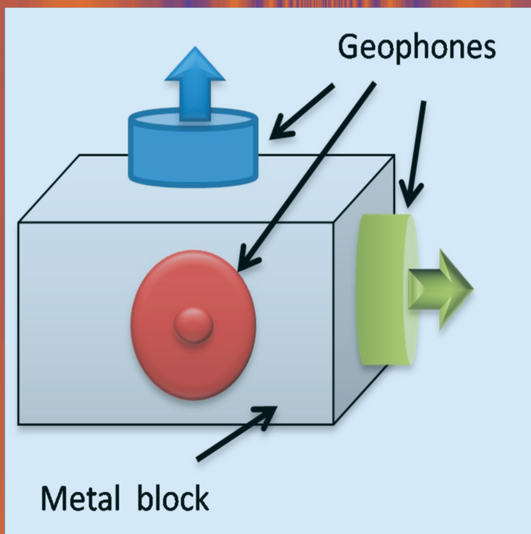
*Fast*TIMES

Low Cost Tromograph System for Microtremor Seismic Acquisition



Integrating Global Positioning System Technologies with Geophysical Surveys

December 2013

Volume 18, Number 4

In this issue, a description of a low cost tromographic system for microtremor seismic acquisition and a discussion on the integration of global positioning system technologies with geophysical surveying.

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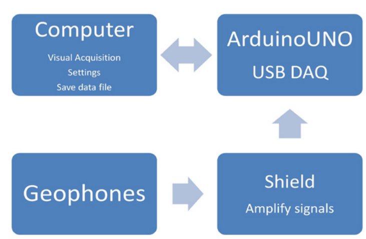

*Fast*TIMES

*Fast*TIMES (ISSN 1943-6505) is published by the Environmental and Engineering Geophysical Society (EEGS). It is available electronically (as a pdf document) from the EEGS website (www.eegs.org).

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.

JOINING EEGS

EEGS welcomes membership applications from individuals (including students) and businesses. Annual dues are $90 for an individual membership, $50 for introductory membership, $50 for a retired member, $50 developing world membership, complimentary corporate sponsored student membership - if available, and $300 to $4000 for various levels of corporate membership. All membership categories include free online access to JEEG. The membership application is available at the back of this issue, or online at www.eegs.org.

SUBMISSIONS

To submit information for inclusion in *Fast*TIMES, contact a member of the editorial team:

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*Fast*TIMES is published electronically four times a year. Please send articles to any member of the editorial team by February 15, 2014. Advertisements are due to Jackie Jacoby by February 15, 2014.

CALENDAR

2014

February 18	Webinar - Application of Geophysics to Agriculture: Methods Employed http://www.ag-geophysics.org (See page 47 for additional information.)
March 16 - 20	SAGEEP 2014 Boston, Massachusetts, USA http://www.eegs.org/Annual-Meeting-SAGEEP/SAGEEP-2014 (See page 43 for additional information.)
April 6 - 9	3rd International Workshop on Induced Polarization (IP) Ile d'Oleron, Charente-Maritime, France http://ip.geosciences.mines-paristech.fr/
April 27 - May 2	European Geosciences Union - 2014 General Assembly Vienna, Austria http://www.egu2014.eu/ (See page 45 for additional information.)
June 20 - 23	6th International Conference on Environmental and Engineering Geophysics Xi'an, China http://tdem.org/iceeg2014/en (Note: Antonio Menghini, antonio.menghini@aarhusgeo.com, a JEEG Associate Editor, will be co-chairing a session on airborne geophysics. See page 45 for additional information.)
August 24 - 30	22nd EM Induction Workshop Weimar, Germany http://www.emiw2014.de
October 26 - 31	Society of Exploration Geophysicists International Exposition and 84th Annual Meeting Denver, Colorado, USA http://www.seg.org

Please send event listings, corrections or omitted events
to any member of the *Fast*TIMES editorial team.

NOTES FROM EEGS
PRESIDENT'S MESSAGE

Catherine Skokan, President
(cskokan@mines.edu)

Your EEGS Board has been busy over the last few months. Highlighted are three of our efforts.

1) Our SAGEEP 2014 Boston planning is well under way and we plan to reach our typical 200 papers and posters regularly featured at SAGEEP. The popular student event is on tap as well along with some great opportunities to see the sights in Boston. Our keynote speaker, Bill Eustes, is an expert in fracing as well as drilling on Mars. His talk will be entertaining and informative for sure. We look forward to seeing all of you in Boston, March 16-20, 2014.

2) We have continued our talks with the SEG with regards to an acquisition. At this point, the Task Force and Board feel that it is time to take the matter to the membership. This vote will happen in early 2014. There are advantages and disadvantages to this step. We hope to educate the membership in order that an informed decision can be made by all. Please read carefully the documents that are sent to you and feel free to ask questions of any board member or task force member on this topic. Task force e-mail addresses are listed below.

3) Finally, no matter what the outcome of the possible acquisition by SEG, EEGS will continue to offer membership benefits and services throughout 2014. We encourage you to renew your membership and look forward to a great upcoming year. (Note: Unless you renew and are a current member, you will not have the chance to cast your vote on the SEG-EEGS merger.)

Catherine Skokan, President

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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:

Allen, Micki
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NOTES FROM EEGS

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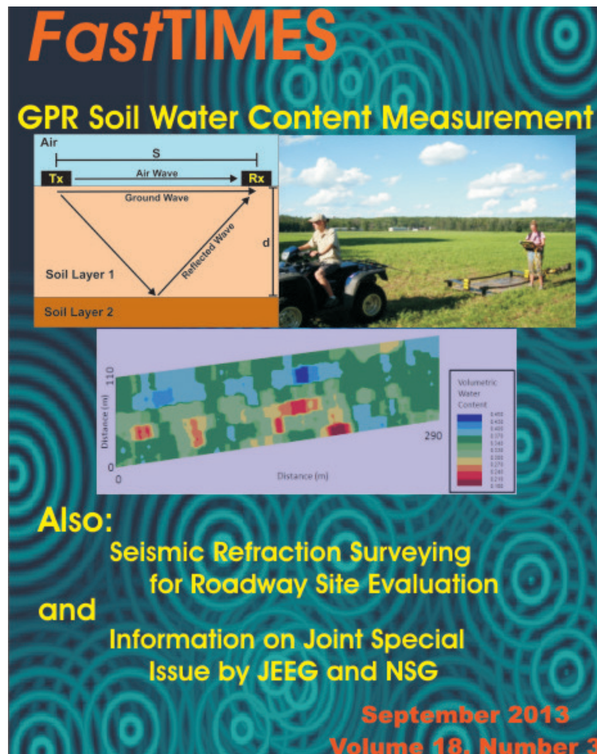
Be sure to renew your EEGS membership for 2014! In addition to the more tangible member benefits (including the option of receiving a print or electronic subscription to JEEG, *Fast*TIMES delivered to your email box quarterly, discounts on EEGS publications and SAGEEP registration, and benefits from associated societies), your dues help support EEGS's major initiatives such as producing our annual meeting (SAGEEP), publishing JEEG, making our publications available electronically, expanding the awareness of near-surface geophysics outside our discipline, and enhancing our web site to enable desired capabilities such as membership services, publication ordering, and search and delivery of SAGEEP papers. You will also have the opportunity to donate to the EEGS Foundation during the renewal process. Members can renew by mail, fax, or online at www.eegs.org.

Sponsorship Opportunities

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 conference, to be held this March in Boston, Massachusetts. Make this the year your company gets involved! Contact Catherine Skokan (cskokan@mines.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/Publications-Merchandise/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/Publications-Merchandise/FASTTIMES you'll now find calls for articles, author guidelines, current and past issues, and advertising information.

Submissions

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 February 15 to ensure inclusion in the next issue. We look forward to seeing your work in our pages.

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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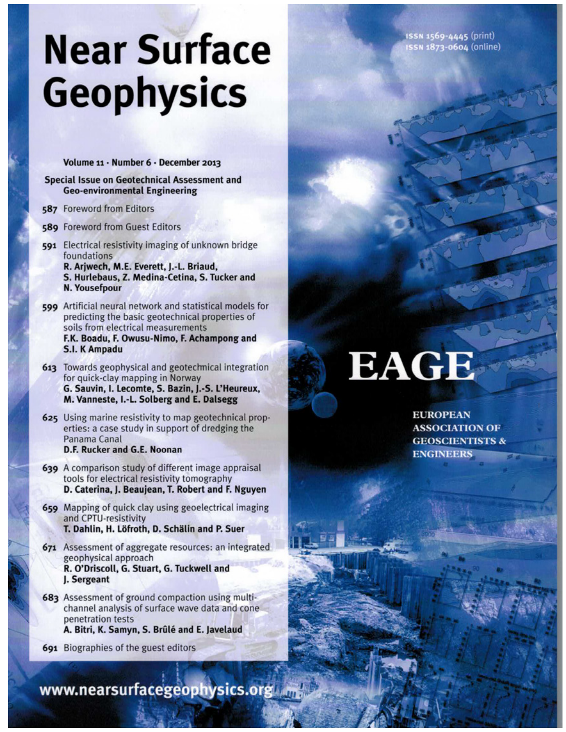
The Journal of Environmental and Engineering Geophysics (JEEG) is the flagship publication of the Environmental and Engineering Geophysical Society (EEGS). All topics related to geophysics are viable candidates for publication in JEEG, although its primary emphasis is on the theory and application of 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 www.eegs.org/Publications-Merchandise/JEEG.

Special Issue

Geotechnical Assessment and Geo-environmental Engineering Geophysics



The past decade has seen a distinct change in the way that geophysical methods are utilized in solving geotechnical and geo-environmental problems. Advances in instrumentation design, computer hardware and data processing software, and availability of new data have all led to novel and highly sophisticated geophysical techniques being routinely applied to geotechnical and geo-environmental problems.

Experts say that the near-surface geophysics community will witness a rapid growth over the next decade. The recent surge in the development of new technologies and analysis tools lends weight to that theory, and today we have numerous means to solve many of the complex engineering problems associated with the natural and built environments. Assessing the stability and integrity of structures such as buildings, bridges, dams, roads, water ways, foundations, underground excavations, mines, landfills, and sinkholes often requires a multi-disciplinary approach and collaboration between experts in geophysics, hydrology, geotechnical and environmental engineering, and geology. A trend to objectify the information about the condition of a structure is beginning to emerge: the development of tools to appraise and integrate data from sources of similar and dissimilar nature.

In response to the rapid and exciting expansion of research, the *Journal of Environmental & Engineering Geophysics and Near Surface Geophysics* have produced a collaborative *"Special Issue on Geotechnical Assessment and Geo-environmental Engineering"* to showcase the state-of-the-art and most pertinent research currently being undertaken in the discipline. Chief Editors, Janet Simms of *JEEG* and Ugur Yaramanci of *NSG*, are delighted to present a jointly worked special issue addressing an active topic in both research and practice, i.e., the application of geophysics for geotechnical and geo-environmental issues. Increasing demand and efforts to meet the needs of activities for environmental issues need a platform to communicate the achievements of science and technology and bring communities together working and doing science in the same subject area.

Special Issue

Geotechnical Assessment and Geo-environmental Engineering Geophysics

Well known individuals in the professional community for their scientific and technical work are brought together to serve as Guest Editors for this special issue: Moe Momayez and Fred Boadu from the U.S. and Nigel Cassidy and Denis Jongmans from Europe. Their efforts shaped the content and quality of the contributions. The unique feature of this special issue is that it is produced jointly by the two journals, with each journal addressing different geophysical methods that are complementary. Subscribers of each journal will receive both the *NSG* and *JEEG* issues of the special issue as on-line access and hard copy (if given). Using this approach, a large community can be addressed and informed about the newest developments, and allows authors to get their work to the attention of a much larger audience and producing more impact.

The Special Joint-Issue of the *JEEG* and *NSG* is a selection of original contributions organized under two themes. *Near Surface Geophysics* presents eight articles on the application of the electrical resistivity techniques to determine the geotechnical properties of the ground, and the integration of geophysical and geotechnical data. The *Journal of Environmental and Engineering Geophysics* contains seven papers that investigate the stability of structures using seismic techniques.

