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

QUARTERLY TECHNICAL PROGRESS REPORT

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**Work Performed Under
DOE Cooperative Agreement DE-FC0795ID13352
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, Idaho**

Effective Date of Contract:	March 20, 1995
Contract Expiration Date:	March 19, 1998
Reporting Period:	Q3CY97 (July-Sep. 1997)

**GENERAL ATOMICS PROJECT 3719/4450
December 1997**

MASTER

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Abstract

General Atomics (GA) leads a team of industrial, academic, and government organizations in the development of 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 TRP team members include Isco, Inc., Photonic Sensor Systems, Inc. (PSS), Georgia Tech Research Institute (GTRI), Secor, Inc. (SECOR), Biode, Inc (Biode), Rapid Clip Neural Systems, Inc. (RCNS), Applied Research Associates, Inc. (ARA) and the U.S. Air Force Armstrong Laboratory Environics Directorate at Tyndall AFB(AL). Government interests are also represented by program managers from DARPA, DOE EM-53, and DOE-Idaho.

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 as well as a developmental sensing technologies contributed by Biode, Inc. and Sawtek, Inc.(see below), 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.

General Atomics has signed Articles of Collaboration with another DARPA TRP awardee, Sawtek, to develop an E-SMART-compatible version of the Sawtek 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. The Sawtek team now also includes Perkin-Elmer.

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

E-SMART TRP

TEAM

- General Atomics (team leader)
- Isco, Inc. • Photonic Sensor Systems, Inc.
- Secor, Inc. • Georgia Tech Research Institute
- Armstrong Lab. Environics Directorate (USAF)
- DARPA • DOE EM-53 • DOE-Idaho
- Tinker AFB (OC/ALC-EMR) (USAF)*
- Rapid Clip Neural Systems, Inc.
- Biode, Inc. • Applied Research Associates, Inc.
- IMAS TRP Team (Sawtek, Inc - team leader)

(bold = original team member; * E-SMART TRP field test site)

VISION

OBJECTIVES

- Develop and promote E-SMART®, an open standard for networking smart sensors at environmental sites.
- Develop and field test new, chemically-specific, multichannel smart sensors for detecting contaminants in air and water.
- Integrate commercially-available technologies into E-SMART devices designed to facilitate environmental sensing and environmental remediation process control.
- Develop a Data Management and Analysis System (DMAS), including network management components and a user interface for data evaluation and visualization.

SCHEDULE

Task Name	1995				1996				1997				1998	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
100 Development														
100.100 Microsensors		-----												
100.200 E-SMART Integration		-----												
100.300 Visualization		-----												
200 Field Testing														
Preliminary Testing		-----												
Integrated Testing														-----
300 Project Management		-----												

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

Executive Summary

Program Management

- Work efforts for GA, Isco, Secor, and Biode were reallocated. Total DARPA project funding was unaffected, however anticipated cost-share increased by about \$30k.

Multichannel Microsensor

- Four preliminary E-SMART microsensor heads have been fabricated—two for testing and development at Isco and two for testing and development at GTRI. These preliminary microsensor heads have been mated to preliminary smart controllers built by Isco, and successfully operated end-to-end.
- A thirteen channel optical chip has been designed and fabricated. This design will be used in the E-SMART BTEX sensor.

Sawtek Integrated Modular Array Sensor (IMAS)

- Sawtek hosted a team meeting in August (8/21-22/97). The IMAS team agreed to participate in the E-SMART field demonstration in early 1998.

Other Sensors and Actuators

- Applied Research Associates delivered a prototype Digital Multiplexer/Data Logger to GA.
- An improved E-SMART sensor housing was developed to transition the original proof-of-concept design to a commercial version.

E-SMART Network Management

- A new version of the E-SMART network management software is being developed.

E-SMART Field Testing

- The E-SMART network continues to operate at Tinker AFB. No data analysis is currently being performed pending additional support from other sources. Maintenance of the network continues at a low tempo. It is expected that the continued operation of the sensors will contribute to an understanding of aging effects and operational issues for in situ sensors.

