*Fast*TIMES

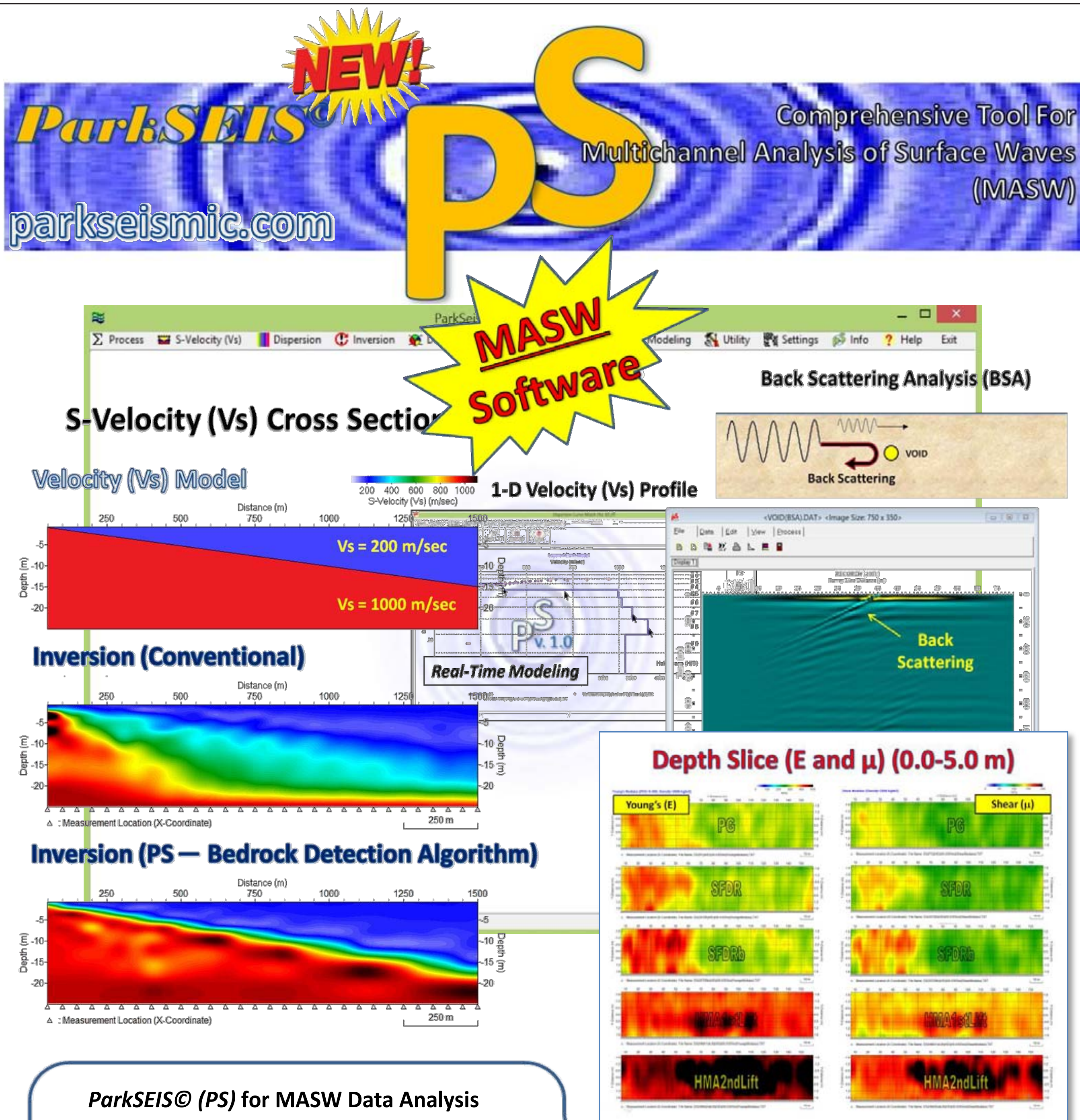
Featured Article:

Electromagnetic Induction Tools for Discrimination of Unexploded Ordnance: From Basic Physics to Blind Tests

Plus:

Important Information on SAGEEP 2015 (March 22 - 26; Austin, Texas)

March 2015
Volume 20, Number 1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In this issue of *Fast*TIMES, the featured article is focused on discrimination of buried unexploded ordinance using electromagnetic induction methods. In addition, expanded information is provided for SAGEEP 2015 (March 22 - 26 in Austin, Texas) with details on technical sessions, short courses, social events, etc.

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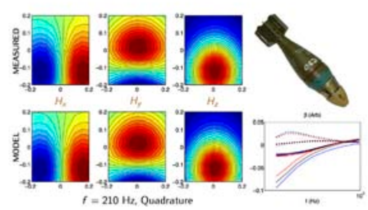

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*Fast*TIMES

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ABOUT EEGS

The Environmental and Engineering Geophysical Society (EEGS) is an applied scientific organization founded in 1992. Our mission:

"To promote the science of geophysics especially as it is applied to environmental and engineering problems; to foster common scientific interests of geophysicists and their colleagues in other related sciences and engineering; to maintain a high professional standing among its members; and to promote fellowship and cooperation among persons interested in the science."

We strive to accomplish our mission in many ways, including (1) holding the annual Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP); (2) publishing the Journal of Environmental & Engineering Geophysics (JEEG), a peer-reviewed journal devoted to near-surface geophysics; (3) publishing *Fast*TIMES, a magazine for the near-surface community, and (4) maintaining relationships with other professional societies relevant to near-surface geophysics.

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CALENDAR

2015

March 22 - 26	Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP) Austin, Texas, USA http://www.eegs.org/sageep-2015 (Note: See pages 31 - 34 and 40 for additional information.)
March 31 - April 1 May 21 - 22	Multichannel Analysis of Surface Wave (MASW) Workshop Lawrence, Kansas, USA http://www.kgs.ku.edu/software/surfseis/workshops.html
May 19 - 22	NovCare 2015 "Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice" Lawrence, Kansas, USA http://www.ufz.de/novcare/ (Note: See page 41 for additional information.)
June 1 - 4	77th European Association of Geoscientists & Engineers (EAGE) Conference and Exihibition Madrid, Spain http://www.eage.org
June 16 - 19	MARELEC 2015 - The World's Foremost Conference on Marine Electromagnetics Philadelphia, Pennsylvania, USA http://www.marelec.co.uk
June 22 - July 2	26th General Assembly of the International Union of Geodesy & Geophysics (IUGG) Prague, Czech Republic http://www.iugg2015prague.com
October 5 - 9	14th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst Rochester, Minnesota, USA http://www.sinkholeconference.com/
October 26 - 31	Society of Exploration Geophysicists International Exposition and 85th Annual Meeting New Orleans, Louisiana USA http://www.seg.org

Please send event listings, corrections or omitted events
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NOTES FROM EEGS

PRESIDENT'S MESSAGE

Moe Momayez, President
(mmomayez@email.arizona.edu)

A LAST WORD

My first SAGEEP was in 1999. When I arrived from Montreal, Canada to Oakland, California, I was unsure of myself, undeniably green, and had no idea what to expect. I definitely did not count on the fellowship and friendship that awaited me.

One of the main reasons I came was to attend a short course on landfill characterization offered by Zonge. In an interesting twist of fate, Zonge is headquartered in Tucson, Arizona - where I myself would also be headquartered in a few short years.

When I walked into the short course that day, I was truly pleasantly surprised. I was welcomed by a diverse group of attendees as one of their own. I learned a lot, exchanging ideas with my peers, and it made a lasting impression on me - and in some cases, sparked lasting relationships.

Fast forward to today: 2015. I am now the outgoing president of EEGS, and this will be my last message. During the intervening years, I have grown intellectually, professionally and personally, in no small part thanks to the relationships and exchanges I have had with our members. I consider many of you my friends, and I have great pride in the time I have spent with you. I consider myself a life-long member of EEGS, and I hope many of you feel the same way.

Much of my efforts over the past few years have been to stimulate renewal and versatility at many levels. The up and coming EEGS leadership is also committed to make changes that will solidify our base and expand our reach through collaboration with other societies in North America and around the world.

If you have been looking for a way to get more involved in near-surface geophysics, becoming a more active member of EEGS is the absolute best way to do it. Join a committee, come meet us at the conference this March, and let's see what we can accomplish together. You will have many opportunities to interact with an amazing group of individuals who may reshape your professional and personal perspective in life, and contribute to the future of our Society.

The deadline for SAGEEP 2015 registration is fast approaching, and many events and short courses are almost full. This spring's meeting promises to be an extraordinary conference and I look forward to meet you in Austin.

Moe Momayez, EEGS President

EEGS Foundation makes great strides in its first years.

Since the launch of the EEGS Foundation, there are numerous accomplishments for which we can all be proud: Establishing and organizing a structure that serves the needs of EEGS; underwriting the legal process, achieving tax-exempt status; and soliciting and receiving support for SAGEEP. In addition, the Foundation helped underwrite the SAGEEP conference held this spring in Keystone.

These are only a few of the tangible results your donations to the Foundation have enabled. We would therefore like to recognize and gratefully thank the following individuals and companies for their generous contributions:

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There are always sponsorship opportunities available for government agencies, corporations, and individuals who wish to help support EEGS's activities. Specific opportunities include development and maintenance of an online system for accessing SAGEEP papers from the EEGS web site and support for our next SAGEEP. Make this the year your company gets involved! Contact Moe Momayez (mmomayez@email.arizona.edu) for more information.

From the *Fast*TIMES Editorial Team

*Fast*TIMES is distributed as an electronic document (pdf) to all EEGS members, sent by web link to several related professional societies, and is available to all for downloading from the EEGS *Fast*TIMES web site (http://www.eegs.org/fasttimes). Past issues of *Fast*TIMES continually rank among the top downloads from the EEGS web site. Your articles, advertisements, and announcements receive a wide audience, both within and outside the geophysics community.

To keep the content of *Fast*TIMES fresh, the editorial team strongly encourages submissions from researchers, instrument makers, software designers, practitioners, researchers, and consumers of geophysics—in short, everyone with an interest in near-surface geophysics, whether you are an EEGS member or not. We welcome short research articles or descriptions of geophysical successes and challenges, summaries of recent conferences, notices of upcoming events, descriptions of new hardware or software developments, professional opportunities, problems needing solutions, and advertisements for hardware, software, or staff positions.

The *Fast*TIMES presence on the EEGS web site has been redesigned. At http://www.eegs.org/fasttimes you'll now find calls for articles, author guidelines, current and past issues, and advertising information.

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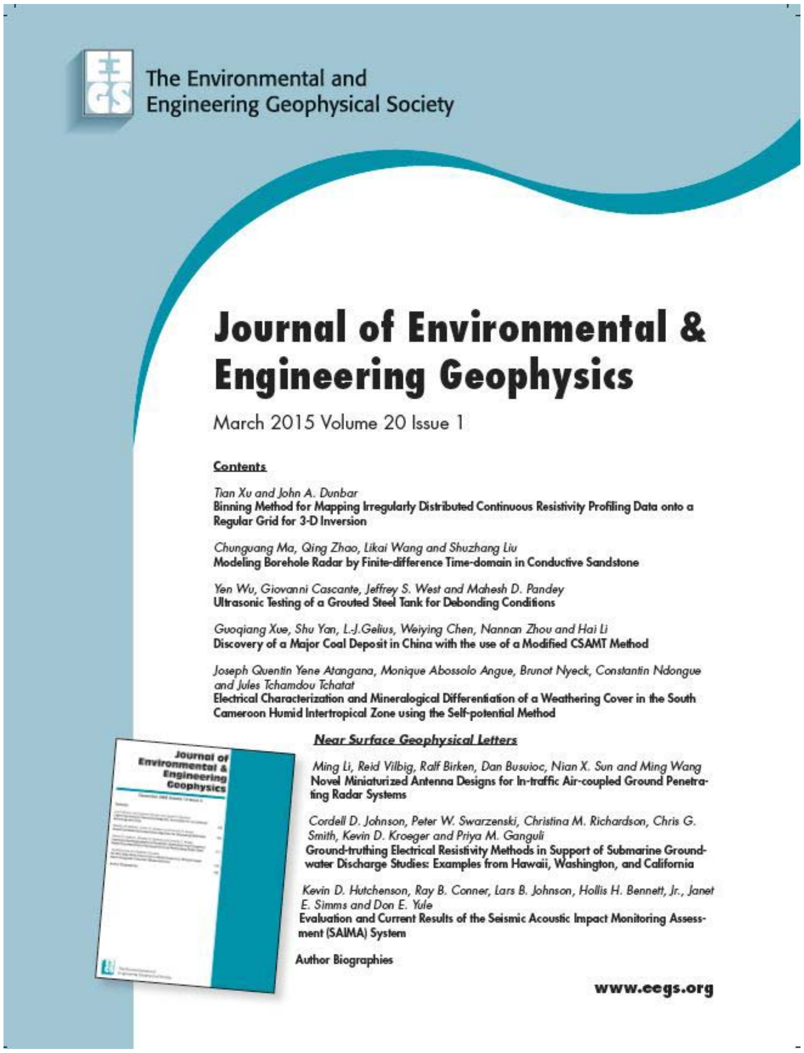
The *Fast*TIMES editorial team welcomes contributions of any subject touching upon geophysics. *Fast*TIMES also accepts photographs and brief non-commercial descriptions of new instruments with possible environmental or engineering applications, news from geophysical or earth-science societies, conference notices, and brief reports from recent conferences. Please submit your items to a member of the *Fast*TIMES editorial team by June 1, 2015 to ensure inclusion in the next issue. We look forward to seeing your work in our pages. Note: *Fast*TIMES is also looking for guest editors who are interested in organizing a *Fast*TIMES issue around a special topic within the guest editor's area of expertise. For more information, please contact Barry Allred (Barry.Allred@ars.usda.gov), if you would like to serve as a *Fast*TIMES guest editor.

JEEG NEWS AND INFO

The Journal of Environmental & Engineering Geophysics (JEEG), published four times each year, is the EEGS peer-reviewed and Science Citation Index (SCI®)-listed journal dedicated to near-surface geophysics. It is available in print by subscription, and is one of a select group of journals available through GeoScienceWorld (www.geoscienceworld.org). JEEG is one of the major benefits of an EEGS membership. Information regarding preparing and submitting JEEG articles is available at http://jeeg.allentrack.net.



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Editor's Note

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The Journal of Environmental and Engineering Geophysics (JEEG) is the flagship publication of the Environmental and Engineering Geophysical Society (EEGS). All topics related to geophysics are viable candidates for publication in JEEG, although its primary emphasis is on the theory and application of geophysical techniques for environmental, engineering, and mining applications. There is no page limit, and no page charges for the first ten journal pages of an article. The review process is relatively quick; articles are often published within a year of submission. Articles published in JEEG are available electronically through GeoScienceWorld and the SEG's Digital Library in the EEGS Research Collection. Manuscripts can be submitted online at http://www.eegs.org/jeeg.

SUCCESS WITH GEOPHYSICS

*Fast*TIMES welcomes short articles on applications of geophysics to the near surface in many disciplines, including engineering and environmental problems, geology, hydrology, agriculture, archaeology, and astronomy. In this issue of *Fast*TIMES, the featured article is focused on discrimination of buried unexploded ordinance using electromagnetic induction methods. In addition, expanded information is provided for SAGEEP 2015 (March 22 - 26 in Austin, Texas) with details on technical sessions, short courses, social events, etc.

FEATURED ARTICLE: ELECTROMAGNETIC INDUCTION TOOLS FOR DISCRIMINATION OF UNEXPLODED ORDNANCE: FROM BASIC PHYSICS TO BLIND TESTS

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Introduction

About 10% of ordnance fired in battle or during military practice fail to explode as intended. Millions of those unexploded objects now litter the landscape worldwide, underground and unseen, and constitute a serious environmental and humanitarian problem. In 2009, Chancellor Angela Merkel of Germany temporarily had to sleep in a hotel because an unexploded bomb from World War II was found across the street from her apartment. An average of three hundred tons of potentially deadly World War I ordnance are unearthed per year in Belgium. Between 2002 and 2006, unexploded ordnance (UXO) injured 2749 people in Afghanistan alone, half of them children; over this period, more injuries were caused by UXO than by landmines.

Keywords: Unexploded Ordnance (UXO), Electromagnetic Induction (EMI) Sensing, Inversion, Classification.

In the United States, UXO are often called "the Army's number one environmental problem." It is estimated that some 3800 sites in the U.S. are potentially contaminated with UXO, covering some 11 million acres of land—an area larger than the states of Vermont and New Hampshire put together—and a further several million underwater. Cleanup of former battlefields and military proving grounds will take several decades if it continues at the present pace. Current estimates (Prouty and others, 2011) place remediation costs at more than $100 per target, a figure that has to be multiplied by hundreds of millions.