In the paper *"Seismic surface-wave prospecting methods for sinkhole hazard assessment along the Dead Sea shoreline"*, **Ezersky et al.** present the results of a surface-wave investigation into evaporite karsts which are caused by slow salt dissolution, and are linked to the mechanism of sinkhole formation along the Dead Sea coastal areas. Vs mapping allowed soft zones associated with karstified salt to be characterized, while roll along acquisition, dispersion stacking, and inverted pseudo-2-D Vs sections made it possible to detect decompacted sediments associated with potential sinkholes occurrences. **Walter et al.** employ passive seismic to monitor landslides at three soft-rock sites in the Austrian and French Alps and in the San Juan Mountains of Colorado, U.S. Their paper *"Slidequake generation versus viscous creep at soft rock landslides: Synopsis of three different scenarios at Slumgullion landslide, Heumoes slope, and Super-Sauze mudslide"* discusses the origin of the process and how it might be directly influenced by the boundary surfaces causing seismic and aseismic modes. Geotechnical and mine planning engineers will be interested in the work presented in *"Seismic reflection for hard rock mineral exploration: Lessons from numerical modeling"* by **Greenhalgh and Manukyan**. The authors show that where there is enough density contrast through the presence of metallic ore, or fractured zones, it is possible to probe ahead of the mining face – a useful tool in the context of narrow vein mining that would help reduce dilution. They propose that numerical modeling of elastic scatterers can help in the design of the field survey and effectively avoid spatial aliasing problems caused by the shape and location of the orebody and the restricted range of view angles. The potential for the ground to liquefy is omnipresent in earthquake-prone regions. **Nobes et al.** employ several near-surface geophysical methods in the article *"Geophysical imaging of subsurface earthquake-induced liquefaction features at Christchurch Boys High School, Christchurch, New Zealand"* to better understand the characteristics of liquefaction in the subsurface and interpret paleoliquefaction features. Monitoring microseismic activity in underground mining operations is mandated by law to warn of potential slope/pillar failures or rockbursts. The average magnitude of mining induced seismic events is between 1 and 3 on the Richter scale. Nanoseismic monitoring (NM) focuses on the detection, location and characterization of extremely low-energy ($M_L > -4.0$) source processes and has been applied by **Wust-Bloch and Tsesarsky** to study pre-failure microcracking in concrete beams and marble plates. Their paper *"Structural health monitoring in natural environments: Pre-failure event location and full-waveform characterization by nanoseismic monitoring"* discusses how the nanoseismic technique can be adapted to monitor unstable archaeological caves excavated in natural chalk, and highlights NM potential for analyzing pre-failure microcracking processes in the broader geological media. **James and Ferreira** use 3-D modeling to compute and compare the response of various cavity targets from a range of techniques such as gravity, gravity gradient, magnetic, magnetic gradient and GPR in their paper entitled *"Geophysical modeling of typical cavity shapes to calculate detection probability and inform survey design"*. This objective approach should resonate with engineers: it aids in assessing the probability of target detection, hence, discriminate the choice of technique(s), improve survey design, and increase the likelihood of success. The analysis of seismic noise recorded from extremely low frequency seismometers (0.2 to 2 Hz) to identify precursors to rock-falls is the topic of the article *"Spectral analysis of prone-to-fall rock compartments using ambient vibrations"* by **Bottelin et al.** They show that the correlation between the primary natural frequency of the rock mass and meteorological parameters can be used to identify the natural frequencies of the unstable rocks and to monitor their evolution through time.

Arjwech and Everett carry out 2-D and 3-D resistivity surveys at three roadway bridges and one railway bridge, and one geotechnical test site, and report their research findings in the paper *"Electrical resistivity imaging of unknown bridge foundations"*. They show that the 2-D electrical resistivity imaging technique used on the ground and underwater is a cost-effective geophysical method, and relatively straightforward for bridge foundation investigations. To infer site-specific engineering parameters (that affect the mechanical behavior of soil) from electrical measurements, **Boadu** uses multivariate regression models to validate the output from neural networks in his paper *"Artificial neural network and statistical models for predicting the basic geotechnical properties of soils from electrical measurements"*. Spectral electrical parameters, including conductivity, phase shift, and loss tangent are related to engineering properties such as fines content, specific surface area and pore size which are essential properties used in site characterization. In the paper *"Towards geophysical and geotechnical integration for quick-clay mapping in Norway"*, **Sauvin et al.** present an integrated approach to characterize hazardous quick-clay sites. The authors emphasize that because of the inherent complexities in integrated approaches, high resolution data, in-depth imaging, and site-specific data calibration would provide the essential parameters for stability analyses. Geotechnical properties of the subsurface material are needed for the expansion of the Panama Canal to be completed in 2015. Limited core, lithographic and stratigraphic data are available from the previous expansion phase that took place over 60 years ago. The paper *"Using marine resistivity to map geotechnical properties: A case study in support of dredging the Panama Canal"* by **Rucker and Noonan** shares the results of an investigation that helped reduce the uncertainty in interpolating material properties between boreholes, by conducting a spatially continuous electrical conductivity survey. Few studies have offered an objective comparison between the powers of various electrical resistivity tomography (ERT) algorithms/tools. **Caterina et al.** propose in their paper *"A comparison study of different image appraisal tools for electrical resistivity tomography"*, a quantitative methodology to appraise the performance of the most commonly used ERT tools such as model resolution matrix, the cumulative sensitivity matrix, and the depth of investigation index. This work paves the way to develop additional appraisal indicators suitable for more comprehensive analyses. A second contribution in this collection on the topic of quick-clays is *"Mapping of quick-clay using geoelectrical imaging and CPTU-resistivity"* by **Dahlin et al.** The authors conducted an integrated 2-D resistivity-IP survey with a combined cone penetration test and resistivity measurement (CPTu-R). The approach has been successful in segregating leached soils from soils with a high salt water content, thus providing an efficient screening tool when used in the early stages of the investigation process. **O'Driscoll et al.** investigate the integration of refraction, multichannel surface waves and resistivity data to determine the spatial variability of aggregate quality in a quarry. Data integration in their paper *"Assessment of aggregate resources: An integrated geophysical approach"* is carried out by linking measured elastic and electrical parameters through regression analysis of cross-plots and using established petrophysical relationships to set up guided inversions of the refraction and resistivity data. **Bitri et al.** present an alternative method to the cone penetration test to determine the mechanical properties of soil in their paper *"Assessment of ground compaction using multi-channel analysis of surface-wave data and cone penetration tests"*. These authors formulate that the shear wave profiles of a site offer the potential to characterize the soil at a higher spatial resolution and a fraction of the time.

SUCCESS WITH GEOPHYSICS

FastTIMES 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 the articles that follow, authors describe a low cost tromograph system for microtremor seismic acquisition and discuss aspects regarding integration of global positioning system technologies with geophysical surveying.

SaaM – A Low Cost Tromograph System for Microtremor Seismic Acquisition Based on the ArduinoUNO

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Introduction

Since the early 1990s, the Horizontal to Vertical Spectral Ratio (HVSR) method, also known as the Nakamura (1989) technique, has been used as a tool for seismic characterization of the subsoil via seismic microzoning (e.g., Duval et al., 2004; D'Amico et al., 2008). This method is based on vibration measurements performed using single station measurements or a system array with different spatial arrangements (for subsoil seismic characterization exploration up to crustal depths). The simple goal of a single-station ambient vibration measurement is to detect seismic impedance contrasts, thus seismic resonance (e.g., Kramer, 1996), in the subsoil, and in particular, determine the fundamental resonance frequency of the soft sedimentary cover, which is a major concern (SESAME, 2004). For computation of the spectral ratios using the Nakamura technique (1989), the Geopsy software developed within the European project SESAME (http://sesame-fp5.obs.ujf-grenoble.fr) was used.

This article describes an inexpensive microseismic acquisition device (tromograph) based on an open-source ArduinoUNO microcontroller prototyping platform. Details are provided on constructing this device for less than $250, including essential information on the design of this instrument and also how to use it. The main design goal of this system was to use open-source

Keywords: Tromograph, Open-Source, ArduinoUNO, Low Cost, Fundamental Period of Resonance, Seismic Microzonation, Nakamura Technique

components as much as possible, in order to reduce design complexity, thereby allowing use of the system for end-users without advanced electronics skills.

The main core of the system is a USB-connected ArduinoUNO microcontroller platform designed initially with a specific emphasis on the ease-of-use in creating interactive physical computing environments. The instrument is small, light, robust, and is useful for seismic microzonation, but also can be employed for seismic monitoring of landslides and other scenarios in which seismic waves are generated. Data interpretation can be accomplished quickly in the field with free software installed on a laptop computer.

Tromograph System Description

The tromograph system is arranged around the ArduinoUNO prototyping microcontroller platform. The complete system includes a computer with acquisition and processing software, the ArduinoUNO prototyping platform, three 4.5 Hz geophones arranged in an orthogonal configuration (Vertical, North-South, and East-West oriented), an amplification circuit, metal enclosure, and cable (Figure 1). The purpose of the computer is to provide an easy, graphical based control to manage principal acquisition parameters (time and gain), and then to evaluate the quality of data acquisition using advanced tools (spectral analysis FFT, filter, average, etc.).

The ArduinoUNO is a data acquisition device that reads analog inputs from external geophones, sending these vibrations in a digital format to the computer to be easily plotted on a graph and saved in a file for further evaluation. The ArduinoUNO's ADC dynamic is 10 bits, which is fairly poor for correct digitalization of small signals from the geophones. Therefore, it is necessary to amplify these signals before input to the ArduinoUNO. A simple op-amp differential amplifier circuit is employed that provides variable gain up to 1000x (Figure 1), which is more than adequate.

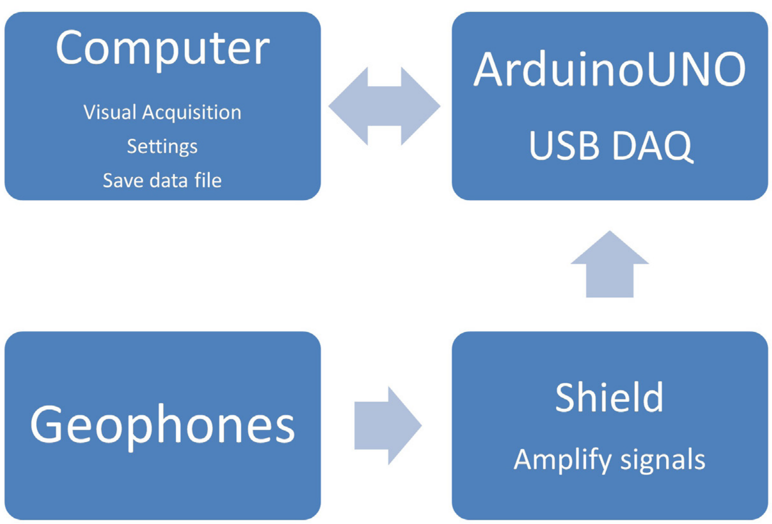


Figure 1: Block diagram of the tromograph system. The computer provides easy interface management, and data can be stored for further evaluation using spectral analysis software.

A geophone is a transducer that converts slight vertical ground motions into a voltage signal. This is usually accomplished through suspending a magnet from a spring within a coil of wire. Tromograph applications require at least three geophones with low resonance frequency. Unfortunately, the cost for geophones with low resonance frequency can be quite high. Initial experiments suggest a good compromise between performance and cost can be achieved with 4.5 Hz geophones. For this research, 4.5 Hz geophones were obtained from Xi'an Senshe Electronic Technology Corporation (model PN 4.5N). An alternative approach would be to employ a MEMS accelerometer integrated circuit chip, which is much cheaper and smaller than a mechanical geophone, but their use increases complexity of interface connection circuitry.

The geophone enclosure needs to be chosen with careful consideration. The quality of microseismic acquisition is strictly linked with correct orientation between geophone and soil.

A metallic aluminum enclosure, with four micrometric regulation legs guaranteed the proper geophone orientation. In order to keep the fixed positions of the geophones orthogonal, we put the geophones inside a metal block with three drilled holes. If it is difficult to find an appropriate metal block, it is also possible to insert the geophones in a gypsum block.

Hardware

Microcontroller

The ArduinoUNO (Figure 2) is an open-source microcontroller board based on the ATmega328. It has 14 digital input/output pins and 6 analog inputs, containing everything needed to support the micro-controller, and it can be simply connected to a computer with a Universal Serial Bus (USB) cable. The ArduinoUNO can be programmed with the Arduino Integrated Development Environment (IDE) software based on the Processing IDE (http://processing.org). The C-based simple program code for the Arduino is referred to as a "sketch". A collection of sketches for specific functions are referred to as "libraries".