Dual Use and Commercialization

- Armstrong Laboratory, Tinker AFB, and General Atomics have been accepted for a poster presentation on E-SMART at the 3rd Annual SERDP Symposium in December, 1997.

1. Work Conducted July-September, 1997

1.1 *Multichannel Microsensor (PSS/GTRI)*

WBS 100.110 - Develop Requirements and Design Configuration

Testing of initial E-SMART microsensor thirteen-channel integrated optic detector chips (based on the previously reported final design) revealed slight, variable curvatures in the input/output grating couplers. These curvatures would require an unacceptable chip-to-chip alignment compensation. The fabrication error sources were identified, and the process for fabricating the input/output grating couplers was refined to eliminate the errors. Chips fabricated with the new process showed no grating coupler curvature.

WBS 100.120 — Develop Coatings & Identify Interferants

No work to report this period.

WBS 100.130 — Design and Develop Glass Waveguides

No work to report this period.

WBS 100.135 — Develop Sensor Protective Techniques

The procedure for patterning an array of BTEX-selective polymer coatings on an E-SMART microsensor integrated optic detector chip was finalized. As previously reported, the procedure relies on photolithographically defined “chemical wells” to create the coating pattern, pre-treatment of the chemical well surfaces with a silated polymer seed layer to enhance adhesion, and a final annealing step to ensure uniform coating thickness. A number of thirteen-channel detector chips have now been successfully patterned using this technique.

An alternate “air-brush” technique for polymer patterning was briefly investigated, but did not appear to offer any advantages.

WBS 100.140 — Characterize Prototype Sensors

Preliminary E-SMART microsensor heads (see WBS 100.170) are being used for two characterization efforts. First, final calibration data is being generated for development of the BTEX pattern recognition algorithm. Second, the impact of environmental

Figure 1. E-SMART BTEX sensor layout

interferants is being investigated (e.g.; non-BTEX chemicals, temperature, pressure). These characterization efforts will continue through the end of the calendar year.

WBS 100.150 — Design Microsensor Electronics & Packaging

Preliminary calibration data for the proposed BTEX-selective polymer coatings (including both BTEX and interferant species responses) was analyzed to confirm suitability for pattern recognition, and a final thirteen-channel pattern of coatings was specified. As illustrated in Figure 1, the layout utilizes four polymers with a coarse, medium and fine resolution channel for each polymer. The analysis indicates a very high likelihood for successful class discrimination (BTEX vs. chlorinated solvents) and a reasonable likelihood for individual species discrimination. The use of three channel lengths per polymer should allow both high resolution (< 1 ppm) and a broad dynamic range (up to analyte saturation in water). In addition to the twelve sensing channels, there is a buried reference channel. The buried reference is intended to allow compensation of spurious effects such as laser wavelength shifts or intensity fluctuations.

Based on the final thirteen-channel coating pattern, an algorithm for conversion of raw interferometer outputs (pixel intensities) to five calibrated phase shifts (one associated with each polymer and one associated with the buried reference channel) was specified. Isco will code this algorithm for real-time computation on their smart controller. The resulting phases shifts, augmented by a thermistor temperature reading, will serve as the inputs for the BTEX pattern recognition algorithm being developed by Rapid Clip Neural Systems.

WBS 100.170 — Build and Test Preliminary Microsensor Model

Four preliminary E-SMART microsensor heads have been fabricated—two for testing and development at Isco and two for testing and development at GTRI. These preliminary microsensor heads have been mated to preliminary smart controllers built by Isco, and successfully operated end-to-end. In one representative test, all thirteen sensing channels were coated with the same BTEX-sensitive polymer, and the raw output from all 128 pixels in the photodiode array was monitored as water contaminated with a varying concentration of toluene was flowed over the detector chip. The time trace for each individual pixel exhibited the expected sinusoidal interferometer response, confirming successful operation of all thirteen sensing channels. The only surprise from these tests was a pronounced fall-off in optical intensity from the center of the photodiode array to the outside of the photodiode array, reflecting a greater than expected Gaussian profile in the diode laser light output. This intensity variation will be corrected by placing a non-uniform intensity filter in front of the photodiode detector. No design modifications are needed before proceeding to fabrication of the final field prototype microsensor heads.

