substrate overcoated with a 140 nanometer (nm) silicon nitride (Si_3N_4) waveguide film and a 40 nm fused silica film was used. The 40 nm fused silica layer serves to provide different chemistries for attaching chemically active films to the waveguide surface. For test measurements, water samples saturated with the organic species of interest were diluted to appropriate concentrations and flowed over the polymer coated waveguide surface.

Forty two polymers have been evaluated, and from those tested seven appear to be promising as candidate coatings based on response and/or discrimination ability. Polymers identified for more rigorous evaluation include the following:

poly butyl/isobutyl methacrylate - PBIBMA	basis	BTEX response interferant response
poly α-methyl styrene - PAMS	basis	BTEX response
ethyl cellulose - EC	basis	BTEX response
poly ethylene vinyl acetate - PEVA	basis	BTEX response
2,6-dimethyl-p-phenyl oxide	basis	chlorinated response
polyamide resin	basis	chlorinated response
Teflon AF™ - TAF	basis	BTEX response

Several polymers including poly butyl/isobutyl methacrylate (PBIBMA) and Teflon AF (TAF) exhibited strong, relatively fast responses to both BTEX and chlorinated solvents. Polymers such as poly(diphenyl-p-oxide) and polyamide resin showed fast responses to chlorinated solvents, but no response to the BTEX molecules. This is believed to be a direct result of size exclusion; the smaller chlorinated solvents (CH_2CL_2, $CHCL_3$, TCE) can fit between the polymer chains, while the larger aromatic hydrocarbons (benzene, toluene and xylene) can not. These polymers provide a chemical method to discriminate BTEX from chlorinated solvents which are expected to be significant interferants to BTEX detection.

In the course of more rigorous testing, PBIBMA was tested against the standard interferant species list. Exposure to tritane, naphthalene, humic acid, ethylene glycol and sodium dodecyl sulfate gave no response, as a size-exclusion mechanism would predict. Phenol and methyl ketone gave response on the order of 0.01 of that for toluene. Small signals were observed for high concentrations of sodium nitrate (0.1M) and sodium chloride (0.1M). Thus, it appears that the only significant interferants for discriminating the BTEX chemicals using PBIBMA are the chlorinated solvents.

1.1.3 Development of Microsensor Signal Processing Specification

An outline of the microsensor signal processing specification was developed, and preliminary discussions were held with Isco, Inc. regarding the basic design approach and the division of responsibility for implementing the specification. The major unknown driving the specification continues to be identification of a suitable photodetector array. A Texas Instruments TSL401 linear diode array (128 elements, 50 µm pixel width, 62.5 µm pitch, 1.2 cm length, $6 unit price) has been purchased to evaluate its sensitivity and noise characteristics.

1.1.4 Evaluation of Preliminary E-SMART Microsensor Model

Work is continuing on a preliminary model of the E-SMART microsensor. This model is being built in a cone penetrometer format under a companion Small Business Technology Transfer (STTR) program. The detailed design of the model was completed and fabrication was begun on the mechanical components. Existing E-SMART electronics and software are in the process of being modified for use as a smart controller. Finally, setup of a soil test chamber and gas chromatograph that will be used to evaluate the model was completed. (Proof-of-principle experiments reported last quarter were conducted using a laboratory optical bench configuration.)

1.2 Sawtek Integrated Modular Array Sensor (IMAS)

Perkin-Elmer has been added to the IMAS TRP team as a commercialization partner upon the recommendation of Sawtek. Sawtek was invited to the E-SMART TRP Team E-SMART Node Specification Review Meeting 10/28/96. Sawtek was also invited to the E-SMART Field Test Demonstration Site Meeting 10/30/96, at Tinker AFB.

1.3 Other Sensors and Actuators (GA)

Temperature, pressure, and gas calibration facilities were prepared for the E-SMART development laboratory at GA. Testing continued and calibration started of off-the-shelf liquid level/barometric pressure, oxygen, and hydrocarbon sensors continued this quarter, for the Tinker AFB demonstration. Initial testing identified and corrected some sources of sensor variation. Some pressure sensor measurements achieve fit rms deviations on the order of .001 psi, meaning that the design goal of 0.1 in. resolution for liquid level may be achievable. The oxygen sensors have provided very good results. The hydrocarbon/MOS sensors exhibited some unexpected dependence on oxygen concentration, therefore the sensor characterization must take this into account.

Eleven E-SMART sensor nodes were constructed for the initial Tinker AFB installation. Six liquid level/barometric pressure and two oxygen sensors were calibrated for the field test. In addition, the behavior of one hydrocarbon/MOS sensor was characterized for vapor response. One oxygen sensor appeared to have a failed transducer, and one hydrocarbon/MOS sensor requires further evaluation. The initial set of nine sensors was installed at the Tinker AFB demonstration test site the week of 9/9/96.

Twelve sensors (8 liquid level/barometric pressure, 2 oxygen, and 2 hydrocarbon/MOS) were fabricated for the second installation at the field site.

1.4 E-SMART Network Management (GA)

E-SMART management software provides the ability to talk to nodes and to display data. The development of algorithms for characterizing each individual sensor for influence of temperature, pressure, and other environmental effects continued.