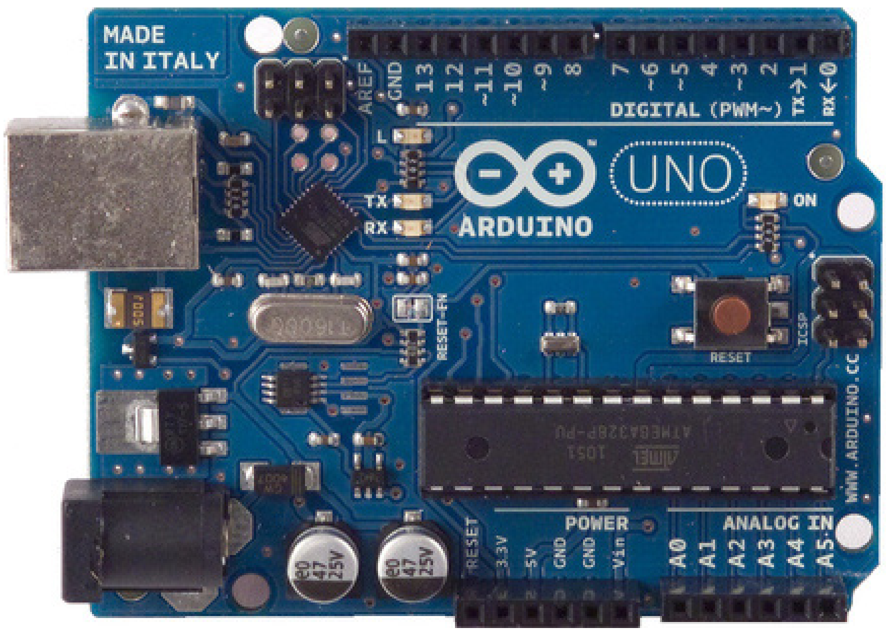


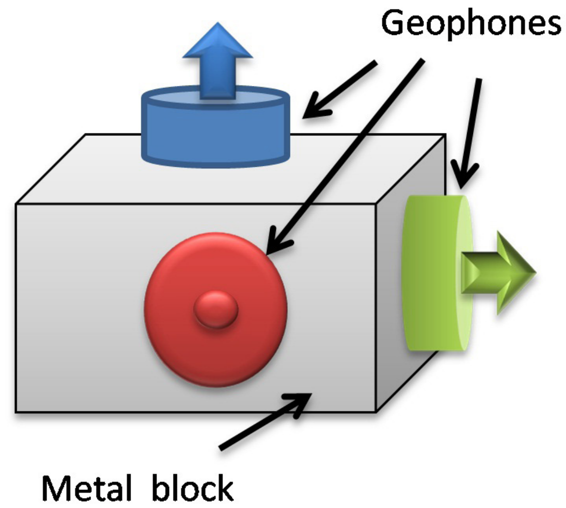
Figure 2: ArduinoUNO microcontroller. Analog IN are used for the geophone input channels. It is possible to connect up to six geophones, although for tromograph applications, only three are required.

The ArduinoUNO can work autonomously without being connected to a computer, or alternatively, it can be programmed to respond to commands sent from the computer via various software interfaces (http://arduino.cc/playground/Main/InterfacingWithSoftware) or to the data acquired from the input channels. Additionally, the ArduinoUNO can be programmed and controlled via third-party programming environments such as LabVIEW. The hardware functionality of Arduino can be extended with external plug-ins referred as "shields" commercially manufactured or created by the user. Shield functions can include networking capabilities such as Ethernet, Bluetooth, ZigBee, TFT touch panel capability, data logging without the need of a computer, or in case of our application, to acquire, filter, and stabilize geophone signals before these signals are sent to the ArduinoUNO.

When comparing the ArduinoUNO to other existing data acquisition device (DAQ) solutions, it should be noted that the ArduinoUNO cannot provide the same level of temporal precision as some of these dedicated precision DAQs. However, for most microseismic acquisition solutions, these other DAQ approaches often greatly exceed needed requirements and are overpriced. The ArduinoUNO DAQ was tested at the website “Measuring Stuff: The Arduino DAQ Chronicles” (https://sites.google.com/ site/measuringstuff/the-arduino), which estimated the analog input sampling rate via serial connection to the hard drive at a baud rate of 9600 bps to be approximately 26 samples per second, and at a baud rate of 115,200 bps to be approximately 517 samples per second. The analog input sampling rate obtained is sufficient to replace oscilloscopes and logic analyzers in some applications as was demonstrated by the Arduinoscope project (http://code.google.com/p/arduinoscope/). The sample rate can be further increased to 8300 samples per second for burst writing the data only to the on-board 2 KB SRAM of the ArduinoUNO. For data acquisition involving microseismic analysis, the useful frequency range is between 0.5 Hz to 40 Hz, and when considering the Nyquist sampling frequency, the minimum sampling rate should be 80 Hz. The ArduinoUNO can provide a sampling rate three times greater than this, which is more than enough for this kind of study. Unfortunately, the low dynamic range of the ArduinoUNO required the use of an external amplification shield before input of geophone signals to the ArduinoUNO.

Geophones and Signal Amplification Shield

The small signal generated by the geophones needed to be amplified before input to the ArduinoUNO. This signal amplification required the integration of an custom amplifier circuit shield within the tromograph system. The geophone's task is to convert slight vertical ground motion into a voltage signal. Each geophone (Figure 3) has an output voltage depending on the acceleration (measured in g's), and for the geophones used in this study, the voltage output was 25 Volt/g. This means that for each "g" of acceleration (= 9.8 m/s^2), the geophone would generate a 25 Volt current. For microseismic studies, the accelerations involved are very low, close to 10^{-3} g, consequently these geophones generate a small signal voltage with a pseudo-sinusoidal wave form (like alternating current, AC) that requires signal amplification using an "operation amplifier" (op-amp), which is a small active (powered) integrated circuit capable of increasing input voltage by a factor of X (Figures 3 and 4).



Boom componenti Ampl. 3ch rev.0.0		
RefDes	Value	Quantity
C1	SR205E104MAR	1
C12	SR205E104MAR	1
C2	10 uF 25 Volt	1
D1	1N4148	1
D2	1N4148	1
D3	1N4148	1
Dip1	ADE0404	1
J1	strip pin 14 2.54	1
J3	strip 18 pin 2.54	1
R1	1 kOhm	1
R15	1 MOhm	1
R16	1 MOhm	1
R17	1 MOhm	1
R2	1 kOhm	1
R22	33 kOhm	1
R23	33 kOhm	1
R24	33 kOhm	1
R3	1 kOhm	1
R4	33 kOhm	1
R5	33 kOhm	1
R6	1 MOhm	1
R7	1 MOhm	1
R8	1 MOhm	1
U1	TLV2264IN	1
U5	CD4066	1
VR1	67WR-1K	1
in_X	2 way 5.08	1
in_Y	2 way 5.08	1
in_Z	2 way 5.08	1
U1	zoccolo dip 14	1
U5	zoccolo dip 14	1
PCB	c.s. Ampl.3ch rev.0.0	1

Figure 3: Left: Arrangement of geophones. Instead of using a metal block (enclosure), it is also possible to use a water soluble gypsum block. Right: Op-amp material list (op-amp circuit diagram shown in Figure 4).

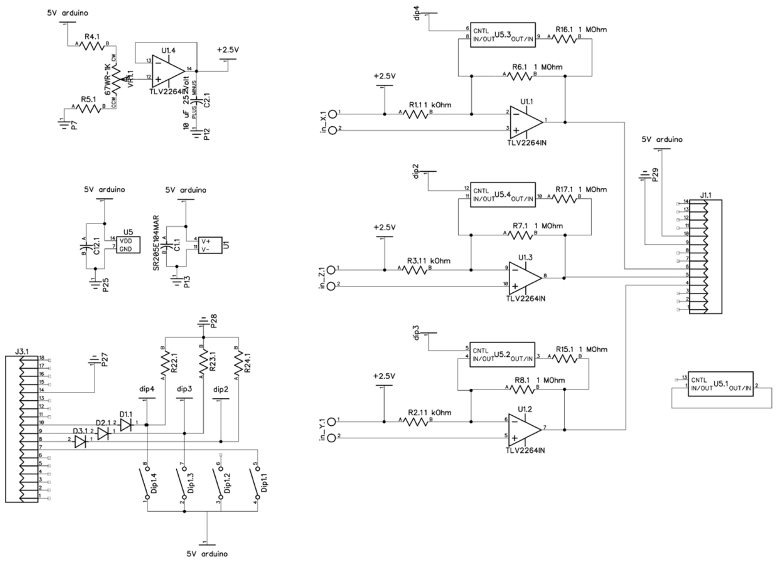


Figure 4: OP-amp electrical circuit diagram.

A detailed discussion of the theoretical basis for the “op-amp ” is beyond the scope of this article; however, it is important to describe some of the features included in the instrument. To amplify and acquire both positive and negative parts of seismic waves, the op-amp required a dual power source or virtual zero reference. To simplify electrical circuitry, a virtual zero reference was chosen that was obtained using a precision voltage divider and successively stabilized using the op-amp in voltage follower configuration, which was mandatory to avoid thermal drift. Two capacitors are employed to filter spurious electrical frequencies. The voltage gain design adopted for the op-amp is based on the following equation:

$$V_{OUT} = V_{IN} \frac{R_F}{R_G}, \qquad (1)$$

where the V_{IN} voltage is from the current provided by geophone, and the R_F and R_G resistor values are chosen in order to obtain a ratio of 1000. Obviously, this ratio can be modified given the pair of resistors employed. In order to provide flexibility for modifying gain, for reducing the amplification factor if required, addressing external noise, or using another platform instead of the ArduinoUNO, a digital potentiometer was incorporated that could be controlled via software using digital ArduinoUNO output or via a hardware set-up with switches. This system permitted the gain to be set at X or 0.5X (where X is the RF/RG ratio). Many op-amp details are provided in Figures 3, 4, 5, and 6.

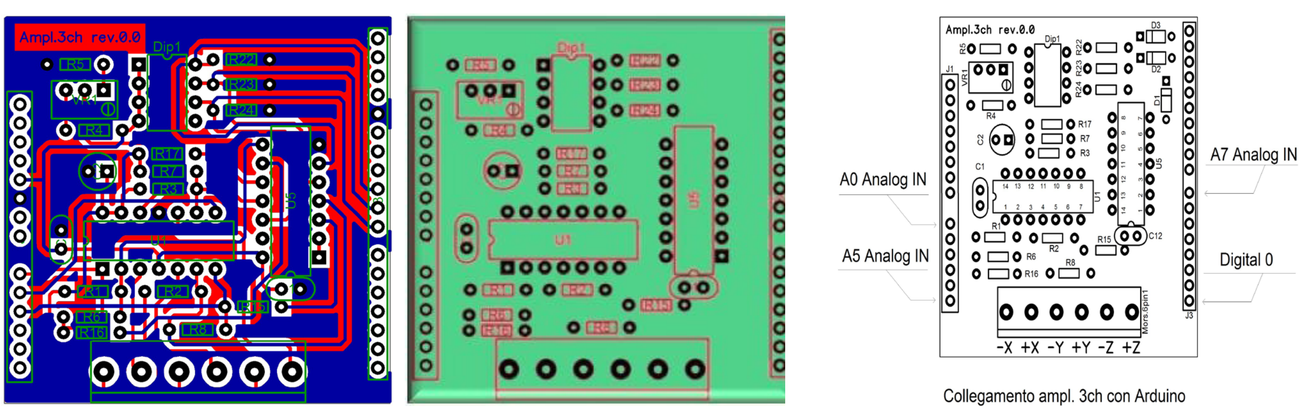


Figure 5: Op-amp circuit board schematic and components layout. The op-amp is pin-to-pin compatible with the ArduinoUNO.

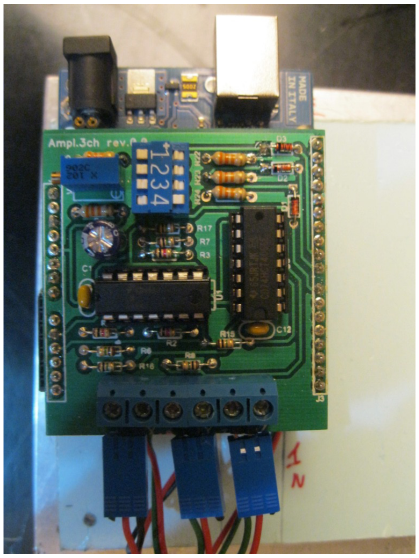


Figure 6: Photo of tromograph op-amp.

Software

The ArduinoUNO needs a "sketch" to be uploaded via the Arduino IDE, so that the ArduinoUNO understands the commands sent from Python, Matlab or LabVIEW code. The software described in this article was done in LabVIEW development (Evaluation version of LabVIEW 2011) with Windows 7. The computer visual interface (Figure 7 - developed using LabVIEW programming language) included a series of virtual instruments, each with a particular function, such as acquisition, control, saving of data, spectral analysis, and calibration. These LabVIEW virtual instruments (VIs, "LabVIEW programs") were developed using the NI LabVIEW Interface for Arduino Toolkit (LIFA, http://ni.com/arduino). The LIFA (LabVIEW Interface for Arduino) comes with its own Arduino sketch that needed to be uploaded to the ArduinoUNO board using the default IDE before running the VIs. This sketch allowed writing and reading digital and analog values from the ArduinoUNO under LabVIEW, with sampling rates up to 120 Hz, which is sufficient for microseismic analysis. For full details on the Arduino IO package, one is referred to documentation of the Arduino IO package.

