FastTIMES

Special Issue on the Application of Drone Technology for Geophysics

The Relevancy of SAGEEP & Drones in Geophysics

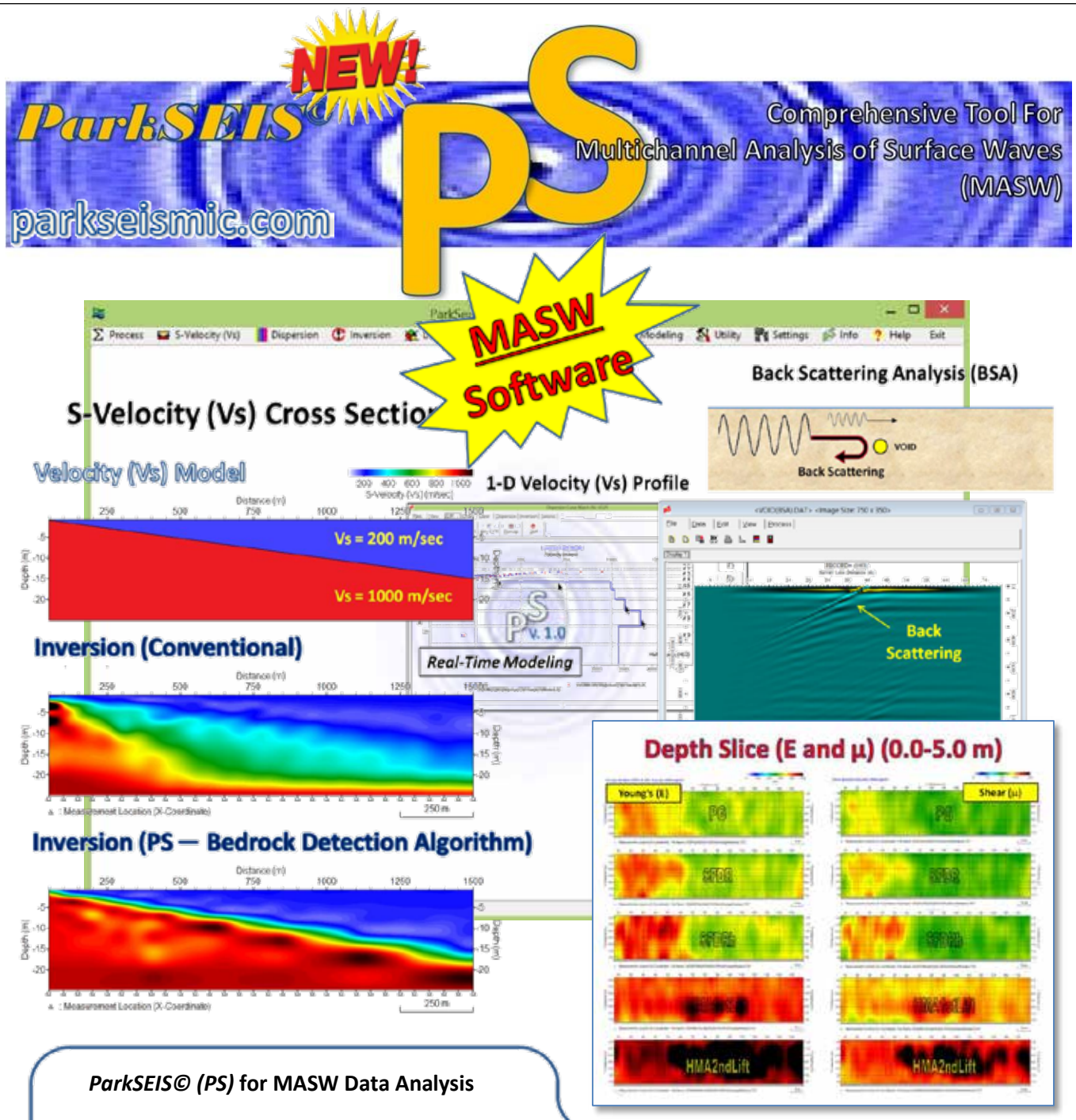
Developing High Sensitivity Magnetometers for Unmanned Aircraft

Hyperspectral Imaging from a UAS Puts Data Scientists at the Controls

The Bureau of Land Management & The Use of Unmanned Aircraft Systems (UAS) for Resource Management

March 2016

Volume 21, Number 1



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This issue of *Fast*TIMES is focused on application of drone technologies for geophysics. The latest information on SAGEEP 2016 is also provided.