Development of the next version of Network Management Software that will be deployed at Tinker AFB, October 1996 took place.

Development of the E-SMART graphical user interface (GUI) continued. The Windows 95 GUI will allow users to install, configure, and access data from devices on the E-SMART network. Efforts focused on construction of software objects that comprise the GUI screens.

Incorporation of an object-oriented approach to networking continued. Network management software has been developed allowing E-SMART nodes to be installed on and to communicate data across the network. Bench-scale testing of the network using prototype E-SMART-compatible pressure sensors was conducted to evaluate network hardware and software, including network connections. These tests will continue throughout development of E-SMART network management.

A browser technology was identified to access E-SMART data on the World Wide Web. Alternative browser technologies are also being investigated.

An evaluation was carried out to determine the best approach for providing remote access to E-SMART data generated from testing at environmental sites, such as Tinker AFB. Remote access alternatives are: (1) use of a fiber optic cable to access site ethernet network, if present; (2) use a 10BaseT telephone line coupled with repeaters to link to site ethernet network, if present; (3) install an E-SMART-specific RF link to site RF network, if present; (4) use a dial-up modem for telephone-only or telephone/Internet communications.

Alternatives for E-SMART Internet connections are continuing to be evaluated. Currently dial-up capabilities exists. It appears that an ISDN line may be the most cost-effective means for Internet access.

The September 1996 issue of Instrumentation & Control Systems featured an article describing the E-SMART, Environmental Systems Management, Analysis, and Reporting neTwork. The article described E-SMART as an example of an Echelon LONWORKS Network Services (LNS) application. Details of how E-SMART utilizes LNS network configuration and management were discussed.

1.5 Field Testing

A draft test plan for the E-SMART prototype environmental monitoring system at Tinker Air Force Base was issued. The test plan describes the objectives, scope, and approach for the field test of the Environmental Systems Management and Analysis neTwork (E-SMART) at the Southwest Tank Area (SWTA) of Tinker AFB. The plan also defines the data requirements, sensor locations, test schedule, and health and safety considerations for the test.

The field test is sponsored in part by the Air Force Air Logistic Command in Oklahoma City, Oklahoma (OC-ALC) under contract number F34601-95-D-0374, Task Order 14, SDRL A025. The goal of the testing is to deploy an E-SMART network in the SWTA site, to evaluate system performance, and to identify opportunities for system improvements. The E-SMART network has a graphical user interface tailored to the SWTA site and allows OC-ALC Environmental Management & Restoration (EMR) Division personnel remote access to data from the site.

During the quarter, there were a number of major accomplishments for the Tinker AFB demonstration.

- Formal completion of all contracting and subcontracting for the demonstration project
- Completion of the "Program Plan for E-SMART Prototype Environmental Monitoring System at Tinker Air Force Base"
- Installation of a mobile office trailer to serve as the environmentally-controlled portable structure to house the E-SMART Data Management and Analysis System
- A formal project kick-off meeting for the Tinker AFB field test held on September 9th at the OC-ALC/EMR office.
- Distribution of the draft Tinker AFB demonstration test plan to OC-ALC for review
- Installation of the Phase I E-SMART network at the SWTA at Tinker AFB

E-SMART demonstration testing at the SWTA at Tinker AFB is divided into three phases, each with a different number of sensors deployed, and each augmenting the functionality of the previous phase. Phasing the deployment allows the E-SMART team to thoroughly evaluate the performance of individual components on the network incrementally, and to identify any changes in network performance as the system is scaled to a larger and more complex installation. One goal for the Tinker AFB demonstration is to have 20 E-SMART sensors networked at one time.

Mobilization of the E-SMART network at the Southwest Tank Area (SWTA) of the Building 3001 site at Tinker AFB was completed. This included (1) preparations at the SWTA site; (2) fabrication, characterization and calibration of the E-SMART sensors and network components; (3) shipment of all E-SMART components to Oklahoma City; and (4) installation of the Phase I network configuration at the SWTA. Installation of the network was begun on September 10th, and the network was monitored on-site until September 13th. During this time, six monitoring wells were fitted with E-SMART well caps and cables connecting them to the E-SMART Data Management and Analysis System (DMAS) housed in the trailer at the site.

Figure 2 shows E-SMART field workers performing installation of the Phase I sensors at the SWTA demonstration site. Figure 3 shows the completed deployment of the first set of nine sensors at the demonstration site. Figures 4 and 5 show side and top views, respectively, of the sensor assembly deployed in Well 1-99 at Tinker AFB. Figure 6 is a photograph of an E-SMART engineer checking the monitoring well interface of the sensor assembly deployed in Well 1-99. Figure 7 is a photograph of an E-SMART engineer reviewing data from the demonstration test in the field site trailer.

Sensors which measure oxygen, VOCs, water level, and barometric pressure were installed in four of the six monitoring wells that were fitted with E-SMART well caps. The configuration of the monitoring wells is summarized in Table 1.