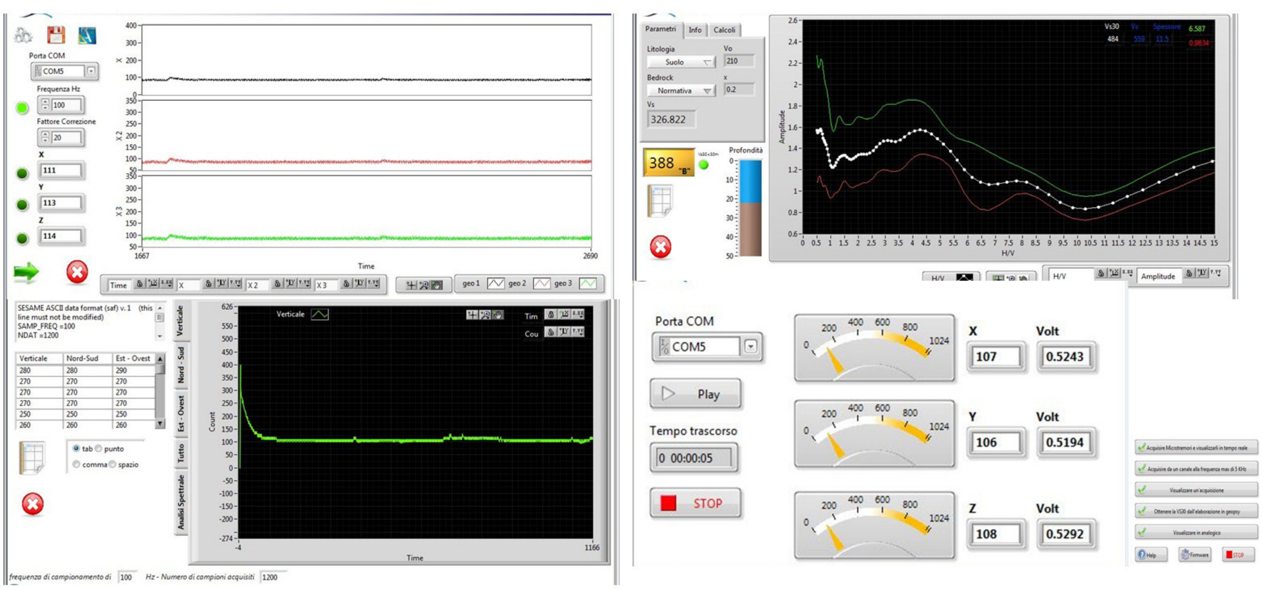


Figure 7: Screenprint from acquisition and management software.

Results

In order to evaluate the quality of data provided from the tromograph described in this article (SaaM), a series of tests in different environments were conducted to compare SaaM to a device that was commercially available. For each site, there were two measurements, one with SaaM and the other with the commercial device. Each 5 minute long microseismic measurement was evaluated using a algorithm provided from the SESAME project (http://www.geopsy.org), using the same filtering parameters. In Figure 8, the plotted HVSR curves were computed from data acquisition in buildings. The blue HVSR curves are from SaaM and the red curves are from the commercial device (24 bit ADC dynamic). Both instruments highlighted the same resonance peaks at 2.1 Hz (Figure 8 - left graph) and 4.2 Hz (Figure 8 - right graph). For the graph on the left, the SaaM and commercial device HVSR curves exhibit good similarity between 4 and 40 Hz, the SaaM curve has an amplitude close to 1 at 0.6 Hz, while both the SaaM and commercial device HVSR curves show a peak at 6 Hz, although this 6 Hz peak is more evident with the commercial device. On the right graph, the differences between SaaM and the commercial device HVSR curves are less evident, with same trends and absolute values at low frequencies, the same resonance peak at 4.2 Hz, and other coinciding smaller peaks at 1 Hz and 30 Hz. The commercial 24 bit ADC normally showed the widest range of amplitudes, which is probably related to scattered environmental noise and partially due to a short acquisition time.

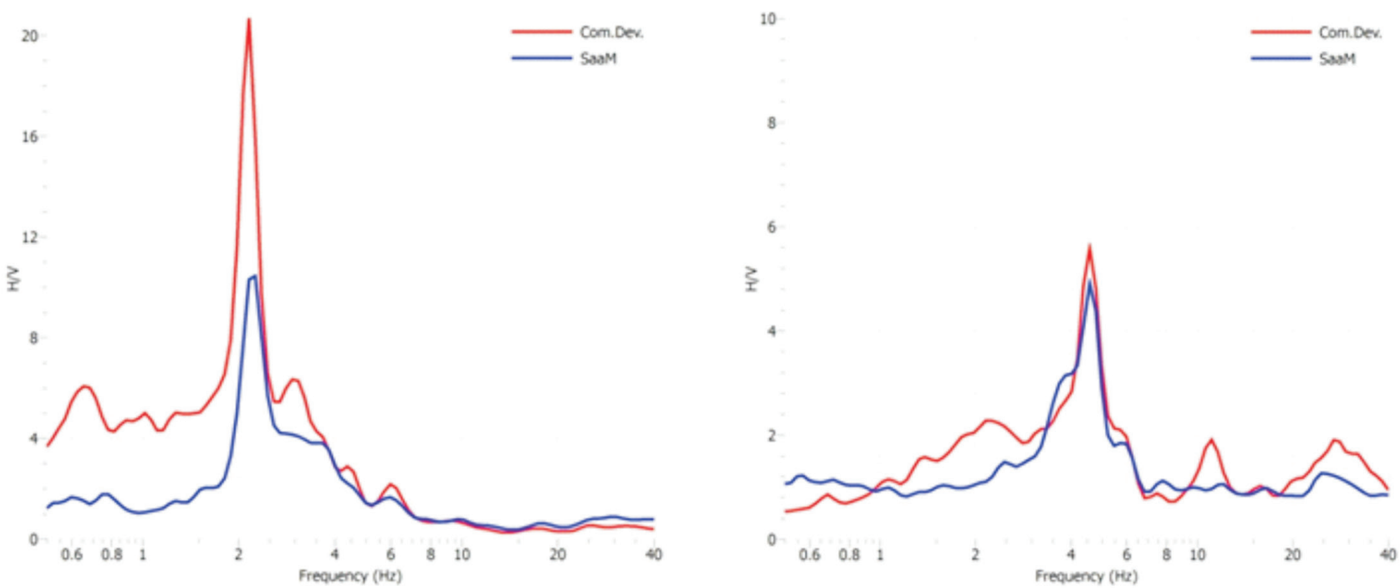


Figure 8: HVSR computation performed on microseismic acquisition sampled with SaaM (blue) and a commercial 24-bit device (red). Each graph is from a different site.

Conclusion

An inexpensive microseismic acquisition device (tromograph) based on the open-source ArduinoUNO microcontroller prototyping platform, was described. This device was put together taking into account the ease of construction, set-up, and utilization for an operator without advanced skills in electronics. The instrument is robust, light, and small. With the free software available, it is possible acquire, visualize in real time, and then save data. Advanced tools are (or should be) developed in order to obtain spectral ratio/frequency for the study of seismic noise and analysis of vibration measurements. The free software described in this article is be obtained from https://sites.google.com/site/geologiageofisicaesismologia/ , which is a large on-line community where other information related to geophysical investigations are reported. The ArduinoUNO can be controlled using various programming environments, and it is not limited to proprietary environments such as LabVIEW. By choosing open-source solutions in respect to both hardware (ArduinoUNO) and the programming environment (Python), there is capability to modify this tromograph system, thereby allowing novel ways of interaction between the developers and end users. Active user communities exist both around Arduino (e.g. Arduino Playground, http://arduino.cc/playground/) and Python (e.g. http://www.python-forum.org/). In conclusion the low-cost and ease of use for this tromograph system makes it an attractive alternative to DAQ-based systems. The system can be used for a wide range of applications in educational and research environments, with users having limited technical skills, and in particular for researchers, students, and universities with limited financial resources.

Acknowledgements

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Duval, A. M., J. L. Chatelain, and B. Guillier, and thè SESAME WP02 team (2004). Influence of experimental conditions on H/V determination using ambient vibrations (noise). http://sesamefp5.obs.ujf-grenoble.fr/Conference/SDEE-jan2004_Duval.pdf (last accessed February 2006).

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INCORPORATING GPS/ RTK POSITIONING INTO GEOPHYSICAL SURVEYS: CONSIDERATIONS AND LEGALITY

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Dr. Freeland is licensed in the State of Tennessee as both a Professional Engineer and a Registered Land Surveyor.

Introduction

Satellite-based positioning is commonplace; it is an integral component to our smart phones, computer tablets, and vehicles. Many geophysicists routinely employ GPS technologies for field positioning. Geospatially linked data are easily mapped and overlaid onto aerial photography using free web-based tools such as Google Earth and Maps. All commercial GIS desktop products allow import of geospatial-linked field data. Geophysical equipment companies increasingly integrate geospatial tools into their hardware and software. Some products allow direct launching of geophysical data into popular GIS products. As this integration evolved with geophysical surveying, GPS technology has introduced numerous professional licensing issues for the geophysicist. In specific instances and locales, GPS integration with geophysics can result in stop-work orders and fines.

Time Stamping

GPS technologies have changed considerably since the 1990s, when the first units were crippled by selective availability. Before the turn of this century, early adopters started acquiring geospatial coordinates for their field data by employing "time stamping". This method involved two sets of independently collected data gathered simultaneously. A GPS receiver was placed next to the field instrument and continuously recorded both time and position. A second data logger recorded the geophysical data point along with a synchronized time, usually in Coordinated Universal Time (UTC). The two files were later merged by using corresponding time records in each data set. One common method for merging the two datasets used the spreadsheet LOOKUP function. The GPS equipment's close proximity and its possible interference with geophysical sensing was a point of contention among early practitioners (Figure 1).

Keywords: GPS/RTK Positioning, Geophysical Surveys, Ground Penetrating Radar (GPR), Electromagnetic Induction (EMI)

Figure 1: Broad-area electromagnetics (EMI) using time stamped DGPS positioning in the 1990's.

NMEA 0183

Legacy GPS units transmitted GPS data to other vendor's devices via a wired cable. Today, many geophysical instruments can accept external geospatial inputs, connecting wirelessly via Bluetooth or Wi-Fi. One popular communication format is National Marine Electronics Association (NMEA 0183), which are transmissions of ASCII comma-separated variable (CSV) text strings. If recorded, the files are easily imported into a spreadsheet. GPS engines typically transmit only those formatted as GGA, GSA, RMC, VTG, and ZDA sentences[1], and these are often individually user-selectable for output. The text strings of spatial position, time, and other parameters are output at user-defined update rates (typically one to five Hz). One of the most commonly used text string output is GGA (Tables 1 and 2).

Table 1. Sample NMEA GGA string example identifiers

Iden	UTC Time	Lat	Long	Fix[a]	No. Satt	HDOP	Alt(m)	Geoid	Time[b]	Station[c]	Checksum
$GPGGA	193214	3542.5 N	8847.0 W	1	9	1	145.687	-28.317	NoData	0101	*57
$GPGGA	183040	3544.1 N	8851.7 W	2	14	0.9	111.953	-28.305	6	0110	*74
$GPGGA	153223	3526.5 N	8836.6 W	4	15	0.6	125.707	-28.137	5	0111	*4D
$GPGGA	165839	3529.0 N	8842.7 W	4	14	0.8	118.061	-28.129	1	0111	*7B
$GPGGA	174641	3538.3 N	8903.4 W	5	15	0.8	105.873	-28.111	1	0111	*75

[a] Fix Quality: 0=Invalid, 1=GPS, 2=DGPS, 3=PPS, 4=RTK fix, 5=RTK float, 6=Estimated (dead reckoning), 7=Manual input mode, 8=Simulation mode

[b] Time since last reference update from reference base station

[c] Unique station identifier value, e.g., 0101=GPS/none, 0108=DGPS/WAAS, 0110=DGPS/WAAS, 0111=RTK

[1]GGA - GPS 3D location and accuracy fix data, GSA — DOP and active satellites, RMC — Recommended minimum data for GPS, VTG — Vector track and ground speed, ZDA — Date and time

Table 2. Example dissection of raw NMEA GGA text string by comma-delimited fields
$GPGGA,123456,4807.038,N,01131.000,W,4,11,0.9,545.4,M,46.9,M,1,0111*49

Field	Content	Description
1	$GPGGA	Global Positioning System fix data ID
2	123456	Position at 12:34:56 UTC
3	4807.038	Latitude 48° 07.038'
4	N	Northern Hemisphere (positive)
5	01131.000	Longitude 11° 31.000'
6	W	Western Hemisphere (negative)
7	4	Fix quality: 1-GPS,2-DGPS,3-PPS,4-RTK,5-float 6-estimated,7-manual,8-simulated,0-invalid
8	11	Number of satellites tracked
9	0.9	HDOP
10	545.4	Height above mean sea level
11	M	Meters
12	46.9	Height of geoid above WGS84 ellipsoid
13	M	Meters
14	1	seconds since last augmenting station update
15	0111	DGPS station ID number
16	*49	String checksum, "*" prefix delimiter,<CR><LF>

The NEMA string transmission (or refresh) rate is important. A rate that is too high can be unnecessary, overwhelming data buffers without flow control. A rate that is too low will be inadequate for accurate mobile positioning. For example, a 1-Hz rate is not sufficient for mobile auto guidance, as there is too much lag time during turns. A rate of more than 5 Hz exceeds the positional capabilities of some GPS engines. Greater than 5-Hz positional update rates are required in construction machine control, and are obtained by augmenting positioning between GPS update intervals using accelerometers.

The latitude and longitude values within a NEMA sentence are not compatible for import into some third-party software that uses signed decimal degrees. These two variables are formatted as "ddmm.mm" in the NEMA sentence, where "d" are degrees and "m" are the remaining decimal minutes of a degree. For those data recorded as positioned in the western or southern hemispheres, a corresponding negative sign must be appended. Conversions are easily performed in a spreadsheet.