This is not because detecting UXO is difficult. Electromagnetic induction (EMI) sensing can easily penetrate the ground and find buried metal, and so can other methods like magnetometry or ground-penetrating radar. What makes UXO decontamination so onerous and expensive is the inability of instruments to discriminate dangerous ordnance from surrounding harmless clutter—shrapnel, metallic rocks, nails, beer cans—that account for more than 95% of hits and that, in the absence of further information, must be treated as dangerous. Metal detectors that beep at everything are useless, as Figure 1 shows.

Figure 1: At the turn of the century, the search for UXO was carried out mostly with magnetometry, which can detect metal but cannot identify anything, resulting in an overwhelming number of false alarms. The magnetometer that took the data is leaning against the bucket in the foreground (photo courtesy of Roger Young).

It is vital to advance the speed and accuracy of the discrimination process. The protocol, sketched in Figure 2, starts with the collection of data over a signal anomaly suspected to contain potentially dangerous buried objects (like those shown in Figure 3) and ends with the decision whether to excavate the contents or not. The intermediate steps consist of inverting the data to extract meaningful parameters—how many targets there are, how deeply buried, of what electromagnetic properties—and classifying these parameters in a way that informs the final decision. The Electromagnetic Sensing Group of the Thayer School of Engineering at Dartmouth College and the Cold Regions Research and Engineering Laboratory of the U.S. Army Corps of Engineers (hereinafter the Group) has performed research on all of the steps mentioned above, with support and coordination from other ERDC laboratories. Its efforts have resulted in instruments that collect data of ever increasing quality and diversity and robust analysis techniques that have led to a more efficient and reliable UXO discrimination process.

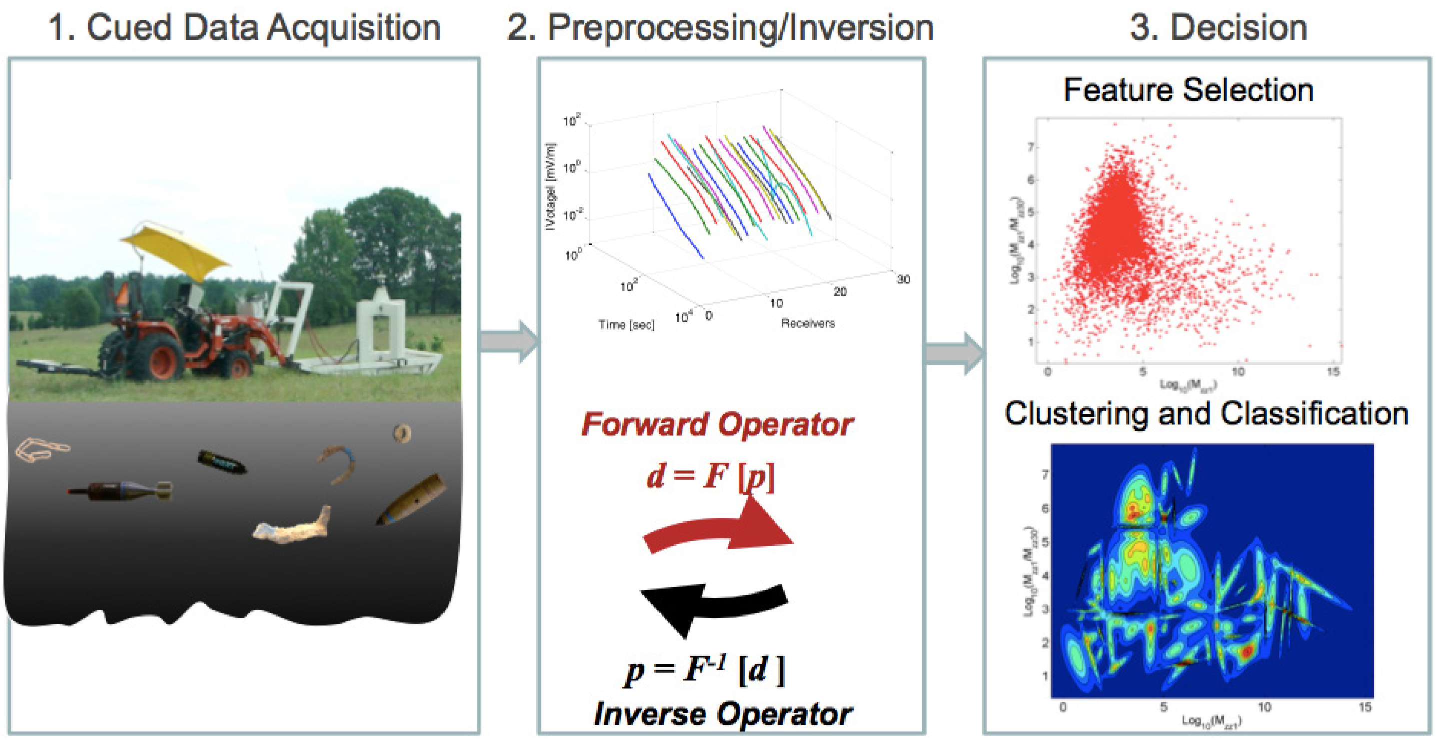

Figure 2: The UXO discrimination process involves data collection, inversion, and classification. The sensor on the left is the MetalMapper.

Figure 3: Ordnance items typically found in practice ranges in the United States. The UXO to be identified come in a wide range of sizes. Typical calibers range from 25 to 155 millimeters in diameter. **a**: 57-mm, MK-188 Rockeye, 40-mm, BDU and BLU bomblets, 25-mm, M42 grenade, and 40-mm grenade. **b**: 2.75" rocket, 81-mm, 60-mm, HEAT round, 105-mm howitzer shell.

The tools developed by the Group have been tried in a battery of blind tests administered by the Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP) of the U.S. military and have consistently obtained excellent results. The present article gives a brief survey of the Group's major undertakings and achievements. It starts with an overview of the physics of electromagnetic induction sensing and then enumerates and describes the analysis methods developed to harness the phenomena. The next section presents a series of instruments whose design has been influenced by the theoretical insights gleaned by the Group. Next comes a description of the increasingly realistic demonstrations that have challenged the Group's discrimination system and have highlighted its virtues. The final section offers some conclusions and extensions and hints at future developments.

Classification Process and Physical Models

Sensing the metal cases of UXO is currently easier than sensing chemical explosives directly. Electromagnetic methods are a natural choice for UXO sensing. Ground-penetrating radar, a technique widely used in geophysics, is beset in this case by ground-surface reflection, signal loss over depth, and signal clutter due to dielectric heterogeneities in the soil. Magnetometry cannot detect non-ferrous objects and has very limited discrimination capability. Halfway between lies the EMI frequency regime, which ranges between tens of hertz to hundreds of kilohertz.

In the EMI range, the ground is essentially transparent. On the other hand, the wavelengths of radiated fields are on the order of kilometers, which makes traditional wavelength-based imaging impossible. Instead, for object identification, model-based signatures must be inferred from the signals. Moreover, target examination has to be done in the near field and with a limited set of viewpoints. All these factors result in very poor spatial resolution and no direct indication of target depth. Overcoming these limitations is at the heart of all the Group's research.

Most electromagnetic induction sensors are composed of separate transmitter and receiver coils. When an operator activates a sensor, the transmitter creates a time-varying primary magnetic field that, by Faraday's law, induces eddy currents and magnetic response in nearby metallic objects, as seen in Figure 4. These disturbances in turn generate a secondary magnetic field whose flux through the receiver can be measured and recorded. From these data one expects to extract parameters such as the three-dimensional location of a target's centroid, the angles that specify its orientation, and some kind of signature that encapsulates its electromagnetic properties.

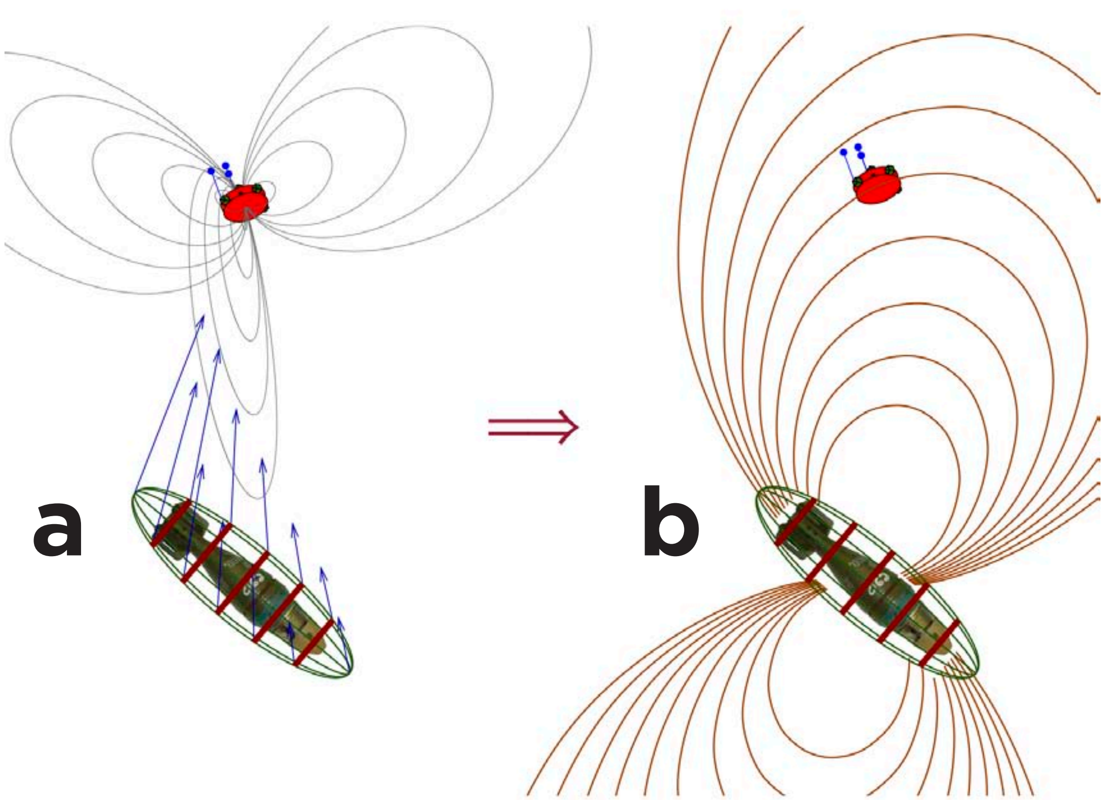

Figure 4: a: The time-dependent primary field of the sensor (curved lines) induces eddy currents and magnetic response in the target. **b**: The currents and magnetization in turn produce a measurable secondary field.

From the beginning, the Group has used analytic and numerical methods in tandem. Early efforts included a full analytic solution of the EMI response of a homogeneous spheroid with arbitrary excitation and, a carryover from the radar world, finite-difference time-domain simulations of integral equation formulations coupled to finite-element treatments of arbitrary bodies of revolution. While very instructive, these methods proved either too restrictive in the kinds of scenarios they could characterize or too detailed and slow for field deployment. Newer methods consist of increasingly elaborate generalizations of the dipole model.

Dipole and Dipole-Based Methods

The dipole model postulates that for a given object it is possible to find a set of axes such that a field pointing in any of the axial directions induces a magnetization parallel to it. These three responses, the principal polarizability elements, combine with the orientation of the object to form a tensor. The object is then replaced mathematically by a point dipole whose moment is the product of the tensor with the primary field. This widely used model is severely limited. It reduces any target, no matter how large and complex, to a point. It also assumes that every part of the target is excited by the same field, even though the fields produced by finite-size coils are highly nonuniform.

Despite its limitations, the dipole model includes the gist of EMI phenomenology. For time-domain EMI systems, the time-dependent decay profiles of the polarizability elements give insight into the size, shape, and composition of a target. Early times correlate with higher frequencies and superficial eddy currents, so objects with large surface area have significant early response. At late times, as eddy currents diffuse and lower frequencies dominate, the response relates to the metal content and the volume of the target. A small but compact object has a weak early response that dies down slowly, a big but hollow object has a strong initial response that decays quickly, and a large and tightly packed UXO-like object has a substantial and sustained response. Two polarizability elements' being equal or nearly so indicates that a target has cylindrical symmetry. Ferrous and non-ferrous objects have significantly different decay profiles.

Many of the methods developed by the Group reduce in essence to distributing assemblies of point dipoles and computing their collective response. The eddy currents and magnetic dipoles induced or realigned by a sensor on and inside a scatterer tend to concentrate at some particular points, the so-called "wave-field singularities," and thus the response of the entire scatterer can be reproduced to arbitrary precision using a set of responding elementary sources placed at those spots (Shubitidze and others, 2010). It is essential to add constraints to prevent overfitting. To study heterogeneous objects, the Group studied various modifications of the dipole model early on. In the "displaced dipole" model, each section of a target is represented by a dipole, and the dipoles are constrained to lie along the symmetry axis. Also considered were "dumbbell" configurations with a central dipole supplemented by two others, facing each other and lying symmetrically along the axis. Newer dipole-based models use insights provided by the method of auxiliary sources (MAS).

MAS

The MAS represents the electromagnetic fields in each domain of the structure under study as being caused by finite combinations of auxiliary sources—in this case, dipoles—located on fictitious surfaces conforming to domain boundaries (Shubitidze and others, 2002). Enforcement of the electromagnetic boundary conditions results in a linear system of equations of straightforward computational solution. Unlike other techniques explored earlier, the MAS does not require detailed mesh structures over a volume. While this method has been invaluable in research that illuminates the fundamentals of UXO EMI phenomenology, it is not well suited to discrimination calculations. The mathematical sources employed are too many and too various to provide useful discrimination parameters, especially relative to the simplicity of just three elements afforded by the dipole model. A possible way out is to surround the scatterer with a prolate spheroid and setting up a reduced set of sources on the supplementary surface, as in the standardized excitation approach (SEA).

SEA

There are two versions of the SEA: the MAS-SEA and the data-derived SEA. In both variants, the target is replaced by a surrounding prolate spheroid and the primary magnetic field at the surface of the spheroid is decomposed as a weighted sum of standardized excitation modes. The response of the target to each of these modes is computed and stored in a library. The effect of a different primary field can be synthesized as a superposition of the catalogued responses with different weights.

The MAS-SEA uses the MAS to build a detailed numerical representation of each possible target and uses the reduced sources as inversion parameters. The data-derived SEA determines the modal responses using precisely controlled measurements and specifies the sources as azimuthal rings of dipole moment. This latter method suffers from ill-conditioning and requires regularization. Also, several modes are required for good inversion, and their physical interpretation is not straightforward. Attempts to simplify the situation led to the NSMS model.

NSMS

The normalized surface magnetic source (NSMS) model encloses a given object with a prolate spheroid and distributes on the surrounding surface a continuum of radially oriented dipoles (Shubitidze and others, 2007). The strengths of these sources, scaled by the normal component of the transmitted primary field, are determined from measured data. A composite polarizability can be found by integrating over the surface of the spheroid. This “total NSMS” varies significantly for different targets but is quite consistent for different samples of the same object.

A shortcoming of the NSMS model as described is that it produces one signature instead of three and is unable to detect symmetry. A modified version circumvents this limitation by distributing full tensor dipoles on a sphere. This method had great success at first but eventually was found to have difficulties with small targets and low-SNR cases. This prompted the development of the orthonormalized volume magnetic source (ONVMS) model.

ONVMS

The ONVMS model is the culmination of the Group’s efforts to produce a physically complete inversion procedure (Shubitidze and others, 2014). The method assumes that a measured secondary field originates from a distribution of elementary dipoles throughout the volume under scrutiny. What distinguishes the method from other multi-dipole techniques is that the spatial functions that connect the dipole sources with the field are turned into an orthonormal basis using a generalization of the Gram-Schmidt method. This eliminates the need to solve large and ill-conditioned systems of linear equations—ONVMS must also invert matrices, but these are only 6 x 6 and always well behaved—and thus removes the need for regularization, accelerates the method, and makes the resulting fingerprints more robust and noise-tolerant.

This generalization of the dipole model simultaneously allows for the presence of several targets in the field of view of the sensor and for the possibility that at least one of the targets is of such size or complexity that it needs more than one dipole to account for the nuances of its response. The method has been successful in analyzing cases with up to six targets, with one of the targets needing two sources for a full description. Figure 5 shows a detailed analysis of a test-stand case that also employs some of the adjunct joint diagonalization procedure outlined below.