Figure 2. Mechanical layout of the E-SMART BTEX sensor "optical bench." Does not include electronic components other than the laser and photodetector array

WBS 100.180 — Build Field Prototype Sensors

Final drawings for the field prototype E-SMART microsensor heads were made. As shown in Figure 2, the final layout is 6.5 inches long and will easily fit inside a 1.4 inch inside diameter housing. A contract was issued for the machining of ten final mechanical assemblies, and fabrication of ten final integrated optic sensing chips was begun. Completion of both is scheduled for October 31st. All other components for the deliverable field prototype microsensor heads (e.g.; diode lasers, photodiode detector arrays) are already on hand.

WBS 100.191 — Microsensor Support (Isco)

No activity this period.

WBS 100.192 — E-SMART/LonWorks Interface (Isco)

No activity this period.

WBS 100.193 — Embedded Software (Isco)

No activity this period.

WBS 100.194 — Probe with Electronics and Optics (Isco)

Worked on the design of the portion of the probe housing that the waveguide holder (optical bench) attaches to plus some work on the stainless tube that houses the electronic and optical components. Built a partial housing to check the fit with the waveguide holder. Built a preliminary probe housing for review at the August TRP meeting. Built and leak tested a 2nd probe housing. Began selection of materials for chemical resistance.

The first prototype version of the Hitachi processor circuit board was assembled and tested. As a result of the testing a second narrower version of the Hitachi processor circuit board was designed. Two of these second prototype version circuit boards were then assembled and tested. During this time the Neuron circuit boards were designed and two circuit boards assembled.

WBS 100.195 — PC-based E-SMART Software (Isco)

No activity this period.

WBS 100.196 — Lab/Local Testing (Isco)

A single polymer microsensor head was tested at different calibrated concentrations of xylene using an Isco gradient system and a flowcell designed and fabricated for the test.

1.2 Sawtek Integrated Modular Array Sensor (IMAS)

Sawtek hosted a meeting of the IMAS TRP Coordinating Committee in Orlando, Florida the 21-22 of August. GA attended, as did a representative from Perkin-Elmer, Sandia National Laboratory, and Pacific Northwest Laboratories. The IMAS team discussed the current status of the sensor technology, results of laboratory testing, requirements for E-SMART integration, and field demonstration opportunities. The team expressed strong support for participating in the E-SMART TRP demonstration in 1998.

1.3 Other Sensors and Actuators (GA, Biode)

WBS 100.200 — E-SMART Integration

Work continued on a new Smart Device Processor design that includes a 32 bit coprocessor and is compatible with the new GA sensor housing design. A set of five prototype boards were built. These boards are now being tested and diagnosed for problems. A second set will be built once the boards have been debugged and possibly revised. The new SDP may also be used to support the Sawtek and Biode sensor technologies.

BIODE, Inc. – Cost Share Projects

DE-FG02-94ER-81717 SBIR cost match effort for Q3 1997

The most substantial, and relevant, of the SBIR projects at BIODE will develop technology for post-closure monitors to detect mercury in groundwater. These monitors must be capable of detecting mercury at levels of less than 2 ng/ml (10 nanomolar) without periodic maintenance or calibration. The application is well suited to the use of E-SMART sensor networking. An array of perimeter sensors would be deployed around the site using either wireless or cabled connection to the E-SMART LAN. A central processing station could monitor the distributed sensors and detect geological transport of Hg (or other hazardous wastes) from the site. BIODE's solution to the problem employs a sensitive piezoelectric nanobalance combined with an electrochemical process. The piezoelectric device is operated in a self-differential mode, in which a cyclic electrochemical process produces a cyclic frequency variation. Aging and temperature effects do not vary cyclically, and therefore have little impact on the measured response. The advantage of operating the sensor in a self-differential mode is the continuous rejection of non-specific sensor perturbations.