Elimination of the Grid Survey

Geophysical surveys of the 20th century commonly employed a pre-established grid of pin flags (non-metallic) and taunt string from which the operator could follow. At established intervals along the transect, the operator used a hand switch to insert a mark within the data (Figure 2). GPR scans were generated at a preset frequency, and these marks could be later used to normalize the number of scans to a constant for a given distance interval. This compensated for pull speed irregularities during collection. Physical layout of the grid and its later removal could take more effort and time than the survey itself. Modifying the transect length or spacing required additional effort.

With integration of GPS, geospatial coordinates linked to each sample eliminated the need of a pre-established grid (Figure 3). Geostatistical methods are now used to interpolate surfaces and to determine if the sampling is adequate. Survey track logs can be displayed on aerial surveys using desktop GIS or Google Earth to verify adequate coverage (Figure 4a).

One example is our irregular-spaced survey of a golf putting green, which we used for mapping its subsurface drainage tile network (Figure 4b). Although more GPR data were obviously gathered than required, this method required less time and effort than for the layout of a traditional grid. Furthermore, this seemingly haphazard survey reduced labor costs, as only one operator was required in the field.

Figure 2: Grid survey layout, towed 900-MHz GPR antenna with hand switch.

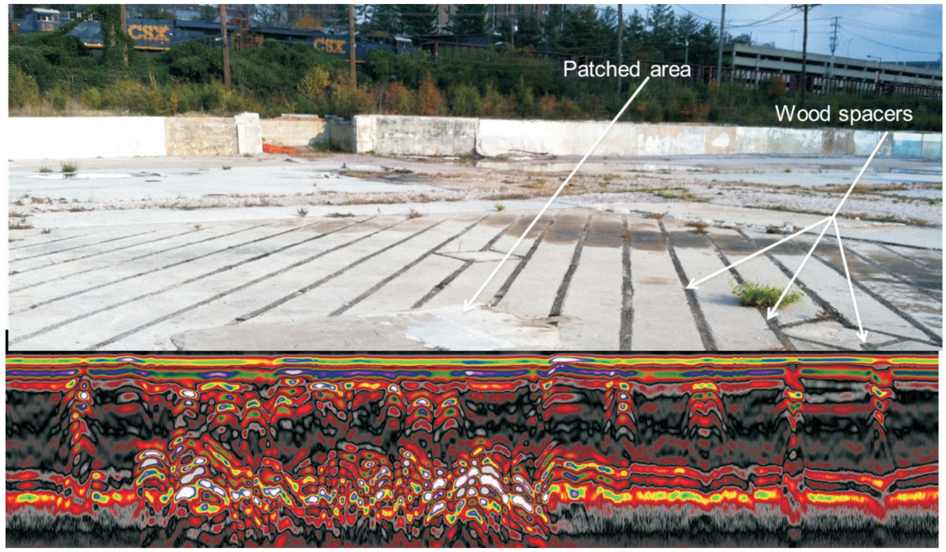

Figure 3: Coordinated surface and subsurface features using GPS.

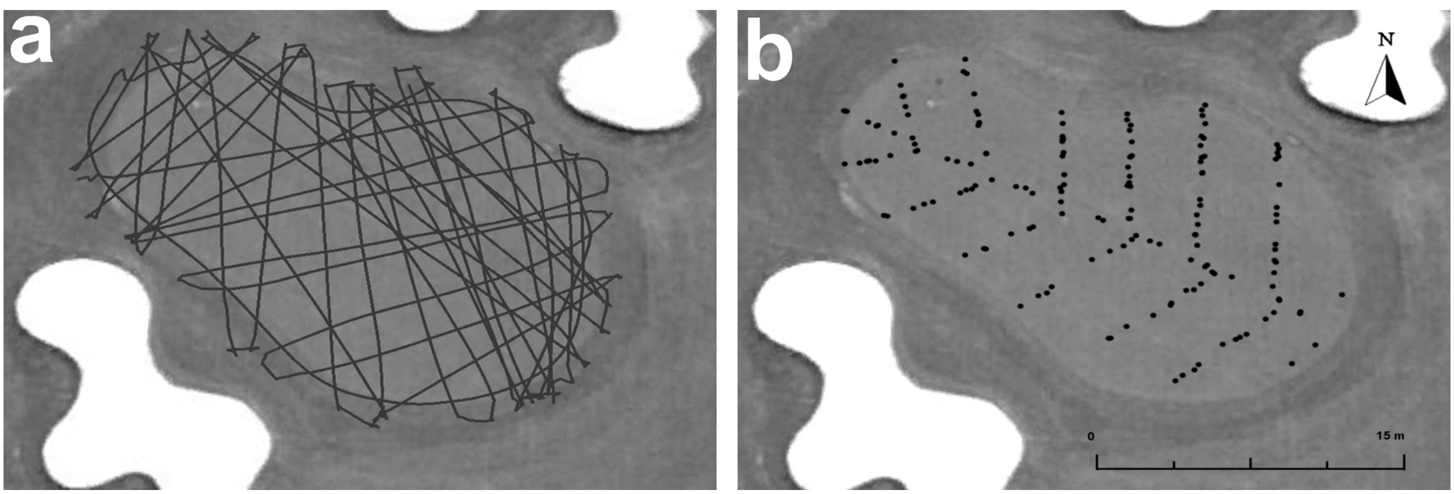

Figure 4: Profiling golf putting green with GPR, (a) irregular-spaced survey and (b) tile picks from its geospatially linked GPR data.

Accuracy and Precision

GPS data vary in both precision and accuracy; both are a function of the equipment used and the situational environment from which the data are logged. Explaining GPS performance specifications is highly complex. In broad terms, modern autonomous GPS can typically provide within 15 to 3 meters of positioning in real-time, and if augmented by an external reference station (e.g., WAAS, Coast Guard), a differential GPS (DGPS) can supply real-time positioning in most instances within 3-m down to sub-meter. This suffices for many broad-area sensing geophysical applications such as resistive, electromagnetic induction, and seismic profiling, which are often taken at fixed positions.

Towed ground-penetrating radar (GPR) is also routinely linked to DGPS receivers (Figure 5). Higher frequency antennas are of higher spatial precision, and in some applications DGPS should be augmented with wheel encoders for finer positioning and rate control of individual scans (e.g., mapping rebar, 3-D profiling). A third type of GPS should be considered for GPR frequencies greater than 200 MHz. As GPR frequencies and scan rates go higher while profiling shallower depths, Real-Time Kinematic (RTK), which is a survey-grade technology capable of sub-centimeter resolution, becomes almost essential for precise survey positioning in real time.

Figure 5: DGPS antenna mounted atop a shielded 200-MHz GPR antenna on sled.

Real-Time Kinematic (RTK)

Real Time Kinematic technology uses the phase shift of the carrier cycles. Conventional GPS code-based technology uses the timing data transmitted by the carrier signal itself. Every cycle of the GPS carrier signal is similar, thus difficultly arises in determining if the cycles used for comparison are correctly aligned or shifted in a number of cycles by an integer value. Resolving this integer ambiguity resolution to obtain an RTK “FIX” solution is computationally intense, and can be both time consuming and frustrating for the operator. The ease at which the “FIX” is obtained largely depends upon the site and situational timing.

A mobile RTK unit (Figure 6) uses a remote fixed base station that it is in continuous communication. The base station broadcasts the phase of the GPS carrier signal that it obtains over its known fixed point; the surveying unit then mathematically compares it to its own phase shift measurements. The comparison allows the surveying unit to more precisely and accurately correct its own position measurements. As the separation distance increases between the fixed base station and mobile surveying unit, the positional accuracy decreases. This separation distance between base station and mobile unit is limited to about 40 km.

Traditionally, this communication is over the UHF one-way radio. However, users are now moving to cellular-based broadband for two-way communication with the base station, whereby the fixed based station is one of a network of distributed commercial or government-owned towers. A Continuously Operating Reference Station (CORS) network consists of a number of RTK base stations across a wide area that are linked to a central server (Figure 7). The server can model an idealized or “virtual” base station for the RTK user’s specific position, providing an optimized accuracy for a particular surveying locale.

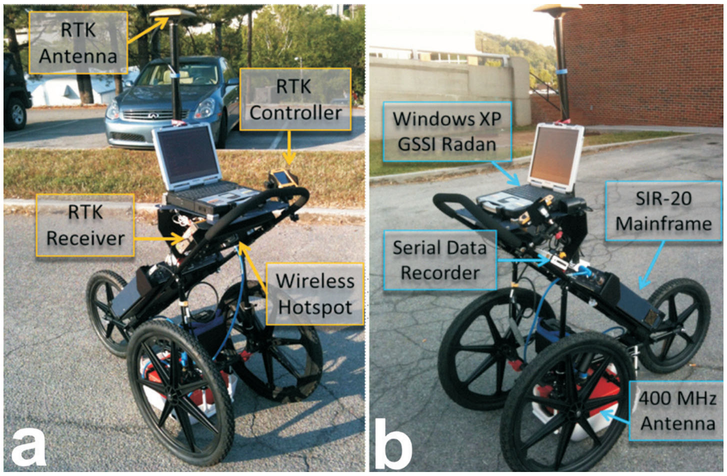

Figure 6: Push cart and integrated mounted components (a) RTK and (b) GPR.

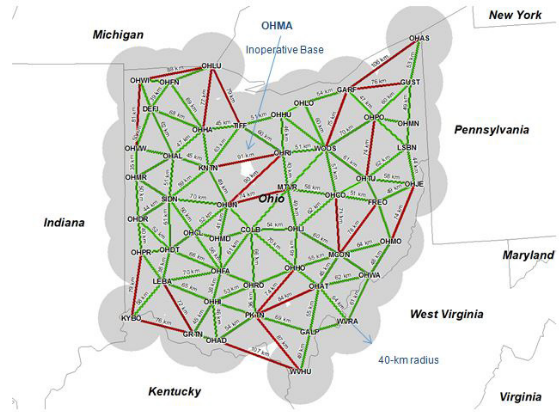

Figure 7: Ohio Department of Transportation, Structured RTK VRS Network.

GPS Interference

Interference of the GPS antenna or its interaction with the geophysical device and its sensing may be a concern. The GPS antenna is a passive non-transmitting device. If it is housed in a metallic case, the case and cabling may interfere with the survey. For example, minor interference has been observed in EMI surveys when the cable extended outward beyond the center point of the device. It should be noted that a high-wattage UHF radio, which may be integral to an RTK unit for communicating long distance to a base reference station, has been found to dramatically interfere with GPR (Figure 8). One solution is to turn off or dramatically decrease the transmitting power of the UHF radio. Broadband cellular, Wi-Fi, and Bluetooth transmissions have not interfered with GPR data collection.

Regardless of its integration and close proximity with geophysical instruments, GPS operation is susceptible to environmental interference. One such example is multipathing, whereby satellite signals reflect off nearby metallic objects. The increased distances of the reflected paths distort the direct path timings. Those that are assumed to normally travel directly to the GPS antenna were in fact reflected. One GPR/GPS application where multipathing occurred was during the measurement of sports turf compaction. Even robust anti-multipathing technology could not completely compensate for these errors when the GPS was completely surrounded by aluminum bleachers in a large football arena (Figure 9).

Figure 8: High-wattage UHF radio used to communicate with base station found to interfere with GPR.

Figure 9: Surrounding aluminum bleachers in a collegiate football arena introduced significant GPS multipathing errors.

There have been concerns raised about the GPR transmission interfering with the very weak GPS satellite transmission. However, a shielded GPR antenna's energy is transmitted downward. Little if no interference in the interaction between GPR and GPS antennas has been noticed, as only shielded GPR antennas have been used with the GPS antenna mounted above or nearby. Figure 10 shows a dual GPR antenna array (400 MHz and 900 MHz) with a center mounted RTK antenna. Use with lower-frequency unshielded GPR antennas may be problematic.

Figure 10: Dual GPR antenna array (400 MHz and 900 MHz, both shielded) with center-mounted RTK antenna on towed sled.

Total Stations and RTK GPS are the precision tools of the licensed professional land surveyor. Non-licensed professionals employing them in commercial enterprise or in a non-professional manner will prompt considerable scrutiny from passing licensed professional surveyors and crews. This activity will be viewed as non-licensed competition that endangers the public safety. A surveying rod or pole with either a GPS antenna or total station prism mounted atop it shows intent to measure with high precision and accuracy. The use of either do not require a license, but will most likely cause inquiries if sighted on high-dollar contract jobs in tight surveying markets (Figure 11). In some states, surveyors are required to report unlicensed activity.

Figure 11: Professional tools used unprofessionally attracts attention.