As shown in Table 1, two barometric pressure sensors have been installed in two different wells at the SWTA (Monitoring Wells I-99 and I-116). Some preliminary data from these sensors is provided in Figure 8. These data indicate that the pressure readings correlate well with one another. (Slight variations in the rate of response are believed to be due to differences in the amount of sealing provided by the respective wells caps.) These readings also correlate well with information from the National Weather Service. On the day the measurements shown in Figure 8 were taken, the weather service quoted a barometric pressure in the Oklahoma City area of 30" Hg which is equivalent to 14.7 psia. However, the Weather Service corrects atmospheric pressure for elevation to adjust its measurements to mean sea level (MSL). When the 1300 ft elevation of the SWTA site is accounted for, the equivalent MSL pressure at the site is 14.0 which agrees with the E-SMART sensor readings.

Readings from the VOC and oxygen sensors in the vadose zone of the wells vary throughout the day (Figure 9). Although the plot shows A/D counts, when converted to equivalent-ethane the VOC concentrations range from almost zero to a concentration indicative of free product in the well. Figure 9 shows the value of continuous in situ monitoring to help fully understand the variations in soil gas concentration over time.

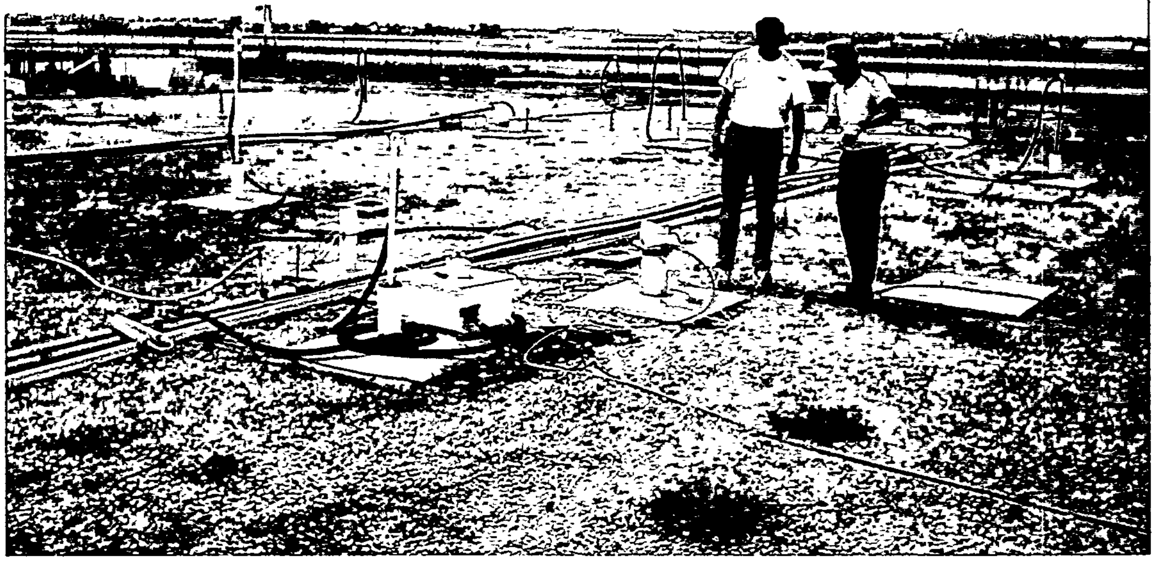


Fig. 2. Field Workers Performing First Installation of
E-SMART Sensors for Tinker AFB Demonstration.

Fig. 3. Completed Deployment of First Nine E-SMART Sensors at Tinker AFB.
E-SMART Trailer Housing Data Management and Analysis System in Background.