Figure 3. (Left) The Plexiglas liquid cell incorporates a platinum counter electrode and a pseudo-reference electrode. The cell is clamped over the gold surface of the dual sensor, which measures 10mm x 16 mm. (Right) The radio frequency electronics printed circuit board includes two oscillator circuits (outer edges of board) and a temperature measurement circuit (center). The initial prototype measures less than 45 mm x 30 mm and is capable of substantial further size reduction.

Evaluation of the mercury sensor has employed a static sample with the solution exposed to the gold surface of the piezoelectric device, as shown on the left in Figure 3. The gold surface also serves as the working electrode in the cyclic voltammetric (CV) electrochemical cell. Negative electrode potentials drive the Hg^{2+} molecules to the gold film and reduce it to Hg^0 . Positive electrode potentials oxidize the mercury to Hg^{2+} and strip the ions. The cyclic deposition and stripping process modulates the surface mass, leading to observable frequency variations that track the ionic deposition and stripping cycle. The electrochemical influence increases sensitivity and simultaneously provides a method to regenerate the gold film. *Since all ionic compounds have unique oxidation*

potentials, a method to discriminate between different ions is inherently available, although the data processing has not been developed yet.

The sensitivity of the SHAPM to different concentrations of mercury was measured. The device was subjected to the electrochemical potentials without any mercury in the KCl solution, and had no response to the potentials. The device was then subjected to several concentrations of mercury, as shown in Figure 4. The frequency of the SHAPM increased and decreased with the applied potentials when the mercury was added, and the magnitude of the oscillation shift changed with the concentration of mercury. The baseline of the SHAPM drifted upward once the mercury was initially added. As stated, these non-cyclic drifts have no impact on the mercury measurement.

Figure 4. The response of the quartz SHAPM to different concentrations of mercury in solution is seen as the frequency shifts with respect to the applied potential. The drift in the oscillation frequency is being investigated to confirm the source of the drift.

The results from Figure 4 were plotted as peak-to-peak frequency shift versus mercury concentration in Figure 5. The trend of the curve shows a monotonic, instrumentable response of the frequency vs. Hg concentration. More data points are needed to obtain a more accurate characteristic curve of frequency shift versus mercury concentration. The frequency shifts were substantially smaller than in previous experiments, taken several weeks prior on the same device. At first, electrode poisoning was suspected; however, recent studies indicate that the mercury solution became depleted as Hg ions were absorbed by the polypropylene container.

Figure 5. The magnitude of the frequency shift increased with the original concentration of mercury. The logarithmic behavior of the results suggests saturation of the gold film. Comparison with previous data taken when the solution was fresh indicate that the real concentration of mercury was much lower.

The quartz shear horizontal acoustic plate mode (SHAPM) hybrid electrochemical-piezoelectric nanobalance has shown good sensitivity to mercury ions in solution, approaching the SDWA limit. The device needs to be characterized further with more experiments that explore repeatability, threshold limits and selectivity prior to field tests. The frequency shifts are cyclically related to the applied potentials, so a reference device is not required. The microprocessor is being developed to read the relative frequency shifts and potentials of oxidization / reduction to increase reliability.

DAMD17-95C-5033 SBIR cost match effort for Q3 1997

This SBIR is directed at laboratory (clinical) tests for biochemical warfare toxins. By extending the effort to stand-alone system capability, such sensors could be integrated into an E-SMART-based perimeter defense network. Standoff detectors (e.g. lidar) and point triggers (particle counters) could trigger the piezoelectric sensor system to perform automatic analysis (identification) of suspicious agents. Effort to date has been focused on the piezoelectric sensing element, attachment chemistry to incorporate biochemical selectivity and the local control requirements. This application of E-SMART technology has not yet been pursued.

State funded research during Q3 1997

The State of Maine has provided funding for two pre-SBIR projects. One extends the mercury detection project by employing a more rugged and potentially more sensitive structure. The other explores genomic detection of bacterial species for bioremediation processes. The former project has resulted in a patent filed on a novel piezoelectric sensor structure. The latter project has resulted in a DOE Phase I SBIR.

Biode, Inc., TRP-funded Research during Q3 1997

Original Scope – Project Management

Project management during Q3 featured the inclusion of additional cost share and the expansion of project scope.