Laws regulating the practice of land surveying vary state-to-state. One can assume that the practice of locating and mapping absolute property boundaries—any property boundary—is regulated and taxed by the state. In order to safeguard the public, this privilege to practice surveying is granted by state commerce regulatory boards only to those individuals who are licensed as land surveying professionals. According to Tenn. Code Ann. § 62-18-102 (State of Tennessee, 2013a) the "*Practice of land surveying means any service of work, the adequate performance of which involves the application of special knowledge of the principles of mathematics, the related physical and applied sciences and the relevant requirements of law for adequate evidence to the act of measuring and locating lines, angles, elevations, natural and man-made features in the air, on the surface of the earth, within underground workings and on the beds of bodies of water for the purpose of determining areas and volumes, for the monumenting of property boundaries and for the platting and layout of lands and subdivisions of land, including the topography, drainage, alignment and grades of streets, and for the preparation and perpetuation of maps, records, plats, field notes, records and property descriptions that represent these surveys.*"

Most persons envision property boundaries as only those lines on maps delineating ownership between neighboring parcels. However, legal property boundaries are all legal boundaries that encompass the "bundle-of-rights" of property title that exist both aboveground and belowground (and water). Many unseen legal boundaries traverse across almost all parcels, such as utility and drainage easements, flood easements, right-of-ways, right-of-view, right-of-access, and mineral and timber rights. There are many written and unwritten legal boundaries associated with real property, most of which are not apparent to the non-surveying mapping professional. Some exist without knowledge to the property owner. All states regulate land surveying, and a number of states regulate the creation of landform topography maps or digital elevation models (DEMs).

Prior to GPS and GIS, those professionals without a surveying license could survey and map without much concern, because their surveys were only relative measurements. Geophysical surveys were mapped on a user-defined grid (see Figure 2) that was not referenced to a standard datum. (For example, relative surveys could reference a wooden stake as an origin with the grid oriented at an arbitrary azimuth toward a tree.) In contrast, land surveyors map their surveys using a common coordinate system (e.g., State Plane Coordinates) and/or with measure and direction to a permanent physical feature (e.g., road intersection) in absolute measure so that the original survey can be retraced.

With GPS-linked geophysical data, the data become absolute measurements to an established datum. Computer-based transformations between State Plane Coordinates and geospatial coordinates are effortless. But mapping with the absolute coordinates can create legal issues, especially if the features surveyed or mapped with GPS are themselves real property boundaries (e.g., sewer lines, drainage culverts, gas pipelines, etc.), or if they are tied and mapped with corresponding GIS-obtained features on an established coordinate system with datum showing real property boundary features.

If the potential for mapping of property boundaries exists, one should consult with a land surveyor who is licensed within the state, or first inquire with the state Land Surveyor Board where the site is located. Three case examples are presented that illustrate how geophysical applications encroached into the land surveyors' domain of their licensed practice. In each case there was the potential for cease and desist demands; these demands can be issued with corresponding threatening civil penalties and stiff monetary fines. Disclaimers on maps stating approximations or "not legal surveys" hold little legal sway. Expertise and knowledge in a given area are not sufficient. The action of locating property boundaries is regulated through a state-issued license that is granted, regulated, and taxed for the protection of public safety.

Again, individual states vary in their land surveying regulations and enforcements. The following three case examples are provided as generic discussion of a theoretical governing state, not as legal advice for a right of practice within any given state. The case examples do have foundation from the author's own experiences with geophysics, land surveying, engineering, and GPS.

Case Examples

Geotechnical Surveys of Brownfields

Industrial brownfields abound with many underground features, with hazardous and innocuous waste and debris lying buried very effectively within the subsurface. Geophysical tools naturally are the "tools of choice" for their safe location and identification. The use of geophysical tools to find these features does not require a surveyor's license. However, marking and mapping real property boundaries, which includes easements and boundary rights, do require a license. Some buried features, when located and revealed, will in themselves then constitute and establish property boundaries and rights (Figure 12).

Figure 12: Brownfield geophysical surveys may "uncover and disclose" property boundaries and rights.

Geotechnical consultants providing brownfield services have been cited for this violation of surveying without licensure by land surveyors' boards. In at least one state, the board ruled that their services, as advertised or as provided, were for locating and mapping real property boundaries. To legally provide this service they must either 1) be a licensed surveyor in that state, or 2) be surveying under the direct supervision of a licensed surveyor. Maps of property boundaries that are geospatially referenced, or are linkable to surface features that can be spatially oriented to a published GPS datum (e.g., aerial photography, surveyor plats), will cause conflict. Stated disclaimers by geotechnical consultants that they are not licensed surveyor, or that their maps show only approximate absolute measurements, hold little significance with regulatory boards.

Call Before You Dig (811) services are comparable to property owners marking their own boundaries to prevent outside incursions. Local utility companies provide their own professional locaters to spray colored lines on the surface using temporary marking paint. These non-permanent markings are only for the excavator's use to highlight the approximate location of any underground utilities that the utilities own (i.e., easements) prior to a planned excavation. Utility companies are legally marking their own existing and known boundary right-of-ways to prevent excavation damage of the buried utilities and to safeguard the public.

Soil Surveys

Geophysicists can find themselves in conflict with several licensing boards while performing a soil survey. For example, GPR technology is ideal for identifying and profiling soil depth to bedrock, especially in shallow sandy soils. I t can be used as an effective mapping tool to aid in subdivision platting layout, especially for locating and mapping soils of sufficient depth and breadth for installing septic drain fields. A minimum soil thickness above bedrock is required of lot sites in the permitting process for new septic drain fields.

Within some states, three separate and distinct regulatory boards govern the licensing of professional engineers, land surveyors, and soil scientists. All three boards can be at odds with one another. Much debate can erupt over conflicting rights-of-practice. There can be legal, legislative, and professional society haggling regarding the rights to perform a particular practice, this to the exclusion of other professions. One such example is in the platting of subdivisions that require septic drain fields (Figure 13). Each of the three prior mentioned boards regulate professionals that have the expertise and knowledge that significantly overlap into each of the others' professional skill set. However, only one profession typically is granted the license to practice a particular task. Within some states, only a licensed soil scientist can delineate and classify soil types and run percolation tests in the mapping of acceptable septic drain field locales on building lots. According to Tenn. Code Ann. § 62-18-204 (State of Tennessee, 2013b) "*no person shall classify soils pursuant to the use and application of the USDA soil taxonomy standard, as revised, to prepare any soil maps, reports, or documents resulting from the classification of soils, other than a licensed professional soil scientist or a subordinate under such soil scientist's direction.*"

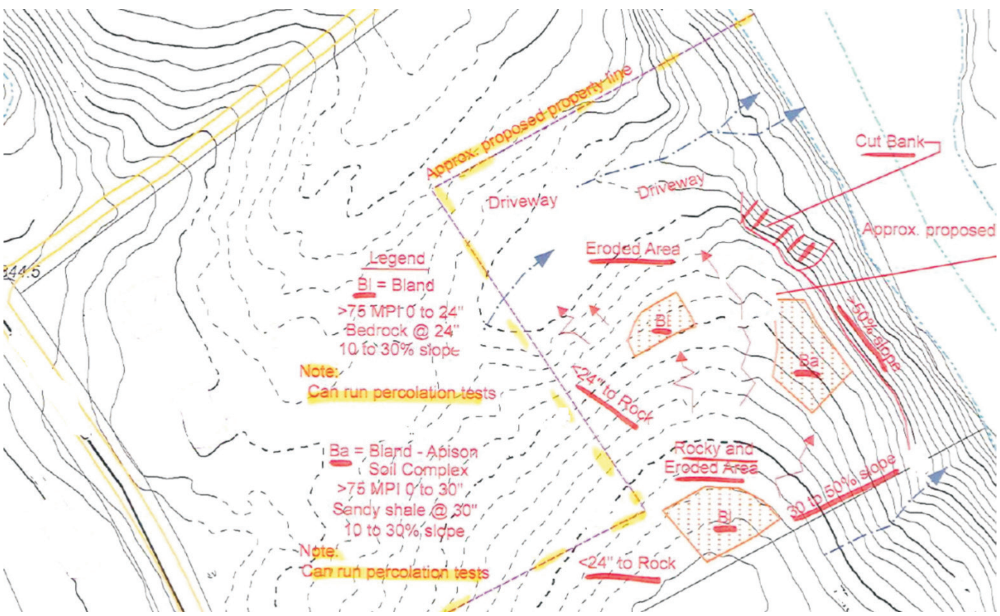

Figure 13: A typical subdivision plat contains property boundaries, acceptable sites on lots for septic drain fields, and drainage/erosion control structures and networks.

However, soil scientists (who argue that they understand how to use a GPS) must first contract with a land surveyor to establish the absolute boundaries and easements of the subdivision lot. Soil scientists may only reference their relative soil map coordinates to the absolute coordinates of the lot boundaries. If the soils map showing acceptable septic drain fields is to be added to the subdivision plat, only the surveyor may add the soils data to the plat. In turn, only professional engineers (who argue that they can run GPS, total stations, percolation tests, etc.) may do design. Acceptable septic drain field locales must not directly conflict with other easements, restrictions, or covenants. All drainage/erosion control networks and structure designs and calculations that safeguard the public's safety fall within the purview of a licensed engineer.

Perhaps one issue that is most contentious with land surveyors is ownership rights of their stamped survey plats and data. All stamped surveyor plats and data of record are considered copyrighted—even those publically recorded—and should not be used in generating other works without the permission of the land surveyor who stamped the plat. Soil scientists, engineers, and geologists who use recorded survey plats to display their own mapping data have caused much contention among regulatory boards and planning commissions.

Gravesite Archeology

One of the most uniquely interesting and applicable uses of GPR is the mapping of unmarked human gravesites. Employing GPR in historic cemeteries and over prehistoric archeological burial sites is routinely practiced. Sites that may contain abandoned cemeteries or pre-historic burials are often surveyed with GPR prior to its commercial development. Found gravesites are either delineated for their protection, or through court order, are respectfully disinterred for relocation.

Buried human remains are protected by the state, even if unmarked and abandoned, and given by the state certain inherent boundary and easement rights (TDEC, 2014). Often the encompassing tract has passed through many generations and numerous unrelated owners, but these property rights endure in perpetuity. Frequently, the current owner is unaware of the human gravesites, but at the moment when located, these gravesites are encircled by property boundaries. The state provides for legal protections against any disturbance within a certain distance of the grave, and allows easements for rights-of-access for visitation and for their upkeep by the deceased's distant relatives. One important fact rapidly surfaces. An unknown grave once found and mapped with GPS, is in itself locating, establishing, and mapping property boundaries (Figure 14).

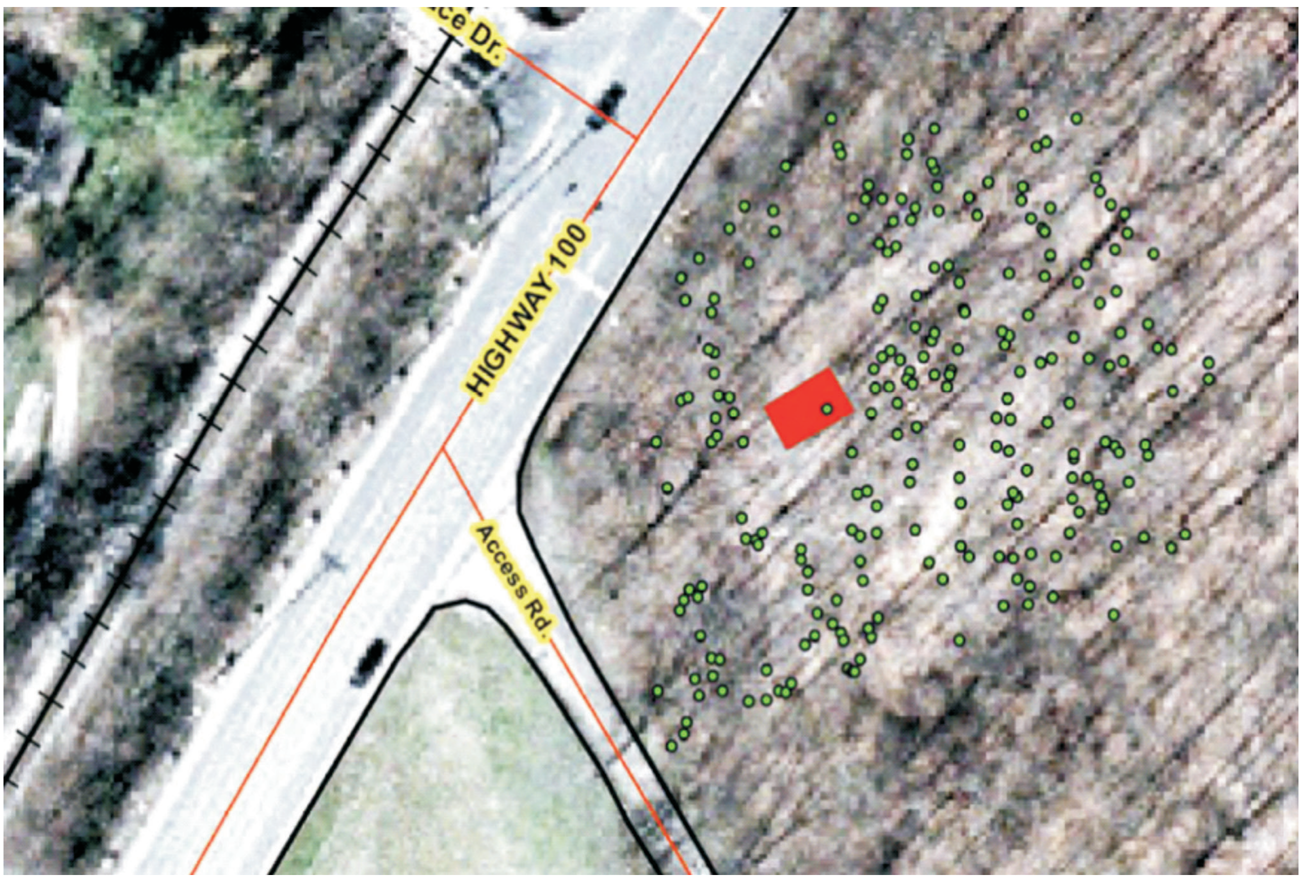

Figure 14: Survey plat of unmarked grave locations marked by GPS location.