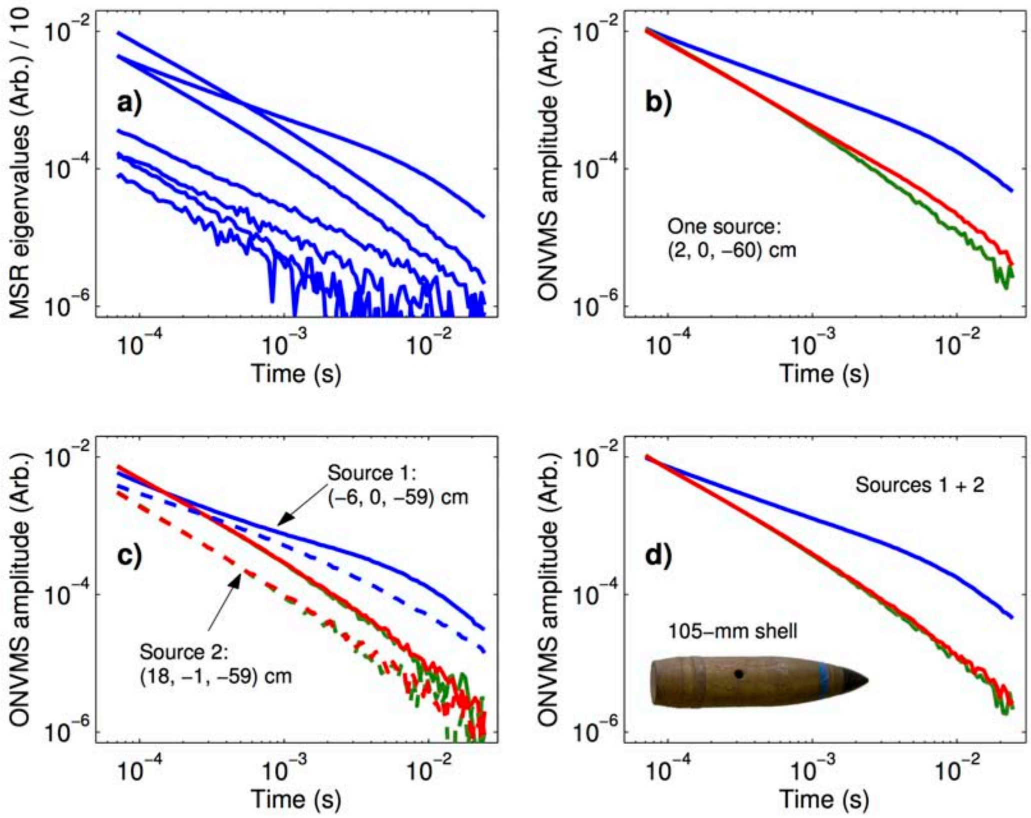

Figure 5: ONVMS inversion of a test-stand measurement involving a 105-mm shell with copper driving band. A JD analysis (**a**) shows three dominant eigenvalues, indicating the presence of at least one target and providing a starting guess for the ONVMS inversion. The ONVMS procedure with one dipolar source (equivalent to the simple dipole model) gives the polarizability elements of (**b**). These are not completely satisfactory because objects with azimuthal symmetry are expected to have two identical transverse elements. A two-source inversion (**c**),(**d**) improves the fit to the measured data, restores the azimuthal symmetry, and reveals that one of the sources is partly describing the driving band. This symmetry is essential to distinguish targets of interest from clutter in noisy data.

Other Procedures

The above models must be supplemented by various other pre- and post-inversion techniques.

Object Enumeration

It is desirable to have a fast and direct way to determine if there are any targets at a given measurement cell, and, if so, estimate their number. To do this, the Group adapted a signal-processing technique based on joint diagonalization (Shubitidze and others, 2012). The method arranges multi-transmitter/multi-receiver measurements into a frequency- or time-dependent set of matrices. The matrices are square if the sensor has as many receivers as transmitters, and if not they can be made square by transpose multiplication.

The number of nonzero eigenvalues of each matrix provides an estimate of an upper bound to the number of targets under interrogation, and the time development of the eigenvalues partially characterizes the targets. A key advantage of the technique is that it requires no inversion for target location or properties. The eigenvalues are tracked through time by diagonalizing all matrices simultaneously. The first panel of Figure 5 shows a test-stand application of the method.

Object Location

Most of the above models combine inversion and search in a single optimization. This straightforward approach is viable thanks to the efficiency and accuracy of the forward models and the good initial target-number guesses provided by joint diagonalization. The optimizer that best interacts with ONVMS is differential evolution, a parallelizable, direct-search genetic algorithm (Storn and Price, 1997).

On the other hand, it is desirable to have good prior knowledge of the locations of the targets to have good starting guesses for the optimization. For one-target scenarios, the Group developed a method that utilizes analytic relations between the location of a point dipole, its magnetic field, and the vector and scalar potentials that give rise to the field (Shubitidze and others, 2008). The method replaces the target of unknown position with a collection of dipoles placed on a known grid. The nonlinear problem of determining the location of the object becomes a linear system of equations for the source strengths.

Object Classification

Once the locations and electromagnetic signatures have been found by inversion, it is necessary to classify the targets as dangerous or harmless, and, if at all possible, to identify each target of interest as a particular kind of UXO. This crucial step involves human expertise and decision-making, though a long-term goal is to eliminate this need.

The Group's classification system uses both template-matching—visual or least-squares comparison of an unknown target's signature to a standardized set stored in a library—and statistical procedures such as hierarchical clustering, Gaussian mixture models, support vector machines (SVM), or probabilistic neural networks, aided by expert judgment (Fernández and others, 2010).

In real-world blind tests, the classification process proceeds in interactive stages and comprises both supervised and unsupervised learning (Bijamov and others, 2014). When there is no training information beyond a list of expected UXO types, the first round consists of unsupervised clustering. The result is a scored list of representative UXO and clutter whose ground truth is requested and used to train classifiers. The process is iterated, recalculating scores at every step to incorporate new information. The final round of classification takes place when all types of ordnance have been found.

Instruments

In response to the advanced models' data needs, the Group helped develop instruments that increase information content by expanding the number of sensor-target viewpoints and measuring all three vector components of the secondary field. It is essential to know with high accuracy the location of the sensor head because the field varies as a high power of the sensor-target separation and small positional uncertainties have large effects.

GEM-3D

The GEM-3D is a handheld frequency-domain sensor developed in cooperation with Geophex. The instrument, pictured in Figure 6, has a wide frequency range from 30 Hz to 100 kHz and outputs all three field vector components. One of the features that make the GEM-3D potentially useful for dependable UXO identification is a lightweight and unobtrusive positioning system that provides sub-centimeter accuracy and can be used in treed or rugged terrain. The system uses the sensor head as a beacon: the full primary field is measured at two points equidistant from the chosen origin and located on a beam whose orientation defines the coordinate axes. The only on-sensor hardware is a lightweight electronic compass.

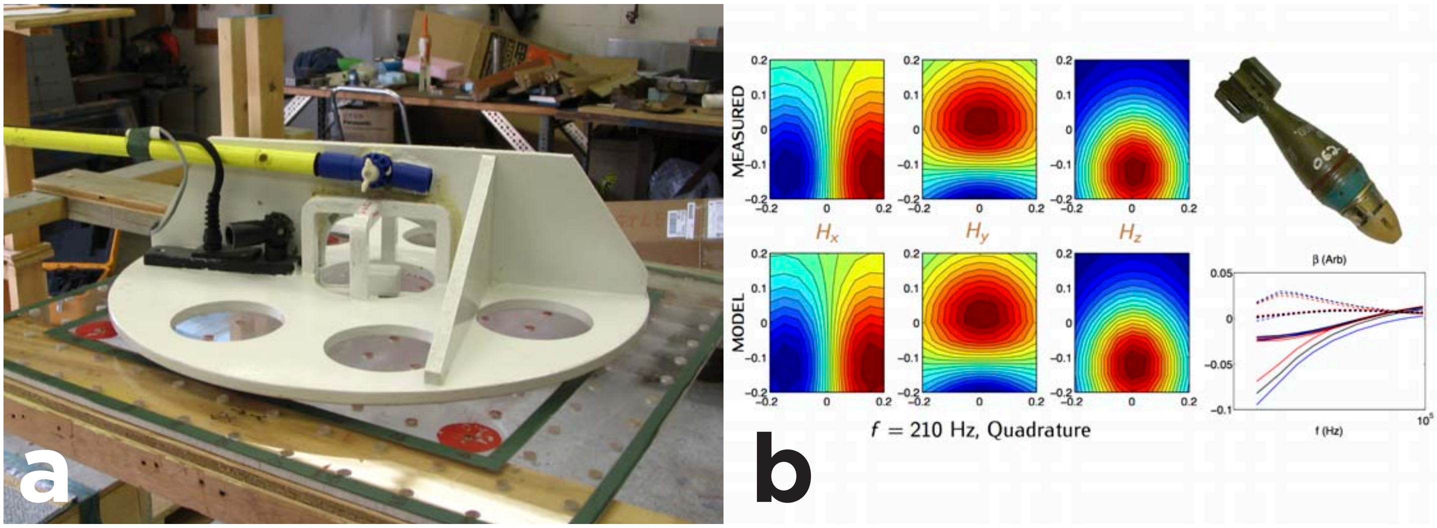

Figure 6: a: The GEM-3D is a handheld frequency-domain instrument that measures the three vector components of the secondary magnetic field. **b**: GEM-3D data taken over a 60-mm UXO pointing 45° nose down, inverted using the dipole model. The left panels compare the measured and modeled field components (quadrature parts) measured at 210 Hz. The right panel shows the inferred polarizability elements (solid: inphase; dashed: quadrature).

MPV and MPV-II

The Man Portable Vector (MPV), developed in cooperation with G&G Sciences, is a time-domain handheld monostatic/multistatic instrument (Fernández and others, 2011). At each sensor location there are five receiver locations at two different heights and three vector components at each receiver, for a total of 15 usable measurements. The sensor can be operated with user-adjustable temporal resolution in either high-SNR static or high-diversity dynamic acquisition mode. The primary field of the MPV is produced by two concentric circular transmitting coils separated by a vertical distance. The instrument is equipped with a laser positioning system that tracks its location with sub-centimeter precision.

The MPV-II, a second iteration of the MPV pictured in Figure 7, was developed to address some limitations of the initial design (Kingdon and others, 2014). The sensor head is one-third smaller and weighs half as much as the original. The receivers are all on one plane, smaller, and set closer together. The new system is more ergonomic, has an enhanced user interface, and communicates wirelessly with the data-acquisition system for increased portability. The positioning system of the MPV-II is beacon-based, like that of the GEM-3D. Figure 8 shows examples of inverted MPV-II data.

Pedemis

The Portable Decoupled Electromagnetic Induction Sensor (Pedemis) was designed for use in rough, broken, or wet terrain (Barrowes and others, 2013). This time-domain instrument can be carried or cart-mounted and can be used for detection or for in-depth interrogation. The 3 x 3 vector receiver array of Pedemis can be attached to the 3 x 3 coplanar transmitter assembly or detached and moved independently. Each data shot provides 243 measurements.

Like the GEM and MPV-II, Pedemis has a beacon-based positioning system: the receivers record the field components when the current is on, and the system takes the readings and finds the location and tilt of the receiver head by optimization. This eliminates the need for a complex, external, corded positioning system to determine the relative positions of transmitters and receivers.

In its first field test, Pedemis was deployed at Aberdeen Proving Ground (APG), a standardized UXO technology demonstration site in Maryland, to survey a blind-test grid whose 400 cells contain either munitions, clutter, or nothing. The instrument and analysis protocol developed by the Group found all the UXO in the blind grid, submitted only four false positives, missed three pieces of official clutter, and discovered 29 extra pieces of clutter that were not in the official roster. These scores are the best to date for any instrument at APG. Figure 9 shows the sensor and an ONVMS analysis of four APG targets.

Figure 7: The MPV-II is a handheld time-domain EMI instrument that gives five three-dimensional data readings per sensor location. To the right of the sensor are the receivers from the MPV-II's beacon positioning system.

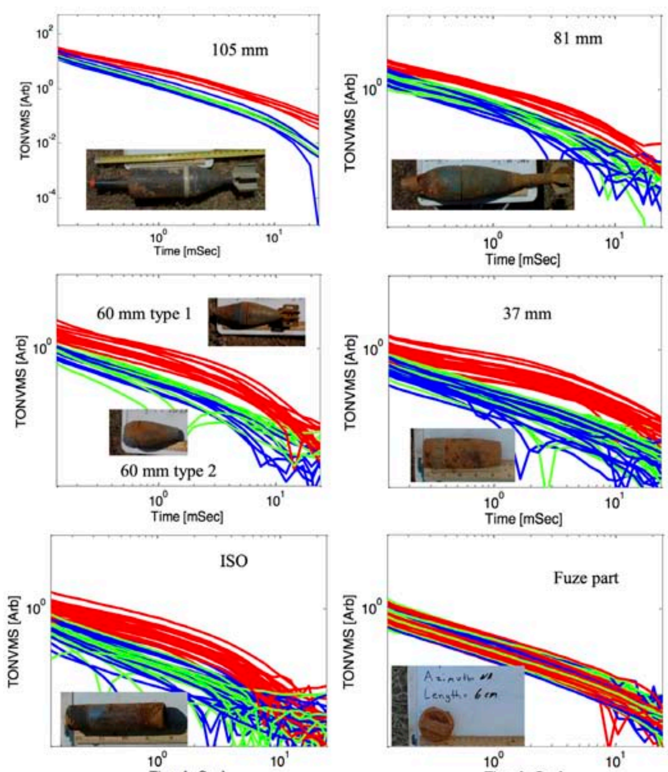

Figure 8: Multiple measurements of the three ONVMS amplitudes (polarizability principal values) for six different kinds of targets, inverted from MPV-II data collected at Camp Beale. Shown are ordnance with calibers of 105-mm, 81-mm, 60-mm (two types), 37-mm, ISO projectiles, and fuze parts.

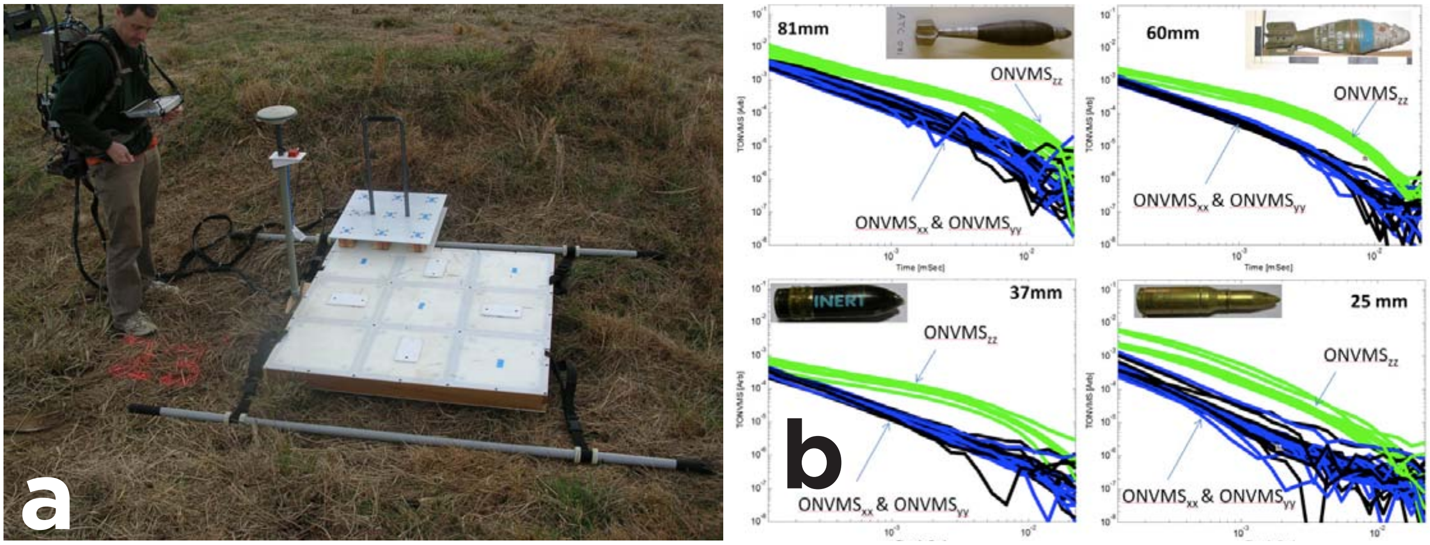

Figure 9: a: The Pedemis instrument has a detachable receiver assembly and is designed for use in rough terrain. **b**: Inverted Pedemis data showing inferred principal ONVMS polarizability values for cases from Aberdeen Proving Ground corresponding to 81-mm, 60-mm, 37-mm, and 25-mm ordnance.