Expanded Scope – Technical effort

Q3 effort at BIODÉ has been directed at the improvement of the local controller for piezoelectric sensors. The current approach is to control electrochemical potentials and measure frequency variations using a local 16-bit microprocessor. The local controller will employ an RS-232 link to an E-SMART gateway. All of the major subsystems have been tested at the breadboard level and Q3 effort has focussed on the initial integration of these systems.

Short-term Goals

Continue to characterize the mercury sensor. Complete the sensor controller and evaluate the response of the sensor to contaminants of interest for field testing at Tinker AFB (e.g. hexavalent chromium). The prototype will be further compressed to a portable, benchtop model with plans for a down-hole capable implementation.

Long-term Goals

The long-term goal is to produce a family of E-SMART capable sensors. One such system could employ details of the frequency-vs.-voltage and current-vs.-voltage curves to identify mixtures of ionic contaminants. Different ions will react with the working electrode at differing potentials and exhibit different mass-charge ratios (frequency shift to current ratios). Such a system would be capable of quantitative analysis of mixtures of RCRA metals (e.g. Hg, Cd, Cr^{IV}, Pb, Se, Cu, etc.).

1.4 E-SMART Network Management (GA)

WBS 100.230 — E-SMART Network Management

Development of the next version of the E-SMART DMAS software continued. A technical approach was chosen and development has begun. Isco will be furnished with a version of the program for node development purposes.

1.5 Field Testing (GA, SECOR)

WBS 200 — E-SMART Field Testing

No major changes were made in the network during this period. Data continues to be logged, however no resources are being dedicated to data analysis at this time. The major advantage in running the network at this time is to get some data on the effects of exposure on the lifetime of the prototype sensors and systems that have been previously installed. In addition, it is hoped that many of the prototype sensors that were installed in Sep/Oct of 1996 will continue to be operational for the TRP team field demonstration next year.

1.6 Visualization

WBS 100.300 — E-SMART Visualization (GA)

Visualization activities will be subsumed within the development of the DMAS system for the duration of the project. This activity will be reported under E-SMART integration activities.

1.7 Program Management

WBS 300.100 —E-SMART Program Management (GA)

Financial reporting issues were resolved with Isco. In addition, reductions in scope were negotiated with Isco and Secor to reflect current estimated cost to complete. The scope for Biode and GA was increased to support development of the Biode mercury sensor and additional program support activities by GA. There was no change in the level of DARPA funding (\$2,693,514). However, the anticipated cost share contribution by the team increased by around \$30k to \$2,723,207. Table I illustrates the scope allocation by team member.

Table I – TRP Team Scope

Team Member	Cost Share	DARPA Match	Total Program
General Atomics	\$ 653,608	\$ 1,140,478	\$ 1,794,086
Biode	\$ 640,000	\$ 70,000	\$ 710,000
ARA	\$ 25,994	\$ 24,978	\$ 50,972
ISCO	\$ 300,168	\$ 203,858	\$ 504,026
PSS/GTRI	\$ 1,043,437	\$ 1,194,200	\$ 2,237,637
SECOR	\$ 60,000	\$ 60,000	\$ 120,000
Total	\$ 2,723,207	\$ 2,693,514	\$ 5,416,721

WBS 300.100 — PSS/GTRI Program Control and Reporting

Routine cost accounting and progress reporting were performed. Because of inadequate staffing at PSS to support ongoing characterization and testing efforts, additional characterization and testing work will be assumed by GTRI, with a corresponding transfer of approximately \$90K from PSS to GTRI. There is no change in the overall PSS/GTRI scope of work or funding.