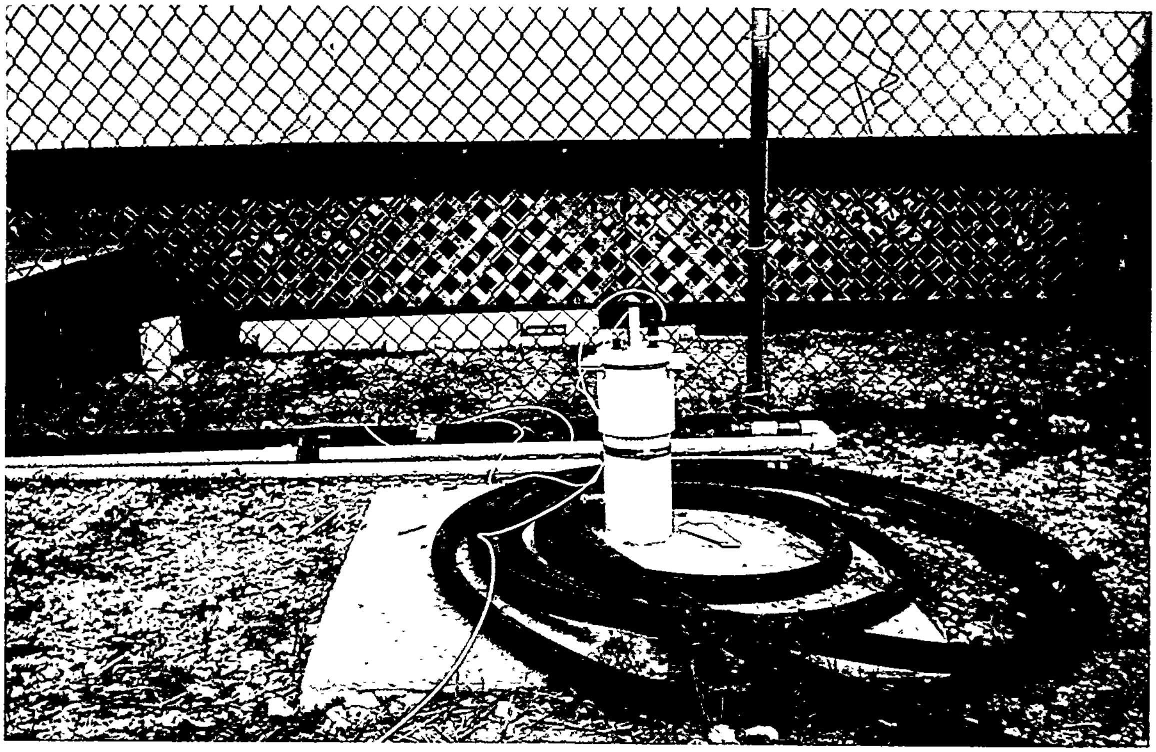


Fig. 4. Side View of Top of Monitoring Well 1-99 with E-SMART Sensor Assembly and Monitoring Well Interface (Well Cap) Deployed at Tinker AFB Demonstration Site.

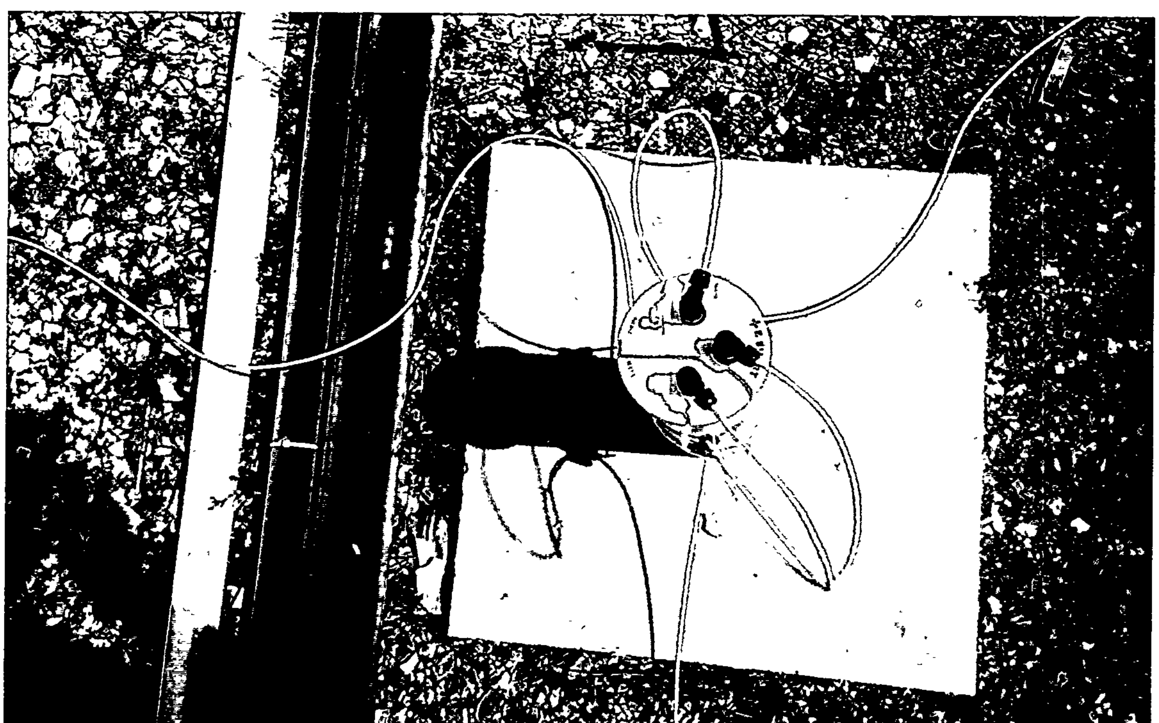


Fig. 5. Top View of Well 1-99 E-SMART Sensor Assembly Focusing on Well Cap.