Other Instruments

The following instruments did not receive specific input from the Group during their development, but have been and continue to be extensively used in the UXO live-site demonstrations and blind tests to which we have applied our discrimination analyses. Both are large, carted time-domain instruments.

TEMTADS

The Time-Domain Electromagnetic Multisensor Towed Array Detection System (TEMTADS), developed by the Naval Research Laboratory and G&G Sciences, has a rigid 5 x 5 array of square coplanar transmitter coils, each surrounding a concentric square receiver. The transmitters fire one by one, and each time the 25 receivers simultaneously measure the flux due to the vertical component of the secondary field. This produces 625 measurements at each sensor location. The sensor's rigid structure eliminates the need for local positioning. A newer handheld version of TEMTADS features a 2 x 2 transmitter/receiver grid and triaxial receiver cubes.

MetalMapper

The Geometrics MetalMapper is designed to characterize a buried metallic target using a single data shot (Prouty and others, 2011). The instrument has three mutually perpendicular square transmitters and an array of seven coplanar vector receivers, giving 63 measurements at each sensor location. Like TEMTADS, the MetalMapper has a rigid structure and does not need a positioning system to locate receivers relative to transmitters.

Test Site Results

Real sites contain assorted types of ordnance of varying sizes and all kinds of clutter in areas of differing terrain, vegetation, and geology. The blind tests administered by SERDP and ESTCP have been designed to ensure that competing hardware and software for UXO discrimination can take on progressively difficult tests in increasingly demanding circumstances and still provide successful discrimination.

After the data collection, each team of analysts must submit a dig-list labeling every anomaly as "dig" or "no dig" and ranking anomalies in order of confidence: that is, at the top of the list must be the targets of interest (TOI)—those anomalies that the analysts are completely confident that should be excavated—and at bottom must be those that undoubtedly are safe to leave buried. Somewhere in the gray area in the middle, the boundary between "dig" and "no dig" is marked as the stop-digging point.

In all cases described below, the Institute for Defense Analyses (IDA) provided independent standardized scoring of the submitted final dig-lists in the form of receiver operating characteristic (ROC) curves. To build a ROC curve, one puts the ground truth side-by-side with the confidence-sorted TOI/non-TOI list. The anomalies are excavated one by one in order of the certainty that they are TOI. With each target correctly identified as TOI, the curve goes up one vertical notch. Every false alarm moves the curve to the right, augmenting the false-alarm count while keeping the TOI count the same. If the classifier does a perfect job, there are no false alarms and the ROC curve is a perfect right angle with the stop-digging point located at the top left. Any misclassified anomalies displace the point down and right. The area under the curve is thus a measure of classifier quality.

Camp Sibert

The first live-site blind test site was held in 2006 at Camp Sibert in Maryland. The commercial Geonics EM-63 sensor took several hundred time-domain data points per cell in 216 square test cells, each of which contained at most one target. The targets of interest were 4.2″ mortar shells, and the aim was to discriminate the shells from explosion byproducts represented by base plates and partial shells. Some cells were empty or had smaller shrapnel or non-UXO related scrap. The Group was given the ground truth for 66 of these cases and was asked to test its inversion and classification methods on the other 150.

In hindsight, the classification task at Camp Sibert was not particularly difficult, given that it involved discrimination of large intact ordnance from smaller clutter. Several different methods gave essentially perfect discrimination. Results from combining NSMS and an SVM classifier appear in Figure 10 (Fernández and others, 2010).

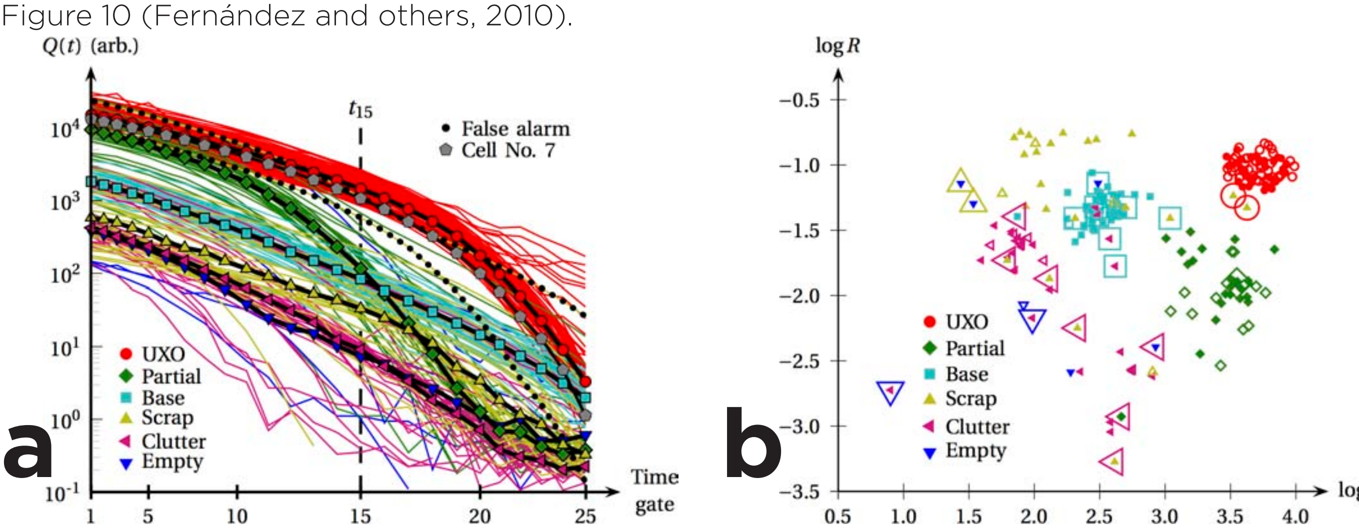

Figure 10: NSMS inversion and SVM classification of the data taken at Camp Sibert during the first ESTCP blind test. **a**: The UXO (red dots) are easily distinguished from the other objects by being large and dense. Munition-related clutter included bent, hollowed shells (green rhombi), which have a large initial response that decays fast, and dense but small base plates (cyan squares), whose weak initial response decays slowly. (*Q* stands for the time-dependent total NSMS amplitude.) **b**: The classification correctly identified all UXO at the top-right corner and had two false alarms due to large pieces of scrap (yellow triangles). The classification parameters are *R*, the ratio of total NSMS at the 15th time gate to that at the first, and *k*, an amplitude that results from fitting the NSMS curves with a combined power-law/exponential decay.

Camp San Luis Obispo

The next ESTCP blind discrimination test took place in 2009 at Camp San Luis Obispo in California. The group studied data collected by the TEMTADS and MetalMapper systems. Four kinds of ordnance were expected at the site—60-mm mortar shells, 2.76″ rockets, 81-mm projectiles, and 4.2″ mortars—and analysts were expected not just to assess whether a target was potentially harmful, but also to classify it by caliber. Each data shot (1282 from TEMTADS and 1407 from MetalMapper) could include more than one target.

The Group used the NSMS model and differential evolution to invert the data. The resulting total NSMS were fed into several multi-class statistical procedures to perform discrimination. One hundred eighty-eight calibration datasets provided by SERDP were used to test the algorithms at all stages and to build a catalog of expected total NSMS values.

The Group correctly identified all large UXO for both sets of data. The algorithm had one false negative for MetalMapper and seven for TEMTADS, all due to small signal to noise ratio. We also observed that NSMS time-decay curves of smaller targets had a large spread that hampered classification. These findings prompted the development of the ONVMS model.

Camp Butner

Another demonstration was held in 2010 at Camp Butner in North Carolina. The test was expected to be challenging because a substantial number of TOI were of similar size to clutter. Also buried were samples of two varieties of 105-mm rounds. These are easier to identify, but their fuzes tend to break off upon impact and constitute another kind of potentially dangerous target. In total, the test comprised 2291 anomalies, of which 171 were considered TOI: one hundred twenty-one 37-mm projectiles of two different kinds, thirteen 105-mm high-explosive anti-tank (HEAT) rounds, thirteen 105-mm HE howitzer shells, and 24 fuzes. TEMTADS and MetalMapper took the data.

The inversion process used joint diagonalization to estimate the number of targets in each anomaly, differential evolution to locate the targets, and ONVMS to extract their intrinsic electromagnetic signatures. The classification was performed using a combination of hierarchical clustering and Gaussian mixture modeling (Bijamov and others, 2014). The Group requested unearthing 70 anomalies for classifier training,

Figure 11 shows the ROC curves obtained by the Group in their TEMTADS and MetalMapper studies (Cazares and others, 2011). The IDA's assessment declared the ONVMS analyses to be the "best results seen at the former Camp Butner," noting that the method correctly identified all potentially dangerous targets and made it unnecessary in principle to excavate more than 90% of the false alarms. In other words, the method would have saved a remediation team the time and money needed to carefully dig 2004 false alarms.

Camp Beale

The next site to be chosen for an ESTCP blind test was the former Camp Beale in California (Nelson and Andrews, 2012). The demonstration was conducted using the MPV-II, the 2 x 2-3D TEMTADS, and the MetalMapper; the Group analyzed data from all three. The site contained a wide mixture of TOI—37-mm, 60-mm, 81-mm, ISO, and 105-mm UXO—and native targets that might be of interest, such as fuzes and fuze parts. The Group analyzed the data with the same combination of techniques that were successful at Camp Butner. All UXO were identified correctly for all sensors, and at least 75% of the thousands of clutter items were left undug. The Group identified two TOI fuze types that were not expected at the site—and that no other group found—and was able to discriminate targets as small as 3-cm fuzes. The ROC curves for the MPV-II data analysis appear in Figure 12.

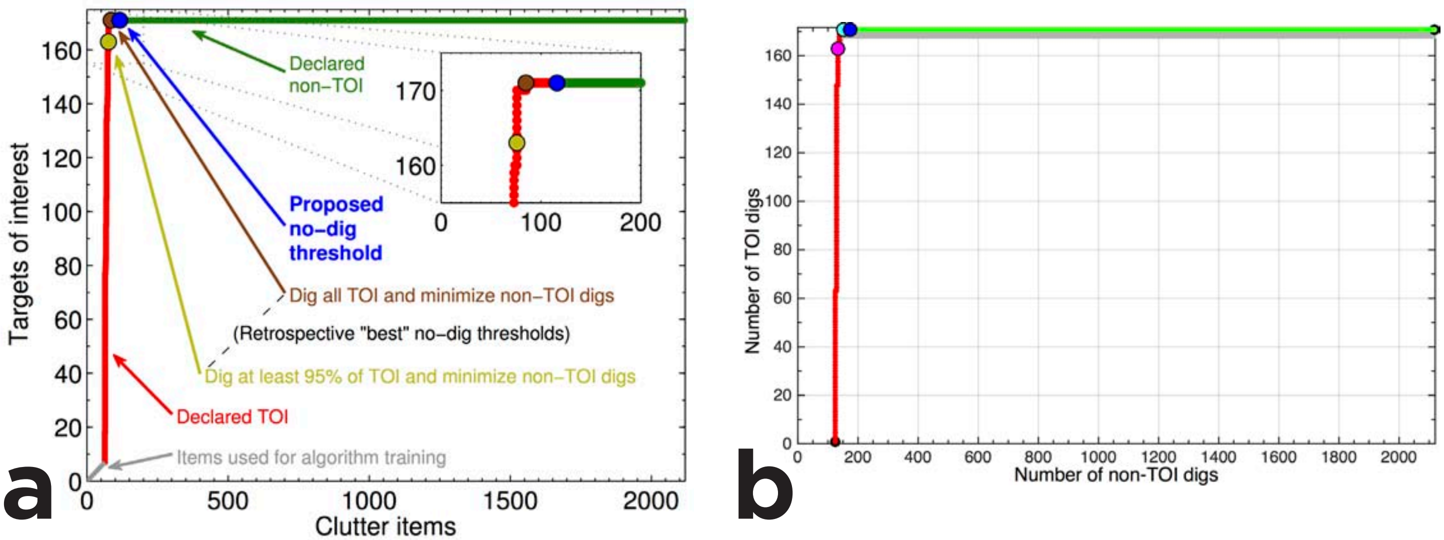

Figure 11: a: Receiver operating characteristic (ROC) curve assessing the Group's inversion protocol at the Camp Butner ESTCP demonstration. The data were taken with TEMTADS. The inset zooms in on the area surrounding the stop-digging point. The rightmost (blue) dot indicates the no-dig threshold proposed by the Group. The middle (brown) and leftmost (yellow) dots correspond to two retrospective optimal no-dig thresholds determined by the Institute for Defense Analyses. **b**: ROC curve for the Group's analysis of MetalMapper data collected at Camp Butner.

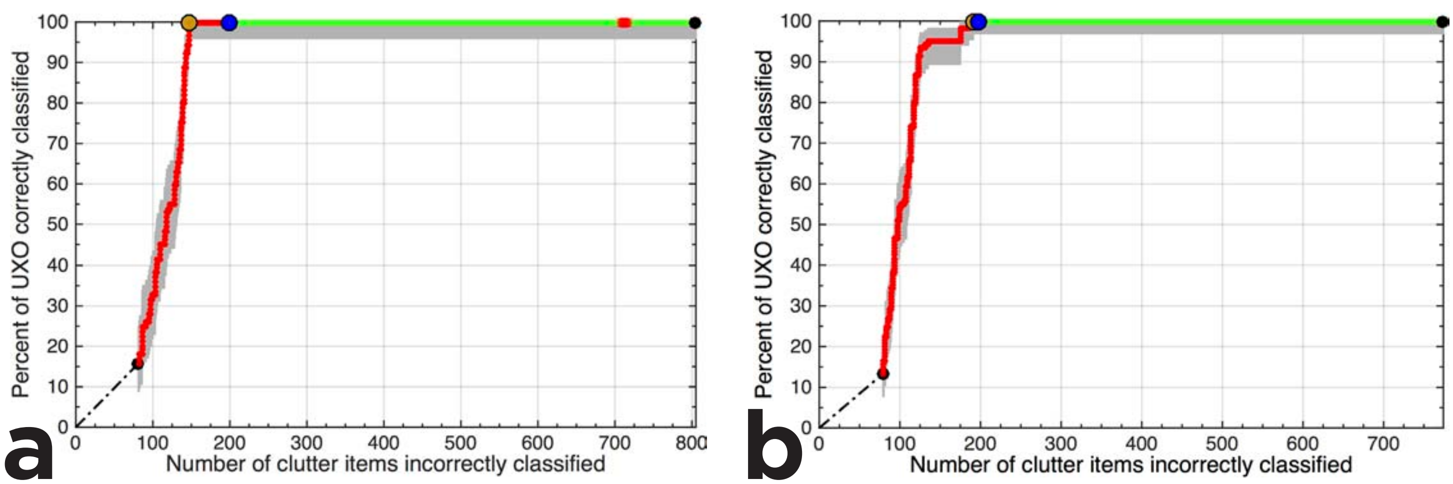

Figure 12: ROC curves scoring the Group's classification results for MPV-II data collected at Camp Beale. The **a** curve shows the outcome of considering fuzes as clutter; the **b** curve considers fuzes to be targets of interest that must be excavated.

Massachusetts Military Reservation

Another ESTCP classification study was held in 2012 at the Massachusetts Military Reservation. The main objective of this study was to detect and discriminate UXO to deter groundwater contamination. The site was highly cluttered. The Group extracted the targets' EMI features from 2 x 2 TEMTADS data and used the recovered parameters to perform classification. The scored result for the 2 x 2 TEMTADS sensor is shown in the left panel of Figure 13; it is very clear that a combination of advanced hardware and software can identify mixed-type and deeply buried TOI with confidence.

Fort Sill

The latest demonstration we note here was held at Fort Sill in Oklahoma (ESTCP, 2013). A wide mix of munitions were expected to be at the site: 37-mm target practice tracers, 60-mm illumination mortar rounds, 75-mm and 4.5″ projectiles, 3.5″ , 2.36″ and LAAW rockets, antitank mine fuzes with and without hex nut, practice MK2 and M67 grenades, 2.5″ ballistic windshields, M2A1 mines with and without bases, M19-14 time fuzes, and 40-mm practice grenades with and without cartridge. The total number of anomalies, hazardous or harmless, was 1908. There were 290 targets of interest, of which 150 had been seeded. Two areas with very high target densities were chosen to determine the point at which each discrimination scheme would break down.

The Group studied data collected with the MetalMapper. Again, joint diagonalization counted the targets, differential evolution located them, and ONVMS characterized them. The scored results appear in the right panel of Figure 13. The Group's result was significantly better than those obtained by the other participants. The technology did not break down: it correctly identified all TOI—with the single exception of a 40 mm grenade right next to the stop-digging point—and could have let remediators leave at least 75% of the clutter in the ground.