This seemingly slight technicality is noted by the author firsthand, because significant controversy erupts whenever unmarked graves are mapped using GPS coordinates that show a gravesite encroaching onto adjoining properties or into easements of third-party interests. Newly discovered human gravesites typically decrease property values. Geophysical survey maps showing the newly revealed gravesites and/or cemetery and property boundaries are most likely to be entered into legal evidence and/or much-heated negotiations, thus highlighting any lack of land surveying licensure among the mapping participants.

Summary and Discussion

Geophysical tools predate GPS, but their recent integration with geophysical surveys is now considered routine. However, GPS use can create legal issues because it converts the spatial coordinates of geophysical data, which historically have been of relative measure of a user's own datum and grid spacing, to an absolute measurement of an established datum and coordinate system. Care should be taken in making geophysical measurements that measure targets that are presented using GPS coordinates of absolute measure to property boundaries, as this falls in many states only within the licensed privilege of the professional or registered land surveyor. Mapping and delineating of soils may be the prevue of the licensed soil scientist.

Regulations and rules pertaining to land surveying can vary significantly among states, federal lands, and Native Indian reservations. Practicing geophysicists should be aware of those state-specific laws of other licensed professions that may overlap their practice of geophysical surveying and mapping with GPS coordinates for a given site and its targets. It may necessitate their conducting a survey with a cooperating licensed land surveyor, soil scientist, geologist, engineer, or other properly licensed professional. Please note that the guidelines, laws, and procedures mentioned in this article are for illustrative and discussion purposes only, and should not be used in place of legal counsel.

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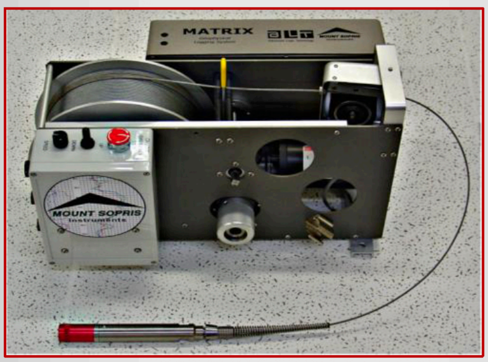
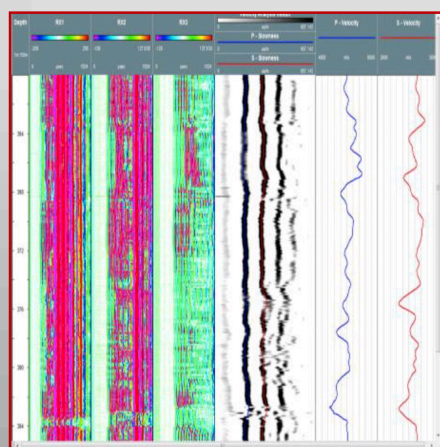
State of Tennessee (2013a). Tenn. Code Ann. § 62-18-102. Land Surveyor General Provisions. http://www.lexisnexis.com/hottopics/tncode/ . Accessed 12/9/2013.

State of Tennessee (2013b). Tenn. Code Ann. § 62-18-204. Soil Scientist Licensure Act of 2009. http://www.lexisnexis.com/hottopics/tncode/ . Accessed 12/9/2013.

TDEC. 2013. Historic cemeteries in the state of Tennessee. General information, laws, and guidelines. http://tn.gov/environment/docs/arch_historic-cemeteries.pdf . Accessed 12/9/2013.





EKKO_Project - New GPR Software

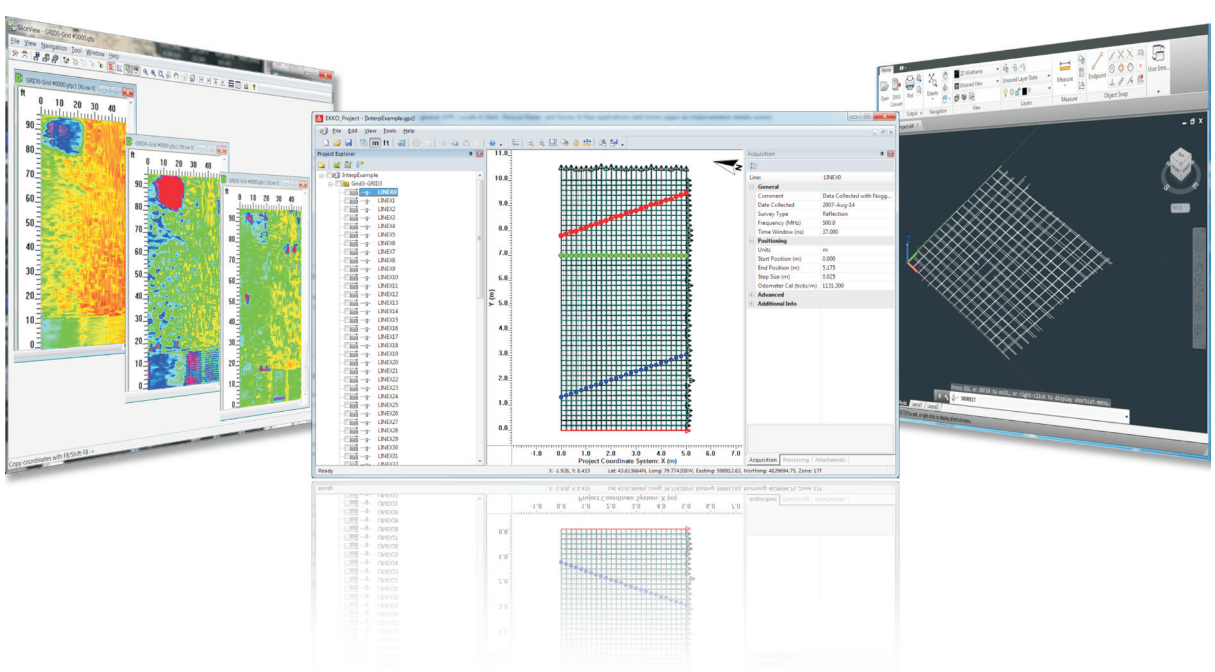
For more than 40 years, Sensors & Software's key personnel have played leadership roles in shaping the field of Ground Penetrating Radar (GPR). Understanding our customers' needs and delivering practical, innovative and cost effective solutions defines Sensors & Software.

Sensors & Software Inc. announces the release of the latest version of EKKO_Project, the most comprehensive software solution for GPR data analysis and management.

The new version of the EKKO_Project delivers many new features that make working with GPR data even easier. Major enhancements include:

- SliceView Module: displays GPR data collected in a grid as a series of depth slices to reveal targets in the subsurface. Large volumes of data can be plotted and viewed quickly to assist in interpreting the orientation and lateral extent of buried objects. Depth slices can be plotted on Google Earth if geo-referenced data is available. Grid data can also be exported as 3D files for visualization in Voxler.
- MapView Window: now available to display survey lines in map form. The software automatically plots all grid data and any single line data collected with GPS in plan view. Maps include a north arrow with any fiducial markers added during data acquisition. Point interpretations created using the Interpretation Module in post-processing also appear on MapView providing a powerful means of visualizing the relationship between features of interest.
- AutoCAD DXF File Output: useful for locators, engineers and construction managers to integrate GPR observations into existing drawings. GPR line paths, fiducials, point and polyline interpretations are saved as separate layers for easy import into AutoCAD software. 3D positions of targets are readily available.

EKKO_Project operates on Windows 7/8 and makes data organization, plotting, editing, processing and reporting a breeze; it is a must for any GPR practitioner.



Contact info@sensoft.ca or visit http://www.sensoft.ca/Products/Software/Details-Features.aspx#EKKOProject for more information.

Quality Assurance for Deep Foundations

Pile Dynamics, Inc.

November 14, 2013 For Immediate Release

Inventors from Pile Dynamics and the University of South Florida receive International NOVA Award for Thermal Integrity Profiler (TIP)

Cleveland, Ohio, USA – George Piscsalko, P.E., and Dean Cotton, with Pile Dynamics, Inc. (PDI), of Cleveland, and Gray Mullins, PhD, P.E., with the University of South Florida in Tampa, Florida, have received the prestigious 2013 NOVA Award from the Construction Innovation Forum (CIF).

The engineers and researchers received the award for the Thermal Integrity Profiler (TIP), an instrument that uses the heat generated by curing concrete to reveal the shape of cast-in-place concrete foundations. The initial research for the TIP was conducted at the University of South Florida. PDI formed a joint venture with Foundation and Geotechnical Engineering (FGE), of Plant City, FL to design the instrument and take it to market.

The TIP measures concrete temperatures during the curing process either by a probe inserted into access tubes or by Thermal Wire® cables embedded in the concrete. "The TIP is an innovation for the deep foundation testing market. It overcomes many of the limitations associated with other non-destructive testing methods, providing an evaluation of the entire cross-section, something that can't be done with those other methods. The TIP test is completed within typically 12 – 48 hours after casting the shaft, thus allowing for an accelerated construction schedule. In contrast, other testing methods are not done until typically 5 - 7 days

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E-mail: info@pile.com • www.pile.com

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after casting," said George Piscsalko, Vice-President of Pile Dynamics and one of the award recipients, adding "We are quite honored to have received such a prestigious award."

In addition to detecting problems either inside or outside the reinforcing cage, as Piscsalko alluded to, TIP is unique in its capability of assessing the positioning of the reinforcing cage and the thickness of the concrete cover.   An additional innovative aspect is the automation of the data collection process when THERMAL WIRES are used.

The Construction Innovation Forum (CIF), who presented the award, is an international, non-profit organization that encourages and recognizes construction innovations. The 2013 NOVA winners, selected from more than 700 nominations from 20-plus countries, were announced November 12 at the Annual Construction Users Roundtable (CURT) National Conference. CURT represents more than 100 of the United States top construction purchasers, the majority of which are Fortune 500 companies.

"Each year since it was created in 1989, the NOVA Awards honor top innovations in construction from around the world that increase quality and efficiency and reduce cost," said Rasha Stino, CIF Vice-Chair. "An expert jury carefully selects award-winning innovations with the assistance of leading engineers serving as investigators. CIF congratulates George Piscsalko, Gray Mullins and Dean Cotton, as well as Pile Dynamics, Inc., the University of South Florida and FGE."

"It is exciting to see the industry recognize a game changing technology", said Gina Beim, marketing director of Pile Dynamics.   "In the past year we saw the interest in Thermal Integrity Profiling increase at a significant pace", she added.

After several months of successful testing on drilled shafts, the TIP is now being employed in the evaluation of augered cast-in-place piles, jet grouting columns, soil nails and micropiles. Pile Dynamics expects the technology to be adopted in more and more countries in the next few years, and is forecasting the number of foundation elements to be tested with TIP to at least double in 2014.

"We are honored to receive the prestigious NOVA award for the Thermal Integrity Profiler. It is a humbling distinction to receive recognition for this innovation in the construction industry." said Dean Cotton, one of the awardees.

PDI manufactures electronic instruments that evaluate the quality and control the execution of deep foundations. Its systems are extensively used around the world. For more information visit www.pile.com/pdi.

COMING EVENTS

FastTIMES highlights upcoming events of interest to the near-surface community. Send your submissions to the editors for possible inclusion in the next issue.

BOSTON

Massachusetts USA
Boston Marriott Copley Place

SAGEEP 2014
March 16-20, 2014

Final Abstracts Deadline: Feb. 14, 2014!

Make Hotel Reservations Now - Online or Call!

Conference Registration Open Soon!

Keynote Speaker Alfred William Eustes Distinguished Lecturer 2014 - 18, Colorado School of Mines

Preliminary Program Highlights

Short Courses

- Multichannel Analysis of Surface Waves (MASW) Fundamentals Plus
- Overview of Utility Locating Technologies
- Google Earth Applications in Education and Research
- Environmental Applications of the Induced Polarization Method

Field Trip

Cape Ann Field Trip: Full day outing Sunday, March 16 will include a drive up the shore road to Rockport, a visit to the quarry at Halibut Point State Park, lunch on own at the Cape Ann Brewery by the harbor in Gloucester and a stop at the Ryan and Wood Distillery on the return trip.