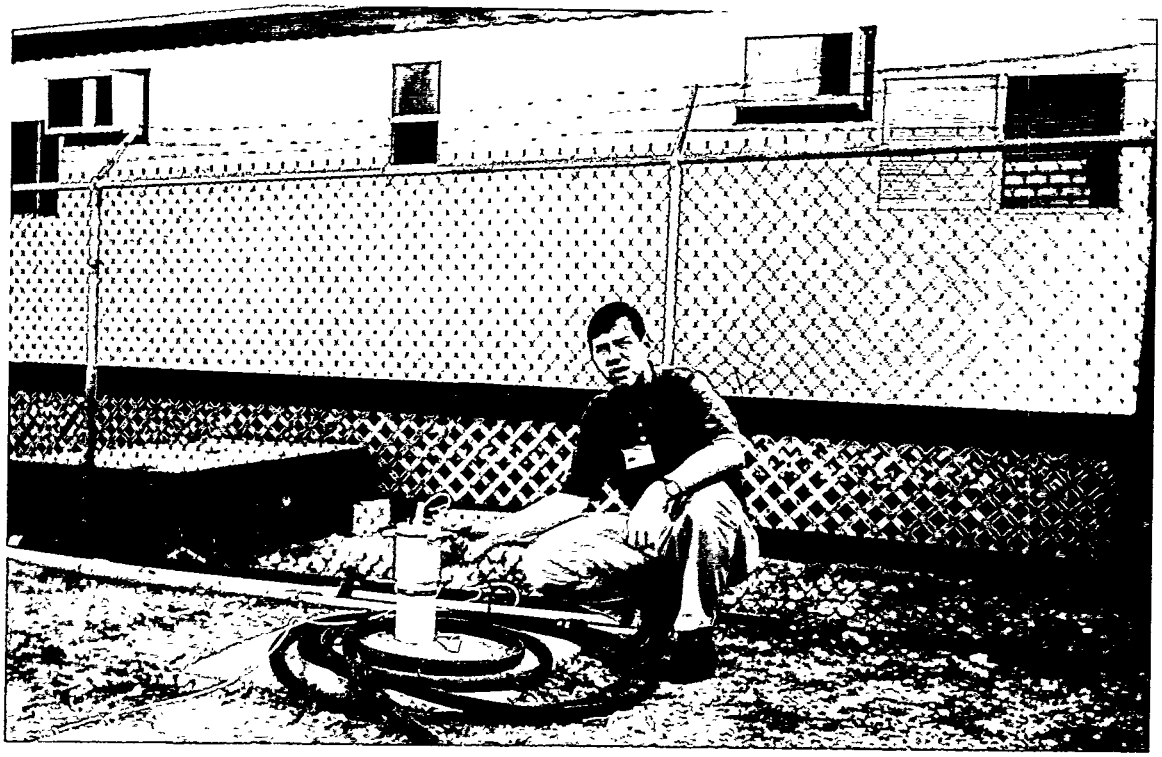


Fig. 6. E-SMART Engineer Checking Sensor Monitoring Well Interface (Well Cap) for Well 1-99 Deployed at Tinker AFB Field Test Site.