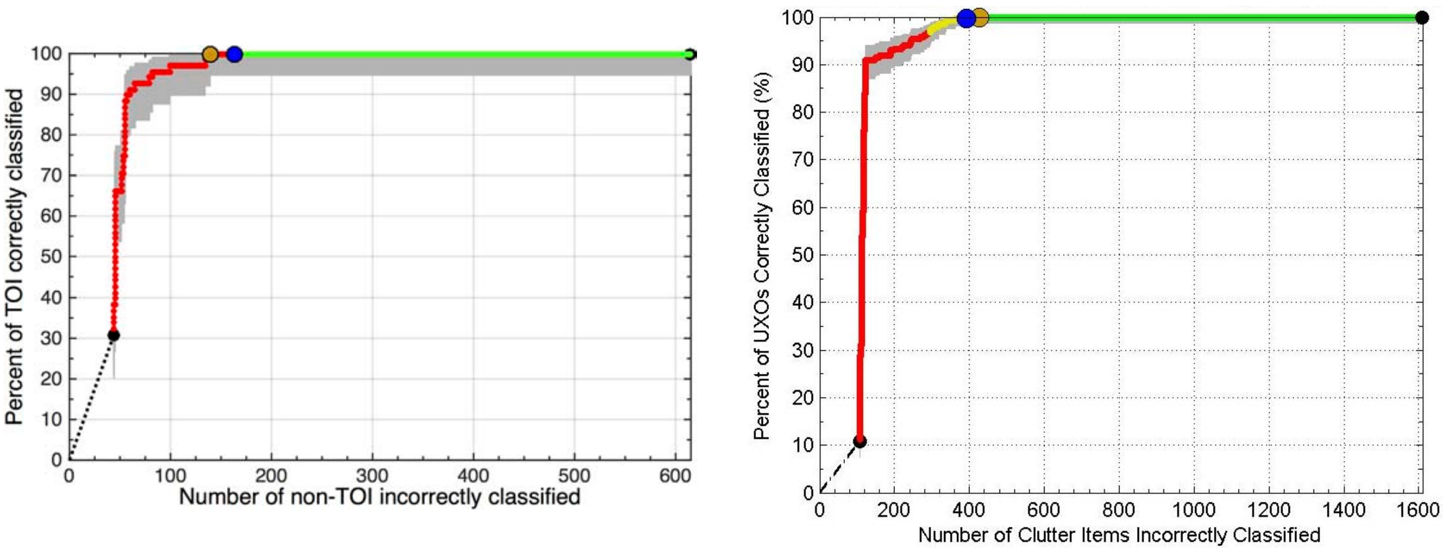

Figure 13: a: ROC curve scoring the discrimination results obtained by the Group using 2 x 2 TEMTADS data collected at the Massachusetts Military Reservation. **b**: ROC curve assessing the performance of the Group's discrimination system on data collected by the MetalMapper at Fort Sill, OK. This site had many difficult targets, among them a set of grenade caps.

Conclusion

The last 15 years or so have seen UXO discrimination evolve, thanks to the vision and support of SERDP, ESTCP, and ERDC, from prohibitive trial and error with no end in sight into a science with solid foundations, sophisticated apparatus, and a powerful analysis framework. Current results based on the techniques presented here allow UXO personnel to leave many targets in the ground, to the point that even at difficult sites it takes only about two digs to recover a dangerous target. The agencies that led and supported the development of the discipline are now starting to look beyond R&D and kick UXO cleanup into full production gear. The entire remediation process is now being performed by private companies, and the U.S. Army Corps of Engineers is in the process of developing appropriate regulations.

The Group is itself transitioning into this new reality through technology transfer. The MPV has already been used as part of a humanitarian demining operation in Laos and has been proposed as part of a robotic system for roadside-bomb and pipe detection. The MPV-II is being developed commercially. The Group's physically complete models are being incorporated into analysis software for several platforms.

A challenge that remains is to take the analysis tools to the point that they can be used in the field by any operator without the need for expert judgment. Until that happens, the Group will continue to educate and train the UXO community. One of the authors has prepared a detailed presentation of the Group's methods and findings that will appear in a forthcoming book (O'Neill, 2015).

At present, the Group is starting to extend the frequency range under study into the megahertz regime (Grant and others, 2014). A new generation of ordnance will have carbon fibers replacing metal in some sections, making it necessary to develop methods to sense those new objects to support cleanup of future firing ranges and battlefields. The same frequency range can be used to detect subsurface homemade explosives. It goes without saying that expanding the frequency range comes with a whole set of new challenges. The group is also currently studying the application of its earned knowledge to other security-related, environmental, and medical topics: Arctic surveying to investigate permafrost recession, tunnel detection, and the design of hardware for genome sequencing are some examples. In the long run, the Group's research will result in a cleaner, safer, less contaminated environment free from hazardous remnants of military activity.

Acknowledgments

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Welcome to SAGEEP 2015 in Austin, Texas, March 22–26!


Jeff Paine, General Chair


Brad Carr, Technical Chair


Doug Laymon


Dennis Mills


Kealie Goodwin

Dear Colleagues:

We're looking forward to welcoming you to Austin and the 28th Symposium on the Application of Geophysics to Engineering and Environmental Problems! Those of us on the local planning committee are making final preparations for your visit, and we hope to show you some true Texas hospitality. Austin is the Capital of the great state of Texas, and the home of many myths and legends. While the main attraction is the technical program, this SAGEEP is also many other things: a reunion, an exhibition, an opportunity to make friends and colleagues, and to some degree, a party all wrapped in one grand event. Please come and enjoy yourself, socialize, and when it all ends, start making plans to attend the 29th SAGEEP in 2016!

Dennis Mills, Doug Laymon, Brad Carr, Kealie Goodwin (local committee members) and I have tried very hard to infuse this SAGEEP with lots of Austin flavor. From the amphibious Duck Tour on Sunday afternoon to the Tour of the Geologic and Engineering Wonders on Thursday, this SAGEEP has something for everyone. Students: in addition to the regular conference events that are open to all, Kealie has organized a student social event and taco bar on Sunday night on the rooftop of the Rattle Inn. There's also a fajita luncheon and career forum on Wednesday at Serrano's. For those who like barbecue and an outdoor, natural setting, we have combined the outdoor demo, catered barbecue, socializing, and a special presentation on the discovery, excavation, and exhibition of La Salle's famous shipwreck, *La Belle* at the Kali-Kate Pavilion south of town. Micki Allen has arranged the Conference Evening at Max's Wine Dive in downtown Austin, complete with wine, a violinist, a meal, and even a band. The Exhibit Hall is home to some 40 vendors, Sunday's popular Icebreaker, and morning and afternoon coffee breaks. Bill Doll has rounded up a great collection of short courses on marine geophysical surveying, the HVSR method, borehole logging, and Python programming, and has topped it off with a world-class MASW forum.

In addition to the Student Luncheon and Career Forum on Wednesday, Geoscientists *Without* Borders® is putting on the Monday luncheon, and the EEGS business luncheon on Tuesday has been expanded to include a near-surface community forum where attendees can hear from EEGS leaders as well as from representatives of the other near-surface geophysical societies. You'll certainly not go hungry at SAGEEP!

Ah, and the technical program. Brad Carr has led the development of a program that begins with the four best of EAGE/NSGD's Near Surface 2014 conference in Athens and continues through more than 230 oral and poster presentations. Be sure to join us in the poster area at the close of technical sessions on Tuesday and Wednesday to share a beer and visit with the poster presenters.

Finally, the backbone of it all is the stalwart staff at the EEGS business office, led by Jackie Jacoby and Jayma and Jacey File, and Micki Allen, who manages the Exhibition. Be sure to thank them sometime during the week. You'll find them at the registration desk, the Exhibit Hall, or scurrying around the hotel.

You'll surely have a great time while you're here.

Jeffrey G. Paine

Jeffrey G. Paine
General Chair, 28th SAGEEP

SAGEEP 2015 SCHEDULE AT A GLANCE

Sunday March 22

Time	Event
Duck Tour 2:15-3:30 pm	Amphibious Duck Vehicle Tour of Austin or Circuit of the Americas Formula One Track
8am-5pm	SC-1: **AN INTRODUCTION TO PYTHON PROGRAMMING FOR SCIENTISTS - *Creekside I*** Presenters: Enthought Scientific Computing Solutions FORUM: **MASW IN AN URBAN ENVIRONMENT - Soil characterization and microzonation studies - *Capitol View Terrace North*** Presenters: Julian Ivanov, PhD., USA; Jianghai Xia, PhD., China; Chi-Ping Lin, PhD., Taiwan; Oz Yilmaz, PhD., Turkey; Koya Suto, BE, ME, Australia; Vassilis Karastathis, Ph.D., Greece
5:30-7:30pm	Ice Breaker - Exhibit Hall - *Capitol Ballroom*
7:30pm	Student Social and Taco Bar - *Rattle Inn* (walking distance)

Monday March 23

Time	Capitol View Terrace North	Capitol View Terrace South	Creekside I	Creekside II
8:00-10am	**Opening Session: Awards and Keynote Presentations - *Capitol View Terrace* - Brig. Gen. Peter DeLuca on Climate Effects along the Mississippi / Dr. Robert Mace "Drought and What Texas Has Been Doing About It"**			
10:05-10:30am	**Coffee in Exhibit Hall - *Capitol Ballroom***			
10:30am-12 Noon	Best of Near Surface Geoscience 2014			
12 Noon-1:15pm	**Geoscientists *Without* Borders® Luncheon - *Creekside Patio***			
1:20-4pm	Surface-wave Seismology (Ken Stokoe Honorary Session)	Engineering Geophysics John Nicholl Memorial Session	Edwards/Karst Archeological Geophysics	NS Reflection & NS New Sensor Technology
3-3:20pm	**Coffee in Exhibit Hall - *Capitol Ballroom***			
4:30-9pm	**At Kali-Kate Ranch: BBQ, Exhibitor Equipment Outdoor Demonstrations and Dr. Jim Bruseth on The Discovery and Excavation of La Salle's Famous Shipwreck, La Belle**			

Tuesday March 24

Time	Capitol View Terrace North	Capitol View Terrace South	Creekside I	Creekside II
7:40-10am	Surface-wave Seismology (Ken Stokoe Honorary Session)	Engineering Geophysics John Nicholl Memorial Session	NMR for Near-surface Investigations	Transportation and Infrastructure Geophysics
10-10:20am	**Coffee in Exhibit Hall - *Capitol Ballroom* - Poster Viewing in Exhibit Hall Foyer Area**			
10:20am-12 Noon	Surface-wave Seismology (Ken Stokoe Honorary Session con't)	Near Surface Geophysical Data Analysis	NMR for Near-surface Investigations (con't)	Transportation and Infrastructure Geophysics (con't)
12 Noon-1:15pm	EEGS Luncheon and Near Surface Community Forum - *Creekside Patio*			
1:20-3:00pm	UXO and UXO Sensor Technology	Geophysics Applied to Water Resources	Resistivity/Induced Polarization/Self-Potential Methods/Applications	Geophysics for Contaminant and Site Remediation
3-3:20pm	**Coffee in Exhibit Hall - *Capitol Ballroom* - Poster Viewing in Exhibit Hall Foyer Area**			
3:20-6:00pm	UXO and UXO Sensor Technology (con't)	Geophysics Applied to Water Resources (con't)	Resistivity/Induced Polarization/Self-Potential Methods/Applications	Geophysics for Contaminant and Site Remediation (con't)
6:00-6:30pm	**Happy Hour and Poster Viewing on the Terrace**			
6:30pm	Conference Evening - Cocktails, Dinner, Wine and Entertainment at *Max's Wine Dive*			

Wednesday March 25

Time	Capitol View Terrace North	Capitol View Terrace South	Creekside I	Creekside II
7:40-10am	Oilfield Geophysics	Agricultural Geophysics & Material Properties	HVSR, Passive Seismology/Novel Near-Surface Geophysical Methods	Hydrogeophysics CZO, Marine, Polar/ Case Studies
10-10:20am	**Coffee in Exhibit Hall - *Capitol Ballroom***			
10:20-12 Noon	Oilfield Geophysics (con't)	Agricultural Geophysics & Material Properties (con't)	GPR & EMI	Hydrogeophysics CZO, Marine, Polar/ Case Studies (con't)
12 Noon-1:15pm	Student-Focused Career Luncheon (Fajitas!) *at Serrano's (across the street)*			
1:20-3pm	Geophysics and Geologic Hazards	Airborne Geophysics/ Mining	GPR & EMI (con't)	Borehole Geophysics
3-3:20pm	**Coffee in Exhibit Hall - *Capitol Ballroom* - Poster Viewing in Exhibit Hall Foyer Area**			
3:20-6pm	Geophysics and Geologic Hazards (con't)	Airborne Geophysics/ Mining (con't)	GPR & EMI (con't)	
6-6:30pm	**Happy Hour and Poster Viewing on the Terrace**			

Thursday March 26

Time	Event
Short Courses 8am-5pm	SC-2: **RECENT ADVANCES IN BOREHOLE GEOPHYSICS - *Creekside II*** Presenters: Hughbert Collier, Ph.D., P.G., Collier Consulting, John Stowell, P.E., Mount Sopris Instrument Co., Inc. (retired), Jim LoCoco, C.P.G., R.G., Mount Sopris Instrument Co., Inc. SC-3: **NEAR SURFACE CHARACTERIZATION USING THE HVSR PASSIVE SEISMIC METHOD *Creekside I*** - Presenter: John W. Lane, Jr., PhD, USGS
SC-4 8am-5pm Thurs. 9-11:30am Friday	SC-4: **PRACTICAL CONSIDERATIONS FOR SHALLOW MARINE SURVEYS - *Capitol View Terrace North*** Presenter: John Dunbar, PhD, Baylor University
9am-4pm	**Full Day Tour:** The Geologic and Engineering Wonders of Austin featuring Franklin Barbeque Picnic Lunch. Tour Leader: Charles "Chock" Woodruff, Ph.D, P.G.

SAGEEP 2015 Highlights

Technical Program and Abstracts

There are 233 papers for oral and poster presentation on the program for SAGEEP. You can find a list of papers at www.eegs.org/abstracts-sessions . Contact technical chair Brad Carr (bcarr1@uwyo.edu) for further information on presentation dates and times.

Conference Schedule and Special Events

In addition to the stellar technical program, we have several special events planned to introduce you to Austin and to other attendees. We highly encourage you to join us for any or all! We've tried very hard to maximize the enjoyment and minimize the cost. Below is a brief summary of the schedule. Please check the conference schedule posted at www.eegs.org/sageep-2015 for the latest information.

Sunday, March 22

We're offering two afternoon entertainment choices: (1) a short, amphibious Duck vehicle tour of downtown Austin and the city lakes, or (2) a trip to Austin's new Circuit of the Americas, where the U.S. Formula 1 Grand Prix is held. Attendees will be back at the hotel in time for the popular SAGEEP Icebreaker in the evening. Following the icebreaker, students will want to attend a reception on the rooftop of the Rattle Inn, a bar within walking distance of the hotel (taco bar included!). A full-day short course on scientific programming with Python and a world-class MASW Forum are being held on Sunday.

Monday, March 23

The opening session on Monday morning will focus on two keynote speakers who will be discussing observed effects of climate change on the Mississippi River and drought in Texas. We'll also feature the "Best of Near Surface Geoscience 2014" papers presented in Athens before we break for lunch organized by Geoscientists Without Borders®. Conference technical sessions will begin after lunch.

We will end the technical sessions a little early on Monday so we can take a short bus ride to a beautiful and bucolic pavilion and ranch on the outskirts of town for beer and wine, a barbecue meal, socializing, and leisurely viewing of the latest geophysical instrument technology in an outdoor setting. We'll also be treated to From a Watery Grave, a presentation on the discovery and excavation of La Salle's famous ship La Belle on the Texas coast. We may even have an opportunity for selfies with a live longhorn steer! Be sure to practice your horseshoe toss and bring your camera. For the adventurous, there's a cave on-site.

Tuesday, March 24

Tuesday will be full of technical presentations and posters. We are expanding the EEGS business luncheon into a Near Surface Community Luncheon and Forum. There will be a happy hour in the poster area at the close of the day. We'll escape the hotel for the Conference Evening at Max's Wine Dive, where we'll enjoy wine, live music, and dinner.

Wednesday, March 25

In addition to a full day of technical presentations and posters, we will be hosting a Student Career Luncheon and Forum at Serrano's across the street from the hotel that will feature fajitas and focus on informal career guidance for students. The forum will be moderated by a panel of geophysicists from different employment sectors. Interaction with students and contributions from other geophysicists will be encouraged. We plan to close the day with another happy hour at the poster area, which may morph into an informal closing party on the hotel patio and lawn.