Special Events & Networking

Conference Evening
Luncheon - John Ebel/Boston College
EEGS Annual Meeting & Luncheon - Speaker Steve Arcone
Technical Sessions
Student Event

Jutta Hager
VP - SAGEEP
jhager@hagergeoscience.com

Mario Carnevale
Technical Chair
mcarnevale@hagergeoscience.com

www.EEGS.org/Annual Meeting-SAGEEP 2014

COMING EVENTS

BOSTON

SAGEEP 2014

Massachusetts USA
March 16-20, 2014
Boston Marriott Copley Place Hotel

Symposium on the Application of Geophysics to Engineering & Environmental Problems (SAGEEP)

is the leading international conference on non-invasive technology for engineering and environmental site characterization. Approximately 400 professionals will attend this event. Exhibiting companies receive one full complimentary conference registration and two complimentary exhibit personnel registrations for each paid 10′ x 10′ booth space occupied. So, take advantage of your opportunity to be a part of this uniquely positioned symposium in the near surface geophysics community.

Sponsorship Opportunities Available

Geophysical and geo-engineering service companies, developers and distributors of geo-scientific hardware and computer software, college/universities, government agencies, manufacturers and sales representatives of geophysical and geo-scientific instruments, equipment, and related supplies, publishers of scientific books and journals, research institutes and scientific associations are invited to consider remaining sponsorship opportunities. To view the SAGEEP 2014 Exhibitor Prospectus, go to the EEGS web site (www.eegs.org), SAGEEP 2014 menu option, then click on the Exhibitor tab.

EEGS
Environmental and Engineering Geophysical Society

For more information on sponsorship at SAGEEP 2014 contact:
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Fax: 905.474.1968
E-mail: mickiallen@marac.com

ICEEG2014

Xi'an China

6th International Conference on Environmental and Engineering Geophysics

We are pleased to be hosting the 6th International Conference on Environment and Engineering Geophysics in Xi'an, China, form June 20-23, 2014. It is our pleasure to invite you to participate in this exciting event and to enjoy the ancient city of Xi'an.

This conference is designed to be a wonderful opportunity for all attendees to share your knowledge, experience, and friendship. We strongly believe that you will find great value in your participation in the conference and exhibits. Mark your calendar now. Welcome to the ancient city of Xi'an!

Topics

- *Urbangeophysics*
- *Geophysics for mine disaster*
- *Geophysical instruments*
- *Archaeological geophysics*
- *Airborne geophysics*
- *Old mines exploration geophysics*
- *Advances in near surface geophysics*

http://tdem.org/iceeg2014/en

2014 European Geosciences Union General Assembly

Dear Colleagues,

We are very pleased to announce that, in the framework of the 2014 European Geosciences Union General Assembly (www.egu2014.eu<http://www.egu2014.eu>), to be held in Wien, Austria, 27 April – 02 May 2014, we are organizing the GI3.1 Session, entitled "Civil Engineering Applications of Ground Penetrating Radar":

http://meetingorganizer.copernicus.org/EGU2014/session/14231

This Session will be a prestigious forum for a promising discussion and for a wide exchange of experiences and results related to the Ground Penetrating Radar (GPR) use in civil engineering issues. We strongly hope

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that such event might be of potential interest for you and we would like to encourage you and your co-workers to participate by submitting a contribution.

Furthermore, it is our great pleasure to announce that the GI3.1 Session of the EGU-GA will be held jointly with the Second General Meeting of COST Action TU1208 "Civil Engineering Applications of Ground Penetrating Radar" (http://www.gpradar.eu/), that currently is involving more than 200 people among University researchers, software developers, geophysics experts, nondestructive testing equipment designers and producers, end users from private companies and public agencies from over 25 countries worldwide. The Conveners of this Session will be Lara Pajewski, Andrea Benedetto, Andreas Loizos, Evert Slob and Fabio Tosti.

Topics will include: electronics and hardware; software and data processing; direct and inverse electromagnetic scattering problems; inspection for management and safety; surveying of roads – highway pavements – airport runways – bridges – tunnels – buildings – underground utilities and voids; inspection of reinforced concrete and quality control of pre-cast concrete structures; groundwater/pollution evaluation; analysis of geological structures; characterization of materials; novel applications and recent developments; trade-offs between GPR and other nondestructive testing techniques.It is foreseen that a selection of the contributions presented during the Session will be selected for possible publication in various Special Issues of peer-reviewed international journals, wherein extended versions of the abstracts will be published.

The deadline for one-page abstract submission is: 16th of January 2014 (13:00 CET).

Detailed information on how to submit an abstract can be found here: http://www.egu2014.eu/abstract_management/how_to_submit_an_abstract.html . Our Session webpage (http://meetingorganizer.copernicus.org/EGU2014/session/14231) shows a link to the Abstract Submission System. Using this link, you will be asked to log in to the Copernicus Office Meeting Organiser and you may submit your abstract. The 300-500 words text of your contribution may be written by using a text editor of your choice. Please pay attention to the First Author Rule. An Abstract Processing Charge (APC) of € 40,00 has to be paid for each submission.

With Prof. Andrea Benedetto, Prof. Andreas Loizos, Dr. Lara Pajewski and Prof. Evert Slob, we are very much looking forward to seeing you in Wien!

With our best regards,

Andrea Benedetto, Andreas Loizos, Lara Pajewski, Evert Slob and Fabio Tosti

****

Previous editions of the EGU-GA "Civil Engineering Applications of Ground Penetrating Radar" Session:

2011 EGU GA (Wien, Austria, 3 – 8 April 2011)
18 presentations
A selection of 11 high-quality contributions has been selected to be published, as extended papers, on a Special Issue of Taylor & Francis "Nondestructive Testing and Evaluation", focused on "Civil Engineering Applications of Ground Penetrating Radar": http://www.tandfonline.com/toc/gnte20/27/3

2012 EGU GA (Wien, Austria, 22 – 27 April 2012)
24 presentations
A selection of high-quality contributions has been selected to be published, as extended papers, on a Special Issue of the Elsevier Journal of Applied Geophysics, focused on "Ground Penetrating Radar for Nondestructive Evaluation of Pavements, Bridges and Subsurface Infrastructures":
http://www.sciencedirect.com/science/journal/09269851/97

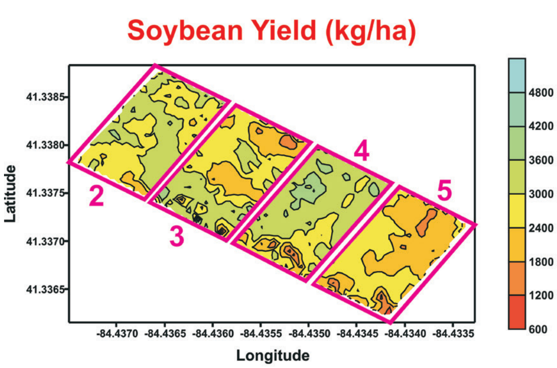
2013 EGU GA (Wien, Austria, 7 – 12 April 2013)
22 presentations

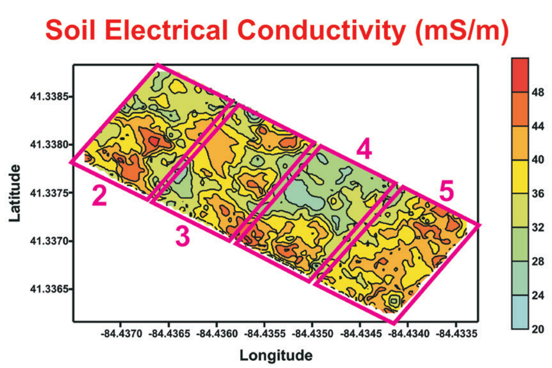
COMING EVENTS

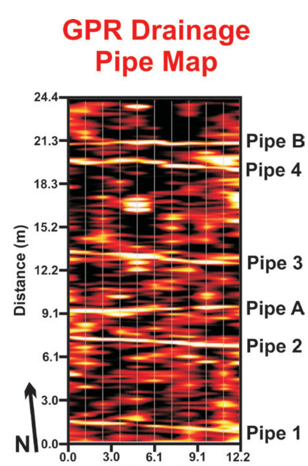
Webinar

Application of Geophysics to Agriculture: Methods Employed

A webinar on the application of geophysics to agriculture will be offered on February 18, 2014, Tuesday afternoon, from 3:00 - 4:30 Eastern Time (2:00 - 3:30 Central Time, 1:00 - 2:30 Mountain Time, 12:00 - 1:30 Pacific Time). This first in a series of agricultural geophysics webinars will focus on the near-surface geophysical methods presently being used for agricultural purposes, which include resistivity, self-potential, electromagnetic induction, ground penetrating radar, dielectric sensors, VIS/NIR/MIR spectrometry, gamma ray spectrometry, mechanical soil compaction sensors, and ion selective potentiometry. Five presenters will provide a short overview of agricultural geophysical methods during the first 30 minutes of the webinar. The last hour of the webinar will be devoted to a panel discussion with the presenters, who will answer questions from the audience. There will be no cost for participating in this webinar; however, enrollment may be limited, so participants will need to register at http://www.ag-geophysics.org in order to obtain webinar login details. One week prior to the webinar, extended versions of the presentations (approximately 20 minutes each) in PowerPoint format, along with a YouTube video link for the presentations, will be posted at http://www.ag-geophysics.org. Those from both the geophysical and agricultural communities will benefit from this webinar and are therefore encouraged to participate.







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 below:

Renewing Members

Welcome back! Thank you for your continued support.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Individual	$90	$100
Retired *Must be Approved by EEGS Board of Directors*	$50	$100
Developing World *From Approved Countries Listed Below*	$50	$100

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).

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
NEW! **Introductory**	$50	$100

Student Members

Students are the future and we offer you a complimentary membership subsidized by our Corporate Sponsors. 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.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
NEW! **Student**	No Cost (Membership is paid by Corporate Sponsor)	$60

Corporate Members

Corporate members enjoy all the benefits of individual membership, a corporate link on the EEGS website, a company profile in *FastTIMES*, recognition at SAGEEP and a 10% discount on advertising in *JEEG* and *FastTIMES*. Additional benefits are listed for each corporate level.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
NEW! **Corporate Student Sponsor** *Includes one (1) individual membership to EEGS and sponsors 10 student memberships*	$300	$310
Corporate Donor *Includes one (1) individual membership to EEGS and one (1) full conference registration to SAGEEP*	$650	$660
Corporate Associate *Includes two (2) individual memberships to EEGS, an exhibit booth and registration at SAGEEP, and the ability to insert marketing materials in the SAGEEP delegate packets*	$2400	$2410
Corporate Benefactor *Includes two (2) individual memberships to EEGS, two (2) exhibit booths and registration at SAGEEP, and the ability to insert marketing materials in the SAGEEP delegate packets*	$4000	$4010

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.

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Algeria
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Azerbaijan
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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
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Madagascar
Malawi
Maldives
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Niger
Nigeria
North Korea
Pakistan
Papua New Guinea
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Yemen
Zambia
Zimbabwe

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Environmental and Engineering Geophysical Society

2014 Membership Application

Renew or Join Online at www.EEGS.org

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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:

Classify Association	Classify Interest or Focus	Specific Areas of Involvement	Professional/ Scientific Societies	Willing to Serve on a Committee?
☐ Consultant	☐ Archaeology	☐ Borehole Geophysical	☐ 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	☐ AGU	
☐ Software Manufacturer	☐ Groundwater	☐ Magnetics	☐ EAGE	
☐ Research/Academia	☐ Hazardous Waste	☐ Seismic	☐ EER1	
☐ Government Agency	☐ Humanitarian Geo.	☐ Other	☐ GeoInstitute	
☐ Other	☐ Mining		☐ GSA	
	☐ Shallow Oil & Gas		☐ MGLS	
	☐ UXO		☐ NGWA	
	☐ Other		☐ NSG	
			☐ SEG	
			☐ SSA	
			☐ SPWLA	

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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
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Subtotals

Membership: $ ____________

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.

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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.

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Environmental and Engineering Geophysical Society

2014 Publications Order Form

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SAGEEP PROCEEDINGS

			Member	Non-Member
	0034	2013 (CD-ROM)**NEW**	$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

	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	Advances in Near-surface Seismology and Ground Penetrating Radar—R. Miller, J.Bradford, K.Holliger Special student rate - $95.00	$109	$149
	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
		EEGS T-shirt (X-Large) Please circle: white/gray	$10	$10
		EEGS Lapel Pin	$3	$3
		SUBTOTAL—SHORT COURSE/MISC. ORDERED ITEMS:		

Publications Order Form (Page Two)
***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						

SUBTOTAL—JEEG ISSUES ORDERED	

SUBTOTAL - SAGEEP PROCEEDINGS ORDERED	
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T-shirt (Medium)			$10	$10	Sold Out
T-shirt (Large)			$10	$10	Sold Out
T-shirt (X-Large)			$10	$10	
T-shirt (XX-Large)			$10	$10	Sold Out
EEGS Lapel Pin			$3	$3	
SUBTOTAL – MERCHANDISE ORDERED:					

TOTAL ORDER:

SUBTOTAL – Merchandise Ordered:	
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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:	

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Card Number: ______________ Cardholder Name (Print): ______________

Exp. Date: ______________ Signature: ______________

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