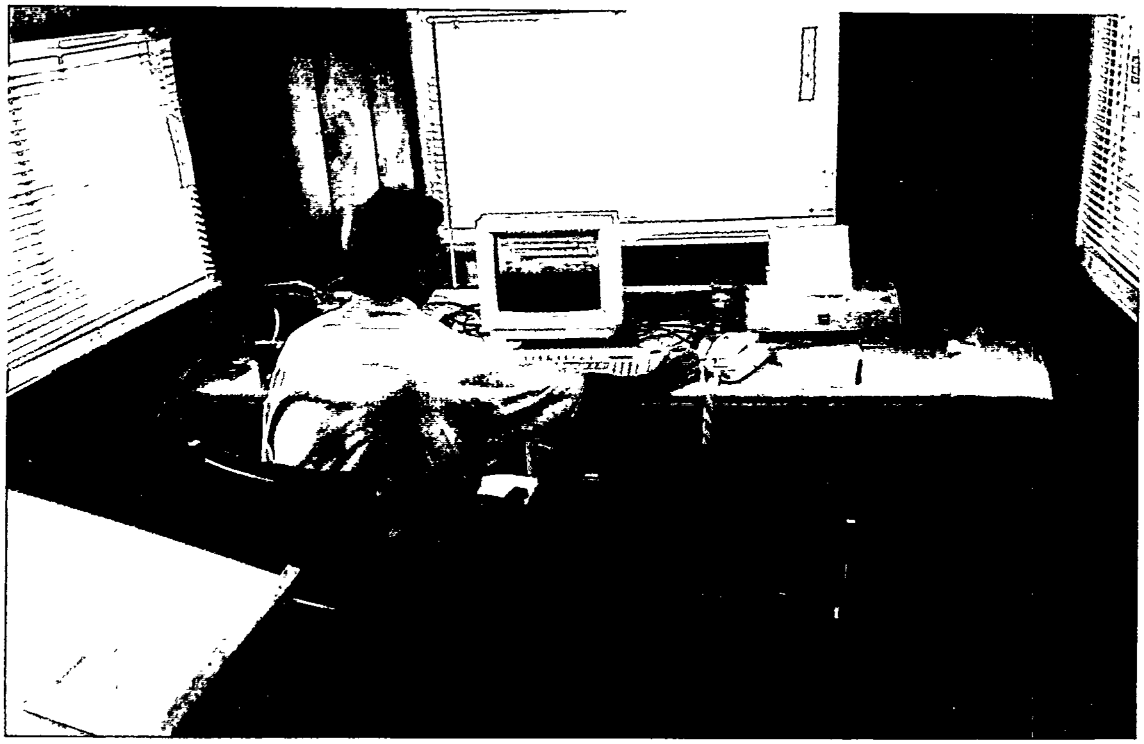
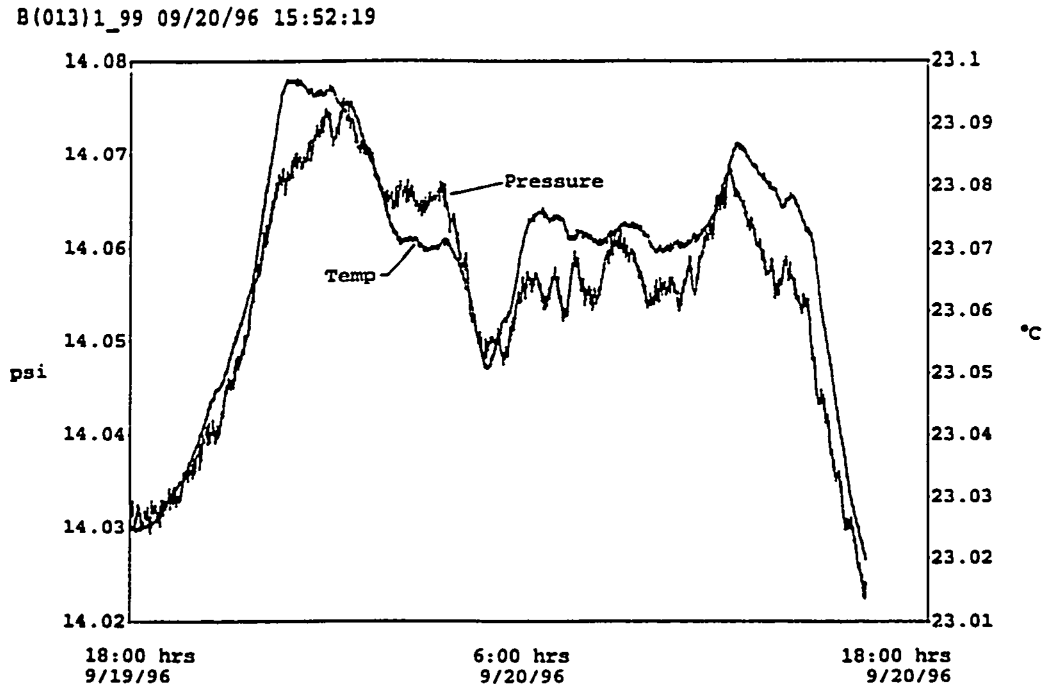
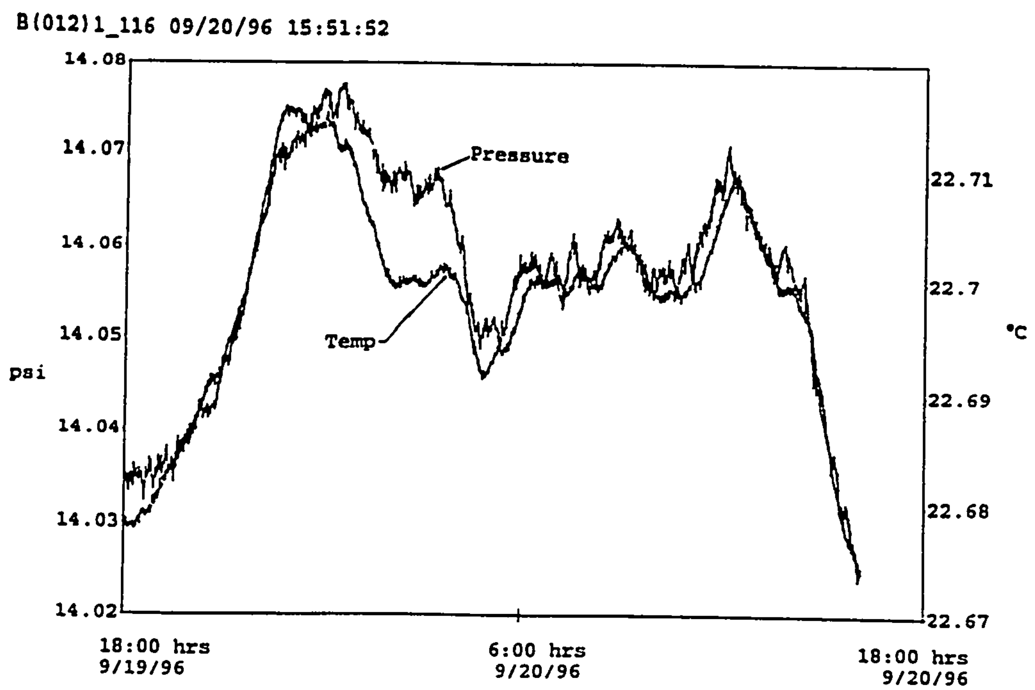


Fig. 7. E-SMART Engineer Reviewing Data from Tinker AFB Demonstration in Field Site Trailer using the Data Management and Analysis System.