Thursday, March 26

Three short courses on passive seismic (HVSR) characterization, borehole geophysical methods, and water-borne geophysics (on a boat!) highlight Thursday. Others are invited to sign up for an all-day field trip to view "The Geologic and Engineering Wonders of Austin." This tour, led by a local consulting geologist, will focus on engineering challenges facing a major city in a karst environment, and the resulting opportunities for geophysicists. A picnic lunch at iconic Zilker Park will feature brisket, ribs, and sausage from Austin's famous Franklin Barbecue (without having to wait in line for hours).

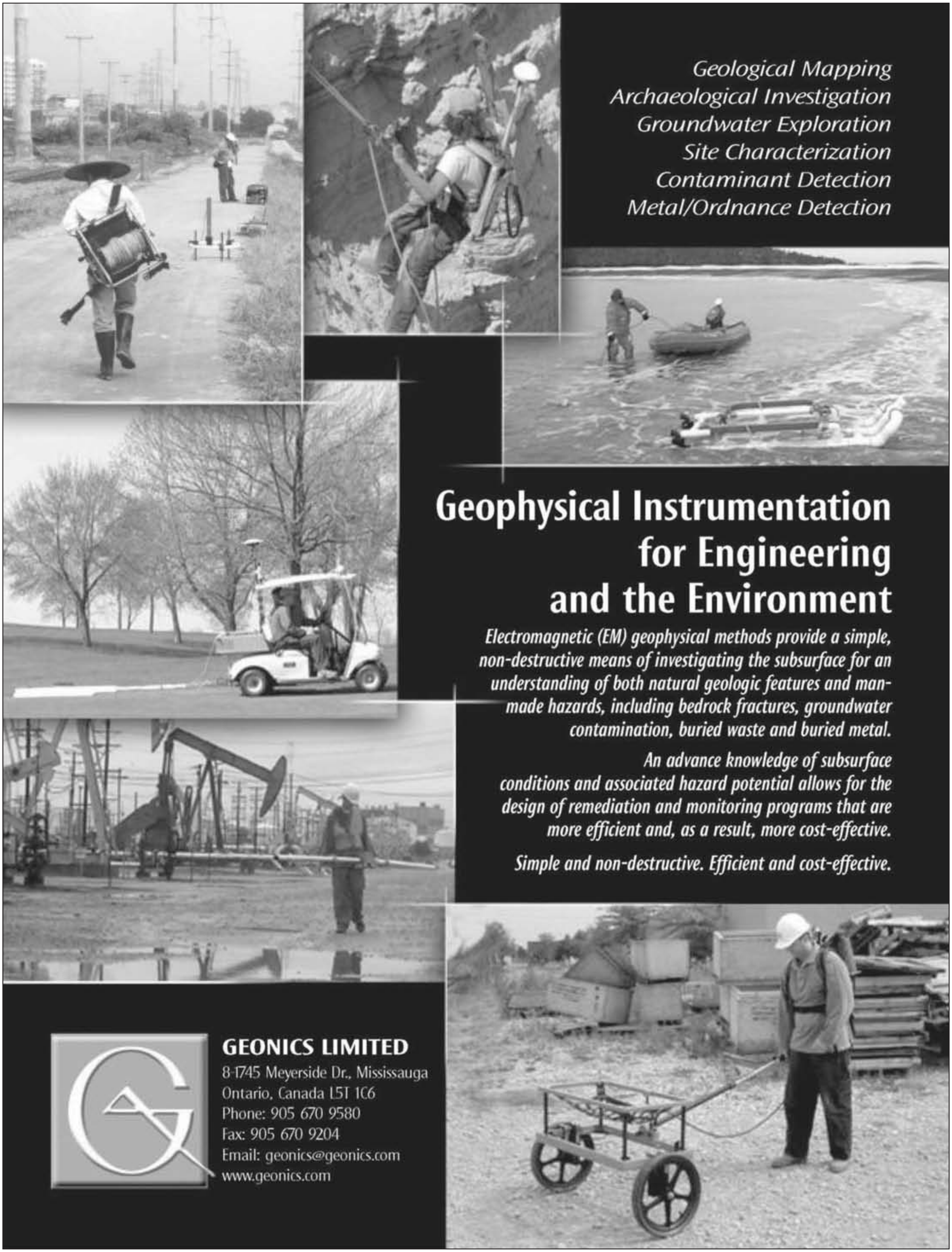
Final Notes

The deadline to reserve rooms at the conference host hotel (Sheraton at the Capitol) has passed. Austin has many other hotels; some with rooms available at reasonable rates within walking distance of the Sheraton. A few accommodation options are listed at www.eegs.org/hotel-venue , but others are also available.

SAGEEP immediately follows SXSW, a major music, film, and interactive festival with strong international appeal. For a listing of events, go to www.sxsw.com/schedule .

Local committee members Dennis Mills (dmills@expins.com), Doug Laymon (doug.laymon@tetratech.com), Brad Carr (bcarr1@uwyo.edu), and I (jeff.paine@beg.utexas.edu) look forward to seeing you in Austin shortly! Please let us know if there's anything you need.

Sincerely,
Jeffrey G. Paine
General Chair, 2015 SAGEEP

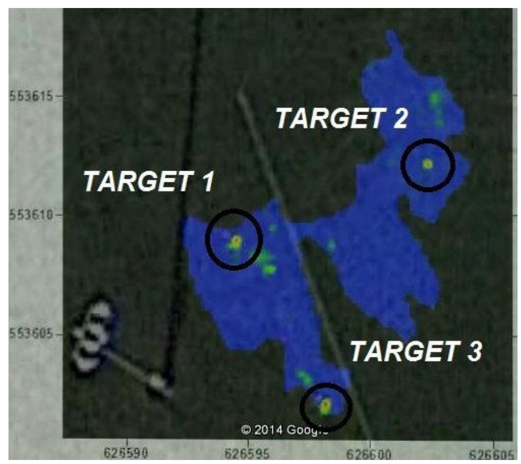

Geological Mapping
Archaeological Investigation
Groundwater Exploration
Site Characterization
Contaminant Detection
Metal/Ordnance Detection
Geophysical Instrumentation for Engineering and the Environment
Electromagnetic (EM) geophysical methods provide a simple, non-destructive means of investigating the subsurface for an understanding of both natural geologic features and man-made hazards, including bedrock fractures, groundwater contamination, buried waste and buried metal.
An advance knowledge of subsurface conditions and associated hazard potential allows for the design of remediation and monitoring programs that are more efficient and, as a result, more cost-effective.
Simple and non-destructive. Efficient and cost-effective.
GEONICS LIMITED
8-1745 Meyerside Dr., Mississauga
Ontario, Canada L5T 1C6
Phone: 905 670 9580
Fax: 905 670 9204
Email: geonics@geonics.com
www.geonics.com

Gem-2 reaches new heights

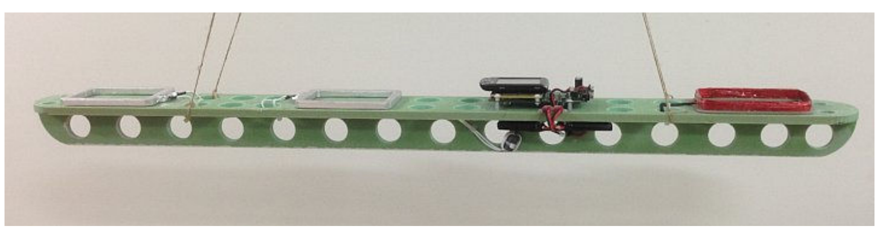
Well, not that high actually, but maybe a world first.

The Geophex GEM-2 is a digital, programmable, broadband electromagnetic sensor. It is a highly versatile electromagnetic instrument for geological, environmental, and geotechnical surveys. Although designed to be hand-held, our users have carried it in Antarctica, pulled it around on sleds, lowered it sideways down boreholes and sealed it in tubes for underwater use.

Now, American Unmanned Systems (AmericanUnmannedSystems.com) and Geophex Ltd., have successfully demonstrated the feasibility of performing EM surveys from an unmanned aerial vehicle (UAV). An unmodified GEM-2 was attached to the landing gear and used to survey an area near Norwalk, CT. A few different aircraft were tested; it was found that direct attachment to the helicopter, rather than hanging from ropes, provided the most stable platform. The processed data clearly shows two targets that were placed on the ground, as well as identifying a buried pipeline.



Looking forward, Geophex has developed a lightweight prototype version of GEM-2 for UAV applications and are working with a few UAV companies to advance the use of unmanned vehicles for conducting EM surveys. Contact Geophex for more information.



Geophysical Survey Systems, Inc.

FOR IMMEDIATE RELEASE

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McNeil, Gray & Rice Inc.
617-367-0100 ext. 148
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Jami Harmon
Geophysical Survey Systems, Inc.
603-893-1109
harmonj@geophysical.com

GSSI Announces Updates to Flexible Ground Penetrating Radar System for Utility Location and More

GSSI, the world's leading manufacturer of ground penetrating radar (GPR) equipment, announces updates to its popular UtilityScan® GPR system, the industry standard for efficiently identifying and marking the location and depth of subsurface utilities, including gas, sewer, and communication lines. The newly released 3D data collection and playback mode for the premium UtilityScan® DF model now provides an x-ray like image of the ground, in addition to the standard 2D mode used for real-time utility locating. New software features allow users to input target markings while using a GPS unit to aid in utility classification.

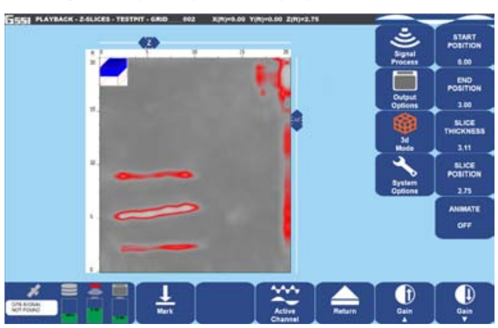
Ideal for locating a variety of metallic and non-metallic targets, the UtilityScan DF has an innovative dual-frequency antenna and touch screen monitor that together allow users to simultaneously view shallow and deep targets in a single scan. Also available is the UtilityScan® LT, a lower-cost GPR solution based on the original UtilityScan, making it perfect for real-time utility location. With a battery operation life of up to eight hours and a survey speed up to 6.25 mph (10 km/h), data collection is fast and efficient.

In addition to utility detection, the UtilityScan family of GPR solutions is configurable to the needs of a variety of other applications, including environmental remediation, road inspection, concrete scanning and geological, archaeological and forensic investigations. With ten different cart, antenna and control unit configurations, the UtilityScan can be tailored to meet a wide range of needs. All UtilityScan configurations deliver exceptionally high-quality data and are rugged enough to withstand years of field usage.

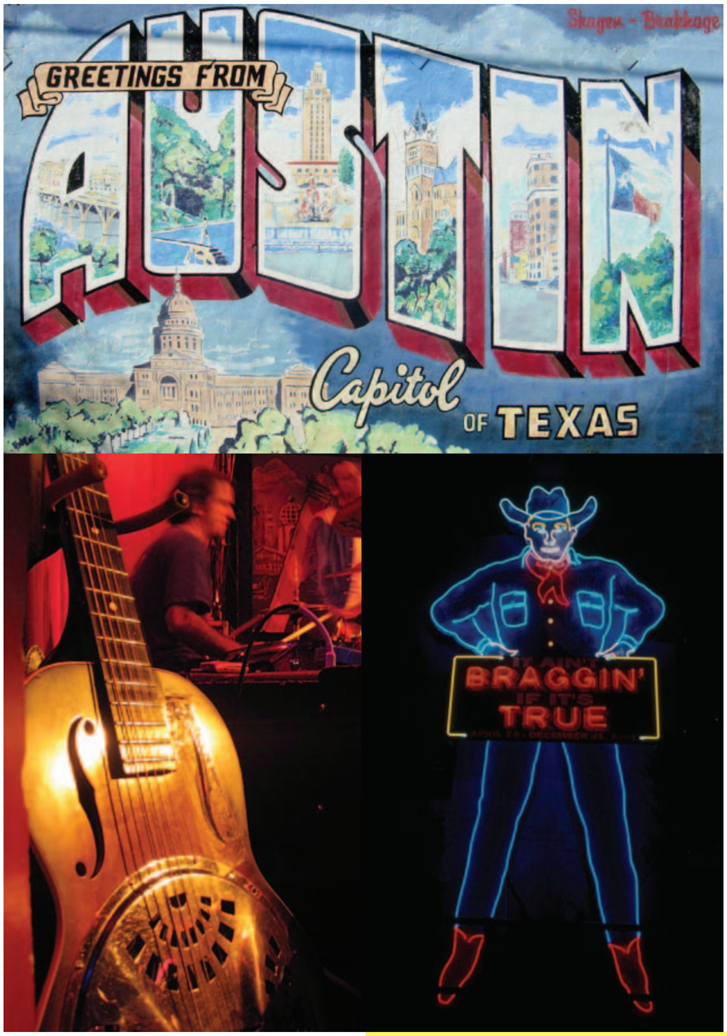
###

About GSSI

Geophysical Survey Systems, Inc. is the world leader in the development, manufacture, and sale of ground penetrating radar (GPR) equipment, primarily for the concrete inspection, utility mapping and locating, road and bridge deck evaluation, geophysics, and archaeology markets. Our equipment is used all over the world to explore the subsurface of the earth and to inspect infrastructure systems non-destructively. GSSI created the first commercial GPR system nearly 45 years ago and continues to provide the widest range and highest quality GPR equipment available today.



www.geophysical.com
12 Industrial Way • Salem, NH 03079-2837
Tel: 603.893.1109 • Toll Free: 800.524.3011 • Fax: 603.889.3984



www.EEGS.org/SAGEEP 2015

The Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP) provides geophysicists, engineers, geoscientists and end-users from around the world an opportunity to meet over a 5-day period to discuss near-surface applications of geophysics and learn about recent developments in near surface geophysics.

Make hotel reservatons now. Conference Registration Opens soon.

TEXAS USA

SAGEEP 2015
March 22-26

Registration Opens Soon!

Special Sessions

Keynote Presentations

Equipment Demonstrations

Pre and Post Conference Field Trips

Early Bird Conference Registration Deadline March 6, 2015!

Over 230 Oral and Poster Presentations

Short Courses/Forum

Texas-Style BBQ Event

Commercial Exhibition

Student Events

Conference Evening

COMING EVENTS AND ANNOUNCEMENTS

DEADLINES
Early registration – April 1, 2015
Abstract submission – Feb. 27, 2015

Early Registration Fee:

$375 Fee for individuals

$225 Reduced fee for students

$475 Regular registration fee (after April 1, 2015)

$300 Reduced regular fee (after April 1, 2015)

Exhibition Opportunities:

Companies interested in an information booth should contact

novcare@ufz.de

Organizing Committee:

Peter Dietrich/Thomas Vienken/ Georg Teutsch (*UFZ- Helmholtz Centre for Environmental Research)*
Jim Butler/Geoffrey Bohling/ Gaisheng Liu (*Kansas Geological Survey, University of Kansas)*
George Tsoflias (*University of Kansas)*
David Hyndman *(Michigan St. University)*
Remke van Dam *(Gap Geophysics Australia)*
Carsten Leven (*University of Tübingen)*
Kamini Singha *(Colorado School of Mines)*
Dave Rudolph *(University of Waterloo)*

Date:

May 19-21, 2015

Location:

The Oread, 1200 Oread Avenue, Lawrence, Kansas 66044, US

Airport: Kansas City Int. Airport (MCI)

Information about Online-Registration / Abstract Submission:

www.ufz.de/novcare

Organizing Office:

NovCare Organizing Office
Ms. Uta Sauer
UFZ - Helmholtz Centre for Environmental Research, Dep. Monitoring and Exploration Technologies
Tel +49 341 235-1893
novcare@ufz.de

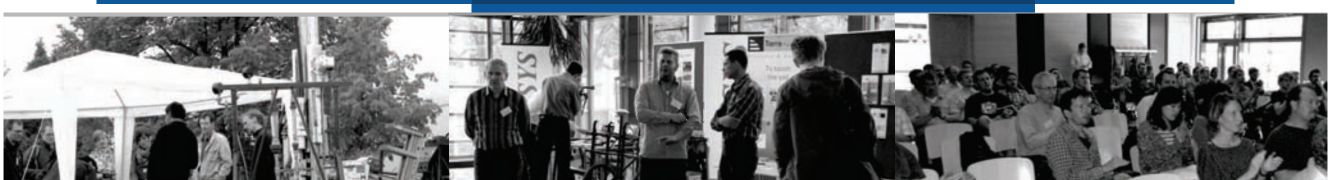
NovCare 2015

Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice

Call for Abstracts

International Conference NovCare 2015 Lawrence, Kansas

May 19-21, 2015



International Conference: Novel Methods for Subsurface Characterization and Monitoring: From Theory to Practice

As societal concerns about the long-term sustainability of groundwater supplies mount, there is a pressing need to improve our understanding of the subsurface and to better monitor and characterize natural and anthropogenic-influenced systems.