1.8 Dual Use and Commercialization (GA, Armstrong Lab)

WBS 300.200 — Dual Use and Commercialization

The DoD issues an SBIR solicitation twice a year, describing its R&D needs and inviting R&D proposals from small companies -- firms organized for profit with 500 or fewer employees, including all affiliated firms. (DoD is now accepting proposals in response to SBIR solicitation number 98.1, which opened on October 1, 1997 and closes January 1998.) Companies apply first for a six-month phase I award of \$60,000 to \$100,000 to test the scientific, technical, and commercial merit and feasibility of a particular concept. If phase I proves successful, the company may be invited to apply for a two-year phase II award of \$500,000 to \$750,000 to further develop the concept, usually to the prototype stage. Proposals are judged competitively on the basis of scientific, technical, and commercial merit. Following completion of phase II, small companies are expected to obtain funding from the private sector and/or non-SBIR government sources to develop the concept into a product for sale in private sector and/or military markets.

The Air Force Research Laboratory (includes the former Armstrong Laboratory) has an SBIR Phase I solicitation (AF98-027) for "Development and Integration of MEMS Based Sensor Technologies with E-SMART." The objective is to provide a suite of sensor technologies that can be implemented with E-SMART for addressing Environmental, Safety, and Occupational Health (ESOH) sensing and monitoring needs. The Air Force has an increasing need to quickly and accurately analyze the environment for chemical constituents. The cost of monitoring contaminated sites and point sources using current sampling and analysis techniques is extremely labor intensive and costly. More than half of the contaminated sites in the DOD will require long-term monitoring. Using today's methods, the cost of monitoring could exceed the cost of remediation. A number of DOD operations produce significant amounts of emissions which are largely uncharacterized, including aircraft operations, jet engine testing and aircraft painting/depainting operations, which will suffer operational restrictions when the new standards are promulgated. The current measurement techniques also involve field sampling followed by laboratory analysis, which are time consuming, labor intensive and costly. The purpose of this effort is to develop and integrate an on-site or remote, real-time, in situ measurement techniques with E-SMART to determine the chemical composition and concentrations. MEMS based instruments and techniques that allow on site, continuous measurements without sampling are especially desirable, however other sensing approaches that provide advantages similar to MEMS will be considered. E-SMART promises to integrate advancements in sensor technology with proven communication, electronic control, and analysis technology to produce a reliable, versatile, intelligent, cost-effective, environmental monitoring and control system. E-SMART establishes standardized open network protocols for sensors, sampling systems, and graphical user interfaces for data visualization and evaluation. Only direct measurement techniques and submittals which include the basic planned strategy for

taking the concept from development through commercialization of the final product will be considered.

The Air Force Research Laboratory is also planning a Pollution Prevention program starting in FY00 entitled: "Environmental Systems Management, Analysis, and Reporting Network (E-SMART) Application to Process Control" to transition E-SMART technology from the demonstrations at Tinker AFB. E-SMART has been implemented as a prototype environmental monitoring system at Tinker AFB. This project will adapt the E-SMART technology for industrial process monitoring and control. Optimization of industrial maintenance processes through monitoring and process controls has the potential to significantly reduce the amounts of hazardous materials utilized in these processes, thereby reducing TRI releases, hazardous waste streams, HAP emissions, and correcting compliance issues. An additional benefit will be cost savings in equipment, materials, and manpower.

GA continued preliminary work on setting up an E-SMART Standards Organization to promote E-SMART devices and maintain the E-SMART standard.

2. Problems

Isco worked with GA to resolve the problems in generating current cost information. Isco also re-estimated its costs to complete the project.

3. Plans for the Next Quarter

- Planning for the field demonstration in 1998.
- Sensor integration and development.
- Software development.
- Prototype sensor testing.

4. Milestones and Deliverables

E-SMART System for In-situ Detection of Environmental Contaminants - Quarterly Technical Progress Report, Quarter 2, Calendar Year 1997 - completed and delivered per contract requirements.

Financial Status Report-Standard Form 269A, Reporting Period 7/1/97-9/30/97 - completed and delivered per contract requirements.

5. Papers and Conferences

- General Atomics, the Air Force Research Laboratory Environmental Technology Division (formerly Armstrong Laboratory Environics Directorate) and Tinker AFB

had a conference poster accepted for the 3rd Annual Strategic Environmental Research and Development Project (SERDP) Symposium to be held December 3-5, 1997 in Washington D.C. The poster was entitled, The E-SMART Technology Reinvestment Project and Beyond.

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

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