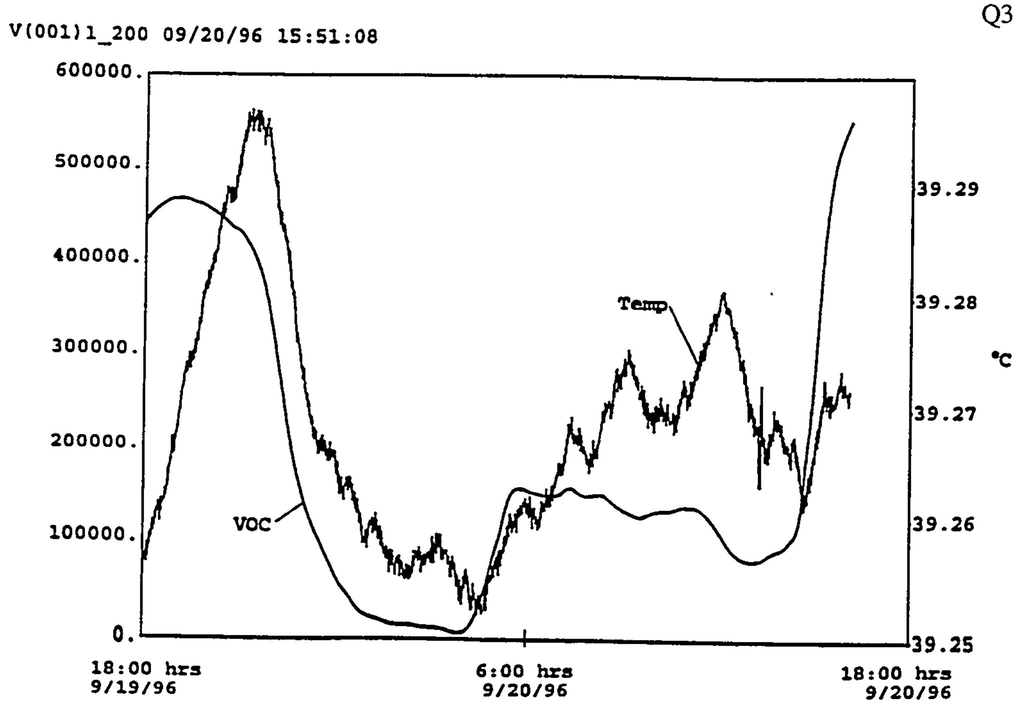


(a) From Sensor P013 in Well I-99

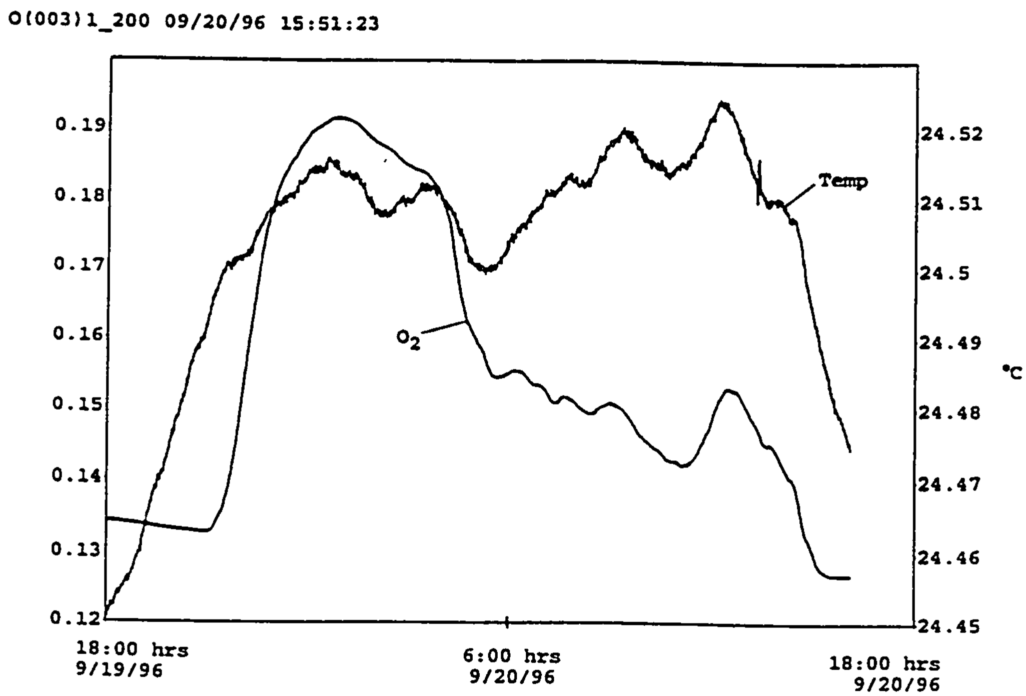


(b) From Sensor P012 in Well I-116

Fig. 8. Barometric Pressure Sensor Data from Tinker AFB Demonstration.



(a) From Sensor VOC001 in Well I-200



(b) From Sensor O2003 in Well I-200

Fig. 9. Hydrocarbon/VOC and Oxygen Sensor Data from Tinker AFB Demonstration.

Table 1: Installation of E-SMART Phase I Sensors

Well Number	Configuration
I-99	E-SMART Well Cap & Cables P013 Barometric Pressure Sensor P014 Water Level Sensor P015 Water Level Sensor P010 Water Level Sensor
I-109	E-SMART Well Cap & Cables O2001 Oxygen Sensor
I-116	E-SMART Well Cap & Cables P012 Barometric Pressure Sensor P009 Water Level Sensor
I-200	E-SMART Well Cap & Cables O2003 Oxygen Sensor VOC001 VOC (MOS) Sensor
I-98	E-SMART Well Cap & Cables
I-119	E-SMART Well Cap & Cables

Figures 8 and 9 include temperature traces along with their respective transducer readings. These temperatures are measured by a thermister mounted on each E-SMART sensors. The purpose of these thermisters is to provide real-time temperatures at the transducer heads which can be used in their respective calibration curves. Note from Figure 8 that the temperature of sensor VOC001 is relatively high [39°C (102°F)]. Sensor VOC001 incorporates a metal oxide transducer which contains a heater. The thermister is measuring the effect of this heater, not the ambient temperature in the well.