The environmental research community is facing an increasing demand for investigation methods that have high accuracy and resolution across a range of spatial and temporal scales. Uses for these methods include the identification and parameterization of relevant physical and biochemical processes, as well as the assessment of interactions between these processes through space and time. A particular emphasis is placed on methods that are cost-effective, rapid, and minimally disturb the investigated system.

The 4th NovCare Conference in 2015 will showcase newly developed and refined methods, novel applications of existing methods, and new concepts for subsurface characterization and monitoring. NovCare 2015 will again provide an outstanding platform for researchers and practitioners from all over the world to share research on innovative methods for characterization and monitoring of aquifers, soils, and watersheds. Selected papers of NovCare 2015 will be published in a special issue of the ISI journal *Environmental Earth Science*.

EXPECTED SESSIONS ON:

Thematic Areas

- Integrated characterization of the unsaturated and saturated zones
- Characterization at interfaces (stream-aquifer interactions, coastal settings, etc.)
- Opportunistic characterization (natural/anthropogenic stimuli and tracers of opportunity)
- New tools for watershed characterization
- Geotechnical site characterization
- Long-term monitoring

Relevant Technologies

- Geophysics
- Direct-push technology
- Hydrogeochemical field techniques
- Hydrogeological investigation techniques
- Joint inversion of multi-method and multi-scale data
- In situ measurements
- Wireless sensor networks

Keynote Speakers

Rick Miller *(Kansas Geological Survey)*
Rosemary Knight *(Stanford University)*
Jens Tronicke *(University of Potsdam)*
Esben Auken *(Aarhus University)*
Brian Pellerin *(U.S. Geological Survey)*
Matthew Becker *(California St. Uni.Long Beach)*
Yongcheol Kim *(KIGAM)*
James Jarwitz *(University of Florida)*
Randall J. Hunt *(U.S. Geological Survey)*

Abstract Submission

Contributions as either oral or poster presentations are welcome.

Please submit the abstract for your oral or poster presentation to

novcare@ufz.de

Deadline for abstract submission:

February 27, 2015

Agricultural Geophysics Webinar Series

Videos of the presentations and panel discussions for the first two agricultural geophysics webinars in 2014 can be accessed at http://www.ag-geophysics.org. The title of the first webinar was "*Application of Geophysics to Agriculture: Methods Employed*", and title of the second webinar was "*Using Ground Penetrating Radar in Agriculture*". This is an ongoing series, with the next webinar scheduled for April/May 2015. The next webinar will focus on agricultural applications of geophysical methods used to measure soil electrical conductivity. Information and registration (no cost) for the next webinar will be available through http://www.ag-geophysics.org in March 2015.

COMING EVENTS AND ANNOUNCEMENTS

FUNDING AVAILABLE FOR ENVIRONMENTAL TECHNOLOGY DEMONSTRATIONS

ALEXANDRIA, VA, January 8, 2015—The Department of Defense (DoD), through the **Environmental Security Technology Certification Program** (ESTCP), supports the demonstration of technologies that address priority DoD environmental requirements. The goal of ESTCP is to promote the transfer of innovative environmental technologies through demonstrations that collect the data needed for regulatory and DoD end-user acceptance. Projects conduct formal demonstrations at DoD facilities and sites in operational settings to document and validate improved performance and cost savings.

ESTCP is seeking proposals for innovative environmental technology demonstrations as candidates for funding beginning in FY2016. This solicitation requests pre-proposals via Calls for Proposals to Federal organizations and via a Broad Agency Announcement (BAA) for Private Sector organizations. **PRE-PROPOSALS ARE DUE BY MARCH 12, 2015.**

Detailed instructions are on the ESTCP website: https://serdp-estcp.org/Funding-Opportunities/ ESTCP-Solicitations/Environmental-Technologies-Solicitation.

DoD organizations (Service and Defense Agencies) may submit pre-proposals for demonstrations of innovative environmental technologies in the following topic areas**:**

- Environmental Restoration - Technologies to address the reduction of the Department's current and future liabilities through cost-effective management and remediation of contaminants in soil, sediments, and water, as well as the treatment of wastewater on fixed installations.
- Munitions Response in Underwater Environments — Technologies to address the reduction of the Department's current liabilities due to unexploded ordnance and discarded military munitions at underwater sites.
- Resource Conservation — Technologies to support the sustainability of installations and training and testing areas.
- Weapons Systems and Platforms — Technologies to reduce, control, or eliminate the sources of wastes and emissions in the manufacturing, maintenance, and use of weapons systems and platforms.

The Broad Agency Announcement (BAA) and Call for Proposals (CFP) from Federal Organizations Outside DoD are seeking pre-proposals for environmental technologies in the following topic areas**:**

- Management of Contaminated Groundwater
- Detection, Classification, and Remediation of Military Munitions in Underwater Environments

WEBINAR – JANUARY 16: ESTCP Director Dr. Anne Andrews and Deputy Director Dr. Andrea Leeson will conduct an online seminar "***ESTCP Funding Opportunities***" on **January 16, 2015**, from **1:00-2:00 p.m. Eastern Time**. This briefing will offer valuable information for those interested in new ESTCP funding opportunities. During the online seminar, participants may ask questions about the funding process, the current ESTCP solicitation, and the proposal submission process. **Pre-registration for this webinar is required**. To register, visit https://cc.readytalk.com/r/bjmshmowuzug&eom. If you have difficulty registering, please contact the ESTCP Support Office at partners@hgl.com or 703-736-4547.

Coming Soon!
The FY 2016 ESTCP Installation Energy Solicitation
is due out on or about February 5, 2015.

###

Individual Membership Categories

EEGS is the premier organization for geophysics applied to engineering and environmental problems. Our multi-disciplinary blend of professionals from the private sector, academia, and government offers a unique opportunity to network with researchers, practitioners, and users of near-surface geophysical methods.

Memberships include access to the *Journal of Environmental & Engineering Geophysics (JEEG)*, proceedings archives of the Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP), and our quarterly electronic newsletter, *FastTIMES*. Members also enjoy complimentary access to SEG's technical program expanded abstracts, discounted SAGEEP registration fees, books and other educational publications. EEGS offers a variety of membership categories tailored to fit your needs. Please select (circle) your membership category and indicate your willingness to support student members below:

☐ **Yes, I wish to sponsor _______ student(s) @ $20 each to be included in my membership payment.**

Individual Members

New this year: Individual members are invited to sponsor student members. Simply indicate the number of students you'd like to support (at $20 each) to encourage growth in this important segment of EEGS' membership.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Individual	$90	$110

Retired Members

Your opportunity to stay connected and support the only membership organization focusing on near surface geophysics. New this year: Retired members are invited to sponsor student members. Simply indicate the number of students you'd like to support (at $20 each) to encourage growth in this important segment of EEGS' membership.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Retired *Must be Approved by EEGS Board of Directors*	$50	$110

Introductory Members

If you have not been a member of EEGS before, Welcome! We offer a reduced rate for new members to enjoy all the benefits of individual membership (except vote or hold office) for one year.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Introductory	$50	$110

Developing World Members

Those wishing to join this category of EEGS membership are invited to check the list of countries to determine qualification.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Developing World *(List of qualifying countries next page)*	$50	$110

Student Members

Students represent EEGS' future and we offer complimentary membership subsidized by Corporate Student Sponsor Members and Individual members who choose to sponsor students. Student members enjoy all the benefits of individual membership (except to vote or hold office). Available for all students in an accredited university up to one year post-graduation. Please submit a copy of your student ID and indicate your projected date of graduation: ___ /____ (Month/Year).

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Student	No Cost (Students sponsored by Corporate Student Sponsor Members and participating Individual Members)	$70

Membership Renewal
Developing World Category Qualification

If you reside in one of the countries listed below, you are eligible for EEGS's Developing World membership category rate of $50.00 (or $100.00 if you would like the printed, quarterly *Journal of Environmental & Engineering Geophysics* (*JEEG*) mailed to you). To receive a printed *JEEG* as a benefit of membership, select the Developing World Printed membership category on the membership application form.

Afghanistan
Albania
Algeria
Angola
Armenia
Azerbaijan
Bangladesh
Belize
Benin
Bhutan
Bolivia
Burkina Faso
Burundi
Cambodia
Cameroon
Cape Verde
Central African Republic
Chad
China
Comoros
Congo, Dem. Rep.
Congo, Rep.
Djibouti
Ecuador
Egypt
El Salvador
Eritrea
Ethiopia
Gambia
Georgia
Ghana
Guatemala
Guinea-Bissau
GuyanaHaiti
Honduras
India
Indonesia
Iran
Iraq
Ivory Coast
Jordan
Kenya
Kiribati
Kosovo
Kyrgyz Republic
Lao PDR
Lesotho
Liberia
Madagascar
Malawi
Maldives
Mali
Marshall Islands
Mauritania
Micronesia
Moldova
Mongolia
Morocco
Mozambique
Myanmar
Nepal
Nicaragua
Niger
Nigeria
North Korea
Pakistan
Papua New Guinea
Paraguay
Philippines
Rwanda
Samoa
Sao Tome and Principe
Senegal
Sierra Leone
Solomon Islands
Somalia
Sri Lanka
Sudan
Suriname
Swaziland
Syria
Taiwan
Tajikistan
Tanzania
Thailand
Timor-Leste
Togo
Tonga
Tunisia
Turkmenistan
Uganda
Ukraine
Uzbekistan
Vanuatu
Vietnam
West Bank and Gaza
Yemen
Zambia
Zimbabwe

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(p) 001.1.303.531.7517 | (f) 001.1.303.820.3844 | staff@eegs.org | www.eegs.org

Environmental and Engineering Geophysical Society	Renew or Join Online at www.EEGS.org
2015 Corporate Membership Application	

EEGS is the premier organization for geophysics applied to engineering and environmental problems. Our multi-disciplinary blend of professionals from the private sector, academia, and government offers a unique opportunity to network with researchers, practitioners, and users of near-surface geophysical methods.

Memberships include access to the *Journal of Environmental & Engineering Geophysics (JEEG)*, proceedings archives of the Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP), and our quarterly electronic newsletter *FastTIMES*. Members also enjoy complimentary access to SEG's technical program expanded abstracts, discounted SAGEEP registration fees, books and other educational publications. EEGS offers a variety of membership categories tailored to fit your needs. We've added value to all the Corporate Membership categories and added two new Website Advertising opportunities. We've packaged the two for an even greater value! Please select (circle) your membership category and rate. EEGS is also offering an opportunity for all EEGS members to help support student(s) at $20 each. Please indicate your willingness to contribute to support of student members below:

☐ **Yes, I wish to support ____ student(s) at $20 each to be included in my membership payment.**

Category	2015 Electronic JEEG	2015 Basic Rate	2015 Basic + Web Ad Package
Corporate Student Sponsor *Includes one (1) individual membership, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES and Sponsorship of 10 student memberships*	$310	$320	$820 a $1515 value!
Corporate Donor *Includes one (1) individual EEGS membership, one (1) full conference registration to SAGEEP, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES*	$660	$670	$1170 a $2005 value!
Corporate Associate *Includes two (2) individual EEGS memberships, an exhibit booth and registration at SAGEEP, the ability to insert marketing materials in the SAGEEP delegate packets, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES*	$2410	$2420	$2920 a $4290 value!
Corporate Benefactor *Includes two (2) individual memberships to EEGS, two (2) exhibit booths and registration at SAGEEP, the ability to insert marketing materials in the SAGEEP delegate packets, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES*	$4010	$4020	$4520 a $6705 value!
NEW! **Website Advertising**	Purchase Separately	Purchase Separately	Package Rates include both website ad locations
One (1) Pop-Under, scrolling marquee style ad with tagline on Home page, logo linked to Company web site	$600/yr.	$600/yr.	
One (1) Button sized ad, linked logo, right rail on each web page	$250/yr.	$250/yr.	

Environmental and Engineering Geophysical Society	Renew or Join Online at www.EEGS.org
2015 EEGS Membership Application	

CONTACT INFORMATION

Salutation	First Name	Middle Initial	Last Name

Company/Organization	Title

Street Address	City	State/Province	Zip Code	Country

Direct Phone	Mobile Phone	Fax

Email	Website

ABOUT ME: INTERESTS & EXPERTISE

In order to identify your areas of specific interests and expertise, please check all that apply:

Role	Interest or Focus	Geophysical Expertise	Professional/ Scientific Societies	Willing to Serve on a Committee?
☐ Consultant	☐ Archaeology	☐ Borehole Geophysical Logging	☐ AAPG	☐ Publications
☐ User of Geophysical Svcs.	☐ Engineering	☐ Electrical Methods	☐ AEG	☐ Web Site
☐ Student	☐ Environmental	☐ Electromagnetics	☐ ASCE	☐ Membership
☐ Geophysical Contractor	☐ Geotechnical	☐ Gravity	☐ AWWA	☐ Student
☐ Equipment Manufacturer	☐ Geo. Infrastructure	☐ Ground Penetrating Radar	☐ AGU	
☐ Software Manufacturer	☐ Groundwater	☐ Magnetics	☐ EAGE	
☐ Research/Academia	☐ Hazardous Waste	☐ Marine Geophysics	☐ EERI	
☐ Government Agency	☐ Humanitarian Geo.	☐ Remote Sensing	☐ GeoInstitute	
☐ Other	☐ Mining	☐ Seismic	☐ GSA	
	☐ Shallow Oil & Gas	☐ Other	☐ NGWA	
	☐ UXO		☐ NSG	
	☐ Aerial Geophysics		☐ SEG	
	☐ Other		☐ SSA	
			☐ SPWLA	

1720 South Bellaire Street | Suite 110 | Denver, CO 80222-4303
(p) 001.1.303.531.7517 | (f) 000.1.303.820.3844 | staff@eegs.org | www.eegs.org

FOUNDATION CONTRIBUTIONS

FOUNDERS FUND

The Founders Fund has been established to support costs associated with the establishment and maintenance of the EEGS Foundation as we solicit support from larger sponsors. These will support business office expenses, necessary travel, and similar expenses. It is expected that the operating capital for the foundation will eventually be derived from outside sources, but the Founder's Fund will provide an operation budget to "jump start" the work. Donations of $50.00 or more are greatly appreciated. For additional information about the EEGS Foundation (an IRS status 501(c)(3) tax exempt public charity), visit the website at http://www.EEGSFoundation.org.

Foundation Fund Total: $ ________________

STUDENT SUPPORT ENDOWMENT

This Endowed Fund will be used to support travel and reduced membership fees so that we can attract greater involvement from our student members. Student members are the lifeblood of our society, and our support can lead to a lifetime of involvement and leadership in the near-surface geophysics community. Donations of $50.00 or more are greatly appreciated. For additional information about the EEGS Foundation (a tax exempt public charity), visit the website at http://www.EEGSFoundation.org.

Student Support Endowment Total: $ ________________

CORPORATE CONTRIBUTIONS

The EEGS Foundation is designed to solicit support from individuals and corporate entities that are not currently corporate members (as listed above). We recognize that most of our corporate members are small businesses with limited resources, and that their contributions to professional societies are distributed among several organizations. The Corporate Founder's Fund has been developed to allow our corporate members to support the establishment of the Foundation as we solicit support from new contributors.

Corporate Contribution Total: $ ________________

Foundation Total: $ ________________

PAYMENT INFORMATION

☐ Check/Money Order ☐ VISA ☐ MasterCard

☐ AmEx ☐ Discover

Subtotals

Membership: $ ________________

Student Sponsorship: $ ________________

Foundation Contributions: $ ________________

Grand Total: $ ________________

Card Number **Exp. Date**

Name on Card

Signature

Make your check or money order in US dollars payable to: EEGS. Checks from Canadian bank accounts must be drawn on banks with US affiliations (example: checks from Canadian Credit Suisse banks are payable through Credit Suisse New York, USA). Checks must be drawn on US banks.

Payments are not tax deductible as charitable contributions although they may be deductible as a business expense. Consult your tax advisor.

Return this form with payment to: EEGS, 1720 South Bellaire Street, Suite 110, Denver, CO 80222 USA
Credit card payments can be faxed to EEGS at 001.1.303.820.3844

Corporate dues payments, once paid, are non-refundable. Individual dues are non-refundable except in cases of extreme hardship and will be considered on a case-by-case basis by the EEGS Board of Directors. Requests for refunds must be submitted in writing to the EEGS business office.

QUESTIONS? CALL 001.1.303.531.7517

EEGS CORPORATE MEMBERS

Corporate Benefactor

Your Company Here!

