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Sensors for SCAPS

Purdue ECT Team
Purdue University, ectinfo@ecn.purdue.edu

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SENSORS FOR SCAPS

THE NEED

As mentioned at (<http://www.ect-purdue.org/Other/scaps>), the Site Characterization and Analysis Penetrometer System (SCAPS) platform consists of a 20-ton truck equipped with vertical hydraulic rams that are used to force a cone penetrometer into the ground at a speed of 2 cm/sec to depths of approximately 50 m in nominally consolidated fine-grained soils when using a 100-m umbilical cable (25 m when using 50-m umbilical cables).

FIGURE 1 DIAGRAM OF SCAPS-LIF SYSTEM (SOURCE: [HTTP://WWW.SPAWAR.NAVY.MIL](http://www.spawar.navy.mil))

During a vertical push, data are continuously collected and recorded with 2-cm special resolution. The SCAPS program is currently conducting field verification investigations on state-of-the-art penetrometer mounted sensor and sampler systems for the real-time in situ detection of petroleum products, explosive compounds, volatile organic compounds (VOC), solvents, and gamma emitting radionuclides. A heavy metal sensing capability is under development. Improved real-time data acquisition/processing algorithms now allow on-site three dimensional visualization of subsurface contaminant plumes, soil classification and stratigraphy. This fact sheet describes the sensors in SCAPS system in order to comply with SCAPS (<http://www.ect-purdue.org/Other/scaps>).

THE TECHNOLOGY

LASER INDUCED FLUORESCENCE (LIF) PETROLEUM, OIL, AND LUBRICANT (POL) SENSOR

The U.S. Army Engineer Waterways Experiment Station (WES) under the sponsorship of the U.S. Army Environmental Center (AEC) patented LIF POL sensor uses ultra violet laser energy to induce fluorescence in POL contaminants. The laser, mounted in the SCAPS truck, is linked via fiber optic cables to a sampling "window" mounted on the side of a penetrometer probe. Laser energy emitted through the window causes fluorescence in adjacent POL contaminated media. The fluorescent energy is returned to the surface via fiber optic cables for real-time spectral data acquisition/processing in the SCAPS truck. The SCAPS LIF POL sensor has undergone numerous successful field investigations at various government facilities to determine soil classification/layering and POL contaminant data. The SCAPS LIF POL sensor is currently undergoing Environmental Protection Agency (EPA) demonstration / validation investigations and has been licensed to private industry for commercialization.

EXPLOSIVES SENSOR

The SCAPS Explosive Sensor probe incorporates electrochemical sensors for the in situ measurement of explosive contamination and geophysical sensors for determining soil classification/layering. The probe is used to collect soil classification information during the penetrometer push, and contaminant information during penetrometer retraction. The probe incorporates an external pyrolyzer system used to transform explosive compounds into electroactive vapors and a pneumatic system to transport these vapors from the soil to the electrochemical sensors inside the probe. The probe's umbilical (a) allows the chemical sensor signal to be monitored continuously at the surface, (b) ensures positive flow of clean air through the vapor sampler, supplies power to the pyrolyzer during analysis, (d) interfaces the geophysical sensors to the SCAPS computer thus providing real-time soil classification data, and (e) supplies grouting fluids to the probe's tip.

THERMAL DESORPTION VOC SAMPLER

The SCAPS Thermal Desorption VOC Sampler combines thermal desorption and cone penetrometer technologies to provide a means for real-time detection and mapping of solvent and hydrocarbon contamination in both the vadose and saturated zones. In operation, the thermal desorption VOC sampler is pushed to a desired depth, an interior rod retracts the penetrometer tip, and a known volume of soil is collected in a sample chamber. While in the sample chamber, heat is applied around the soil sample to purge contaminant vapors. Volatilized compounds are transferred to the surface via carrier gas where they are trapped on tenax, desorbed and analyzed using a field portable gas chromatograph and/or an ion trap mass spectrometer. The soil sample is then expelled, and the cone penetrometer pushed to a new depth where the process is repeated. Alternately, the sampler may be used as a vapor sampler in the vadose zone

by applying a vacuum to the transfer line to draw soil vapors to the surface where they are trapped and analyzed.

FIGURE 2 VOC DETECTION USING THERMAL DESORPTION (COURTESY OF FUJITA RESEARCH)

FIGURE 3 DIAGRAM OF SCAPS-LIF HYDROCARBON (SOURCE: [HTTP://WWW.SPAWAR.NAVY.MIL](http://www.spawar.navy.mil))

X-RAY FLUORESCENCE SENSOR

The XRF Sensor uses tried and tested technology to allow the SCAPS system to detect heavy metals in both saturated and unsaturated soils.

FIGURE 4 XRF DETECTOR SCHEMATIC (COURTESY OF FUJITA RESEARCH)

The XRF can detect heavy metals at levels below 100 ppm, up to the full depth allowable by the penetrometer. The SCAPS XRF Metal Sensor operates by detecting the characteristic wavelengths of X-Rays emitted by metal atoms in the soil when excited by an X-Ray source. The sensors probe tip contains an X-Ray source, which is used to bombard soil particles. These incident X-Rays cause metal atoms to fluoresce at specific wavelengths. These emitted X-Rays are detected at the probe tip and allow identification of metal concentrations in real time.

BENEFITS

Besides the general benefit of SCAPS system (<http://www.ect-purdue.org/other/scaps>), documented cost savings using SCAPS sensors are as follows;

- The SCAPS LIF POL Sensor System documented savings of \$1,000,000 at the Point Loma Fleet Industrial Supply Center Fuel Farm, California, by determining areas free of contamination that were scheduled for excavation and remediation. The reduction in soil volume requiring excavation and remediation was verified by conventional sampling methods.
- The SCAPS Hydrosparge VOC Sampler System documented savings exceeding \$300,000 over conventional well sampling technologies at the Bush River Site, Aberdeen Proving Ground, Maryland. The SCAPS Hydrosparge VOC Analysis System provided near real-time analytical results from 30 mini-

well locations in 8.5 days versus 155 days to install sample, and conduct offsite laboratory analyses from 30 conventional monitoring wells.

STATUS

The SCAPS Program has completed field verification investigations on state-of-the-art penetrometer mounted sensor and sampler systems for the real-time in situ detection of petroleum products, explosive compounds, volatile organic compounds (VOC), solvents, heavy metals, and gamma emitting radionuclides. Improved real-time data acquisition/processing algorithms now allow on-site three-dimensional visualization of subsurface contaminant plumes, soil classification, and stratigraphy.

BARRIERS

- SCAPS technology with sensors is limited to unconsolidated materials and are limited in their penetration depths. It cannot be used to penetrate bedrock layers, concrete footings or foundations, or other high-density barriers.
- Changes in geological density can limit the use of these technologies. The presence of soft layers overlying hard layers can alter in the alignment of the probe and can bend, break, or refuse the rod.

POINT OF CONTACT

Mr. John Ballard, USAE Waterways Experiment Station,

Phone (601) 634-2446, FAX (601) 634-2732 Email: ballarj1@wes.army.mil

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