1.6 Visualization

No activity this reporting period.

1.7 Program Management

Isco

Isco management has approved and signed their subcontract modification. The subcontract modification allows Isco to increase support to PSS/GTRI for development of optics and optoelectronics for E-SMART-compatible microsensors. In addition the modification extends the Isco period of performance to March 1998.

PSS/GTRI

PSS management is reviewing their subcontract modification. Currently, PSS/GTRI has a cost share issue that is not resolved.

PSS/GTRI has a shortfall in being able to provide their 50% cost share for the period January-July 1997. This is due to a constraint imposed by the cost share funding provided by the State of Georgia. This results in a temporary cumulative deficiency in matching funds of $318K during the first half of 1997. A possible resolution of this problem is to utilize Phase II STTR funding for additional cost sharing. DOE-ID approved the use of available STTR funds for cost sharing.

The PSS subcontract modification will increase PSS/GTRI's scope to include optimization of pattern recognition, improvement to waveguide quality, and development of improved fabrication techniques for E-SMART-compatible microsensors. In addition PSS/GTRI would expand on coating chemistry development for E-SMART-compatible microsensors. The subcontract modification would extend the PSS/GTRI period of performance to March 1998.

SECOR

SECOR management has approved and signed their subcontract modification. SECOR's increased workscope provides additional field and environmental requirements support. In addition SECOR is to develop additional E-SMART-compatible software such as a report generator module for the Data Management and Analysis System. The subcontract modification extends the SECOR period of performance to March 1998.

1.8 Dual Use and Commercialization

Interactions with Biode, Inc. continued for development of an E-SMART compatible Hg sensor. This is a SBIR project that currently has DOE funding. Biode has been invited to attend the E-SMART Team Node Specification meeting, at Isco Inc. - Lincoln, NE on October 28th for the purpose of reviewing the node specification.

The Naval Surface Warfare Center (NSWC) is interested in applying E-SMART systems in their Smart Ship Program and other programs.

An abbreviated proposal was submitted to the Naval Facilities Engineering Service Center (NFESC), Port Hueneme, CA, for an E-SMART system demonstration. The proposal is similar to the one put together for the Tinker AFB field demonstration, but will site at a Navy facility and run for 12 months. The Navy will request a full proposal after evaluation if there continues to be interest at NFESC.

The Tinker AFB demonstration for OC-ALC/EMR had scope added for extension of the field test for 5 months and for development of Internet access to the E-SMART network.

PSS/GTRI received an award for a Phase II STTR proposal for development of an E-SMART-compatible Integrated Optic Sensor for Cone Penetrometers. This will allow work to continue on an E-SMART cone penetrometer system for BTEX detection. GA is awaiting PSS/GTRI input on required configuration and completion of a subcontract in order to modify the circuit board memory configuration.

2. Problems

The major problem is the cost share issue that has arisen with PSS/GTRI.

3. Plans for the Next Quarter

A set of E-SMART TRP Team meetings is scheduled for October 28th, 29th, and 30th. The meeting on 10/28 will be at Isco Inc., Lincoln, NE, to review the E-SMART Node Specification. The meeting on 10/29 will also be at Isco Inc. to review the E-SMART TRP Project focusing on GA, PSS/GTRI, Isco, and SECOR progress and future plans. The meeting on 10/30 will be a working meeting/visit to the E-SMART Field Demonstration Site at Tinker AFB, in Oklahoma City.

Optimization of pattern recognition and improvements to waveguide quality and fabrication techniques for microsensors will continue.

Microsensor coating chemistry development will continue, focusing on screening of BTEX-selective polymer coating materials.

Advances in E-SMART network management, data management, and visualization will continue, including continuation of system upgrades.

The Tinker AFB field test will continue. A DOE/DARPA meeting at the field test site will take place in late October.

The E-SMART Node Specification will be revised and reissued after incorporation of comments from team member reviewers after the October node specification meeting.

4. Milestones and Deliverables

E-SMART System for In-situ Detection of Environmental Contaminants - Quarterly Technical Progress Report, Quarter 2, Calendar Year 1996 - completed and delivered per contract requirements.

Financial Status Report-Standard Form 269A, Reporting Period 4/1/96 - 6/30/96 - completed and delivered per contract requirements.

5. Papers and Conferences

A paper was published in the September 1996 issue of Instrumentation & Control Systems entitled *"LONWORKS Network Services Architecture Provides Control Network Operating System."* The paper described the E-SMART, Environmental Systems Management, Analysis, and Reporting neTwork as an example of an Echelon LONWORKS Network Services (LNS) application. LONWORKS is the network protocol used by E-SMART.

6. Financial Status Report

Per contractual direction, DOE form SF-269A, "Financial Status Report", has been completed by GA for this quarter and has been distributed to the following individuals at DOE-Idaho:

- Patrick Trudel, Program Manager
- Chief Financial Officer, Financial Management Division
- Rebecca Rich, Accounting, Financial Management Division
- Wade Hillebrant, Contract Specialist