Corporate Associate

Advanced Geosciences, Inc.
www.agiusa.com

Allied Associates Geophysical Ltd.
www.allied-associates.co.uk

CGG Canada Services Ltd.
www.cgg.com

Exploration Instruments LLC
www.expins.com

Geogiga Technology Corporation
www.geogiga.com

Geomar Software Inc.
www.geomar.com

Geometrics, Inc.
www.geometrics.com

Geonics Ltd.
www.geonics.com

Geophysical Survey Systems, Inc.
www.geophysical.com

Interpex Ltd.
www.interpex.com

Mount Sopris Instruments
www.mountsopris.com

Petros Eikon Incorporated
www.petroseikon.com

R. T. Clark Co. Inc.
www.rtclark.com

Sensors & Software Inc.
www.sensoft.ca

Vista Clara Inc.
www.vista-clara.com

Zonge international, Inc
www.zonge.com

Corporate Donor

Geomatrix Earth Science Ltd.
www.geomatrix.co.uk

Northwest Geophysics
www.northwestgeophysics.com

Spotlight Geophysical Services
www.spotlightgeo.com

Corporate Student Sponsor

Geo Solutions Limited, Inc.
www.geosolutionsltd.com

Spotlight Geophysical Services
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EEGS STORE

Environmental and Engineering Geophysical Society

2015 Publications Order Form

ALL ORDERS ARE PREPAY

1720 S. Bellaire Street, Suite 110
Denver, CO 80222-4303
Phone: 303.531.7517; Fax: 303.820.3844
E-mail: staff@eegs.org; Web Site: www.eegs.org

Sold To:
Name: ______
Company: ______
Address: ______
City/State/Zip: ______
Country: ______ Phone: ______
E-mail: ______ Fax: ______

Ship To (If different from "Sold To":
Name: ______
Company: ______
Address: ______
City/State/Zip: ______
Country: ______ Phone: ______
E-mail: ______ Fax: ______

Instructions: Please complete both pages of this order form and fax or mail the form to the EEGS office listed above. Payment must accompany the form or materials will not be shipped. Faxing a copy of a check does not constitute payment and the order will be held until payment is received. Purchase orders will be held until payment is received. If you have questions regarding any of the items, please contact the EEGS Office. Thank you for your order!

SAGEEP PROCEEDINGS

			Member	Non-Member
	0036	2014 (CD-ROM)	$75	$100
	0034	2013 (CD-ROM)	$75	$100
	0033	2012 (CD-ROM)	$75	$100
	0030	2011 (CD-ROM)	$75	$100
	0029	2010 (CD-ROM)	$75	$100
	0026	2009 (CD-ROM)	$75	$100
	0025	2008 (CD-ROM)	$75	$100
	0023	2007 (CD-ROM)	$75	$100

			Member	Non-Member
	0020	2006 (CD-ROM)	$75	$100
	0018	2005 (CD-ROM)	$75	$100
	0016	2004 (CD-ROM)	$75	$100
	0015	2003 (CD-ROM)	$75	$100
	0014	2002 (CD-ROM)	$75	$100
	0013	2001 (CD-ROM)	$75	$100
	0012	1988-2000 (CD-ROM)	$150	$225
	SUBTOTAL—PROCEEDINGS ORDERED:			

SAGEEP Short Course Handbooks

	0039	2013 Agricultural Geophysics: Methods Employed and Recent Applications - Barry Allred, Bruce Smith, et al.	$35	$45
	0038	2010 Processing Seismic Refraction Tomography Data (including CD-ROM) - William Doll	$35	$45
	0037	2011 Application of Time Domain Electromagnetics to Ground-water Studies – David V. Fitterman	$20	$30
	0032	2010 Application of Time Domain Electromagnetics to Ground-water Studies – David V. Fitterman	$20	$30
	0027	2010 Principles and Applications of Seismic Refraction Tomography (Printed Course Notes & CD-ROM) - William Doll	$70	$90
	0028	2009 Principles and Applications of Seismic Refraction Tomography (CD-ROM w/ PDF format Course Notes) - William Doll	$70	$90
	0007	2002 - UXO 101 - An Introduction to Unexploded Ordnance - (Dwain Butler, Roger Young, William Veith)	$15	$25
	0009	2001 - Applications of Geophysics in Geotechnical and Environmental Engineering (HANDBOOK ONLY) - John Greenhouse	$25	$35
	0011	2001 - Applications of Geophysics in Environmental Investigations (CD-ROM ONLY) - John Greenhouse	$80	$105
	0010	2001- Applications of Geophysics in Geotechnical and Environmental Engineering (HANDBOOK) & Applications of Geophysics in Environmental Investigations (CD-ROM) - John Greenhouse	$100	$125
	0004	1998 - Global Positioning System (GPS): Theory and Practice - John D. Bossler & Dorota A. Brzezinska	$10	$15
	0003	1998 - Introduction to Environmental & Engineering Geophysics - Roelof Versteeg	$10	$15
	0002	1998 - Near Surface Seismology - Don Steeples	$10	$15
	0001	1998 - Nondestructive Testing (NDT) - Larry Olson	$10	$15
	0005	1997 - An Introduction to Near-Surface and Environmental Geophysical Methods and Applications - Roelof Versteeg	$10	$15
	0006	1996 - Introduction to Geophysical Techniques and their Applications for Engineers and Project Managers - Richard Benson & Lynn Yuhr	$10	$15

Miscellaneous Items

	0031	***New Pricing!!*** Advances in Near-surface Seismology and Ground Penetrating Radar—R. Miller, J.Bradford, K.Holliger Special Pricing Available for Limited Time—through March 25, 2015—end of SAGEEP 2015!	$79	$99
	0021	Geophysics Applied to Contaminant Studies: Papers Presented at SAGEEP from 1988-2006 (CD-ROM)	$50	$75
	0022	Application of Geophysical Methods to Engineering and Environmental Problems - Produced by SEGJ	$35	$45
	0019	Near Surface Geophysics - 2005 Dwain K. Butler, Ed.; Hardcover Special student rate - $71.20	$89	$139
	0035	Einstein Redux: A Humorous & Refreshing New Chapter in the Einstein Saga—D.Butler	$20	$25

MISCELLANEOUS ITEMS CONTINUED ON NEXT PAGE...

EEGS STORE

Publications Order Form (Page Two)

		EEGS T-shirt (X-Large) Please circle: white/gray	$10	$10
		EEGS Lapel Pin	$3	$3
		SUBTOTAL—SHORT COURSE/MISC. ORDERED ITEMS:		

Journal of Environmental and Engineering Geophysics **(JEEG) Back Issue Order Information:**
Member Rate: $15 | Non-Member Rate: $25

Qt.	Year	Issue	Qt.	Year	Issue	Qt.	Year	Issue
	1995	JEEG 0/1 - July		**2004**	JEEG 9/1- March		**2009**	JEEG 14/1 - March
		JEEG 0/2 - January			JEEG 9/2 - June			JEEG 14/2 - June
	1996	JEEG 1/1 - April			JEEG 9/3 - September			JEEG 14/3 - September
		JEEG 1/2 - August			JEEG 9/4 - December			JEEG 14/4 - December
		JEEG 1/3 - December		**2005**	JEEG 10/1 - March		**2010**	JEEG 15/1 - March
	1998	JEEG 3/2 - June			JEEG 10/2 - June			JEEG 15/2 - June
		JEEG 3/3 - September			JEEG 10/3 - September			JEEG 15/3 - September
		JEEG 3/4 - December			JEEG 10/4 - December			JEEG 15/4 - December
	1999	JEEG 4/1 – March		**2006**	JEEG 11/1 - March		**2011**	JEEG 16/1 - March
		JEEG 4/2 - June			JEEG 11/2 - June			JEEG 16/2 - June
		JEEG 4/3 - September			JEEG 11/3 - September			JEEG 16/3 - September
		JEEG 4/4 - December			JEEG 11/4 - December			JEEG 16/4 - December
	2000	JEEG 5/3 - September		**2007**	JEEG 12/1 - March		**2012**	JEEG 17/1 - March
		JEEG 5/4 - December			JEEG 12/2 - June			JEEG 17/2 - June
	2001	JEEG 6/1 - March			JEEG 12/3 - September			JEEG 17/3 - September
		JEEG 6/3 - September			JEEG 12/4 - December			JEEG 17/4 - December
		JEEG 6/4 - December		**2008**	JEEG 13/1 - March		**2013**	JEEG 18/1 - March
	2003	JEEG 8/1- March			JEEG 13/2 - June			JEEG 18/2 - June
		JEEG 8/2 - June			JEEG 13/3 - September			JEEG 18/3 - September
		JEEG 8/3 - September			JEEG 13/4 - December			JEEG 18/4 - December
		JEEG 8/4 - December					**2014**	JEEG 19/1 - March
								JEEG 19/2 - June
					SUBTOTAL—JEEG ISSUES ORDERED			

SUBTOTAL - SAGEEP PROCEEDINGS ORDERED	
SUBTOTAL - SHORT COURSE / MISCELLANEOUS ITEMS ORDERED	
SUBTOTAL - JEEG ISSUES ORDERED	
CITY & STATE SALES TAX (If order will be delivered in the Denver, Colorado—add an additional 7.62%)	
SHIPPING & HANDLING (US—$10; Canada/Mexico—$20; All other countries: $45)	
GRAND TOTAL:	

Order Return Policy: Returns for credit must be accompanied by invoice or invoice information (invoice number, date, and purchase price). Materials must be in saleable condition. Out-of-print titles are not accepted 180 days after order. No returns will be accepted for credit that were not purchased directly from EEGS. Return shipment costs will be borne by the shipper. Returned orders carry a 10% restocking fee to cover administrative costs unless waived by EEGS.

Payment Information:

☐ Check #: ________________________________ (Payable to EEGS)

☐ Purchase Order: ________________________________
(Shipment will be made upon receipt of payment.)

☐ Visa ☐ MasterCard ☐ AMEX ☐ Discover

Card Number: ______________________________ CVV# _____
Exp. Date: ____

Important Payment Information: Checks from Canadian bank accounts must be drawn on banks with US affiliations (example: checks from Canadian Credit Sulsse banks are payable through Credit Sulsse New York, USA). If you are unsure, please contact your bank. As an alternative to paying by check, we recommend sending money orders or paying by credit card.

Cardholder Name (Print) ______________________________________
Signature:____

EEGS STORE

Environmental and Engineering Geophysical Society

1720 S. Bellaire Street, Suite 110
Denver, CO 80222-4303
Phone: 303.531.7517
Fax: 303.820.3844
E-mail: staff@eegs.org
Web Site: www.eegs.org

2015 Merchandise Order Form

ALL ORDERS ARE PREPAY

Sold To:

Name: ____________________
Company: ____________________
Address: ____________________
City/State/Zip: ____________________
Country: ____________ Phone: ____________
E-mail: ____________ Fax: ____________

Ship To (If different from "Sold To"):

Name: ____________________
Company: ____________________
Address: ____________________
City/State/Zip: ____________________
Country: ____________ Phone: ____________
E-mail: ____________ Fax: ____________

Instructions: Please complete this order form and fax or mail the form to the EEGS office listed above. Payment must accompany the form or materials will not be shipped. Faxing a copy of a check does not constitute payment and the order will be held until payment is received. Purchase orders will be held until payment is received. If you have questions regarding any of the items, please contact the EEGS Office. Thank you for your order!

Merchandise Order Information:

ITEM DESCRIPTION	QTY	EEGS T-SHIRT COLOR WHITE OR GRAY	MEMBER RATE	NON-MEMBER RATE	TOTAL
EEGS Mug			$10	$10	
SAGEEP 2015 T-shirt (Small)			$18	$18	
SAGEEP 2015 T-shirt (Medium)			$18	$18	
SAGEEP 2015 T-shirt (Large)			$18	$18	
SAGEEP 2015 T-shirt (XLarge)			$18	$18	
SAGEEP 2015 T-shirt (XXLarge)			$18	$18	
EEGS T-shirt (XLarge)			$10	$10	
EEGS Lapel Pin			$3	$3	

SUBTOTAL – MERCHANDISE ORDERED:

TOTAL ORDER:

SUBTOTAL – Merchandise Ordered:	
STATE SALES TAX: (If order will be delivered in Colorado – add 3.7000%):	
CITY SALES TAX: (If order will be delivered in the City of Denver – add an additional 3.5000%):	
SHIPPING AND HANDLING (US - $7; Canada/Mexico - $15; All other countries - $40):	

GRAND TOTAL:

Payment Information:

☐ Check #: ____________ (Payable to EEGS)

☐ Purchase Order: ____________
(Shipment will be made upon receipt of payment.)

☐ Visa ☐ MasterCard ☐ AMEX ☐ Discover

Card Number: ____________CVV# ____ Cardholder Name (Print): ____________

Exp. Date: ____________ Signature: ____________

Three easy ways to order:
Fax to: 303.820.3844
Internet: www.eegs.org
Mail to: EEGS
1720 S. Bellaire St., #110
Denver, CO 80222-4303

THANK YOU FOR YOUR ORDER!

Order Return Policy: Returns for credit must be accompanied by invoice or invoice information (invoice number, date, and purchase price). Materials must be in saleable condition. Out-of-print titles are not accepted 180 days after order. No returns for credit will be accepted which were not purchased directly from EEGS. Return shipment costs will be borne by the shipper. Returned orders carry a 10% restocking fee to cover administrative costs unless waived by EEGS.

EEGS STORE

Environmental and Engineering Geophysical Society

1720 S. Bellaire Street, Suite 110
Denver, CO 80222-4303
Phone: 303.531.7517
Fax: 303.820.3844
E-mail: staff@eegs.org
Web Site: www.eegs.org

2015 SAGEEP T-SHIRTS Order Form

ALL ORDERS ARE PREPAY

Sold To:

Name: ____
Company: ____
Address: ____
City/State/Zip: ______________________________________
Country: _____________________ Phone: _______________
E-mail: ______________________ Fax: _________________

Ship To (If different from "Sold To"):

Name: ____
Company: ____
Address: ____
City/State/Zip: ______________________________________
Country: ___________________ Phone: _______________
E-mail: ______________________ Fax: _______________

Instructions:
T-Shirts can be picked up at SAGEEP 2015! Please complete this order form and fax or mail to the EEGS office listed above. Payment must accompany the form or materials will not be shipped. If you wish to pick your order up on site in Austin, TX, mark your form with a check in the space below. **If you will be picking up your T-Shirt(s) at SAGEEP, do not include tax or shipping and handling** – listed prices are inclusive of all fees. Faxing a copy of a check does not constitute payment and the order will be held until payment is received. Purchase orders will be held until payment is received. If you have questions regarding any of the items, please contact the EEGS Office. Thank you for your order!

SAGEEP 2015 T-Shirt Order Information:

ITEM DESCRIPTION	QTY	ONE COLOR/ BLUE	MEMBER NON-MEMBER RATE	PICK UP AT SAGEEP (CHECK)	TOTAL
SAGEEP 2015 T-Shirts – Sizing Chart Available online (http://www.eegs.org/program)					
SAGEEP 2015 T-Shirt (Small)			$18		
SAGEEP 2015 T-Shirt (Medium)			$18		
SAGEEP 2015 T-Shirt (Large)			$18		
SAGEEP 2015 T-Shirt (X-Large)			$18		
SAGEEP 2015 T-Shirt (XX-Large)			$18		
SUBTOTAL –					

TOTAL ORDER:

SUBTOTAL – Merchandise Ordered:	
STATE SALES TAX: (If order will be delivered in Colorado – add 3.7000%):	
CITY SALES TAX: (If order will be delivered in the City of Denver – add an additional 3.5000%):	
SHIPPING AND HANDLING (US - $7; Canada/Mexico - $15; All other countries - $40):	
GRAND TOTAL:	

Payment Information:

☐ Check #: ______________________ (Payable to EEGS)
☐ Purchase Order: ______________________
(Shipment will be made upon receipt of payment.)

☐ Visa ☐ MasterCard ☐ AMEX ☐ Discover

Three easy ways to order:
Fax to: 303.820.3844
Internet: www.eegs.org
Mail to: EEGS
1720 S. Bellaire St., #110
Denver, CO 80222-4303

Card Number: ________________________ Cardholder Name (Print): ________________________

Exp. Date: ___________________________ CVV#______ Signature: _____________________________________

THANK YOU FOR YOUR ORDER!

Order Return Policy: Returns for credit must be accompanied by invoice or invoice information (invoice number, date, and purchase price). Materials must be in saleable condition. Out-of-print titles are not accepted 180 days after order. No returns for credit will be accepted which were not purchased directly from EEGS. Return shipment costs will be borne by the shipper. Returned orders carry a 10% restocking fee to cover administrative costs unless waived by EEGS.