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Special Drone Issue

*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.

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*Fast*TIMES is published electronically four times a year. Please send contributions to any member of the editorial team by May 15, 2016. Advertisements are due to Jackie Jacoby by May 15, 2016.

CALENDAR
2016

March 3	22nd Annual 3D Seismic Symposium Denver, Colorado, USA http://www.rmag.org/3d-seismic-symposium (Note: See page 50 for additional information.)
March 3 - 4	SurfSeis - Multichannel Analysis of Surface Waves (MASW) Workshop Lawrence, Kansas, USA http://www.kgs.ku.edu/software/surfseis/workshops.html
March 6 - 7	2nd Society of Exploration Geophysicists and Dahran Geoscience Society Workshop on Near Surface Modeling and Imaging Manama, Bahrain http://www.seg.org/events/upcoming-seg-meetings/2016/ns-modelling-imaging-2016
March 20 - 24	Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP) Denver, Colorado, USA http://www.eegs.org/sageep-2016 (Note: See page 43 for additional information.)
April 17 - 22	European Geosciences Union General Assembly 2016 Vienna, Austria http://egu2016.eu/home.html
May 9 - 13	Geophysics and Remote Sensing for Archaeology Pompeii, Italy archeoschool@irea.cnr.it (Note: See page 47 for additional information.)
May 18 - 24	59th Annual Meeting of the Association of Environmental & Engineering Geologists Kona, Hawaii http://www.aegweb.org/ (Note: See page 51 for additional information.)
June 6 - 8	4th International Workshop on Induced Polarization Aarhus, Denmark http://hgg.au.dk/ip2016/
August 21 - 24	Australian Society of Exploration Geophysicists 25th International Geophysical Conference and Exibition Adelaide, Australia http://www.conference.aseg.org.au/index.html
November 4	Rocky Mountain Geo-Conference Lakewood, Colorado, USA http://www.aegrms.org/2016Geoconf.pdf

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

PRESIDENT'S MESSAGE

Lee Slater, President

(lslater@rutgers.edu)

SAGEEP or Bust: Memories of an Ageing Dodge Minivan

SAGEEP remains the only US based conference exclusively focused on near surface geophysics. SAGEEP 2016 in Denver promises to be a stimulating meeting where academia, industry and regulators unite to share their expertise in environmental and engineering geophysics. Browsing through the program, I am inspired by the breadth of the sessions, the participation of the academic community and the impressive number of international speakers planning to make the trip from various countries across the globe. I am delighted that EEGS has the honor of announcing both an EEGS / Geonics Early Career Award recipient and a Frank Frischknecht Leadership Award at SAGEEP this year. These awards recognize remarkable achievements by our community, and are a cause for celebration.

I well remember my first SAGEEP meeting. It was 1998 and the destination was Chicago. I was a postdoctoral researcher working under Stewart Sandberg at the University of Southern Maine (USM). Stewart was a big fan of SAGEEP as he recognized the value of interfacing academia with the professional sector. Stewart was also a major advocate of undergraduate research and committed endless time and energy in getting students from this sleepy college in Maine engaged in geophysics. USM was not a wealthy institution: to get as many students as possible to SAGEEP, he drove an ageing 80's era Dodge minivan the 1090 miles from Portland (ME) to Chicago. The drive was an ordeal: we were stranded in a snowstorm in Buffalo (NY) and the van fell to pieces in Vermont during the return journey. Stewart's dedication to both SAGEEP and the next generation of environmental and engineering geophysics benefitted both immensely. Today, SAGEEP offers the opportunity for academics attending SAGEEP to bring two students free of charge. I hope that EEGS members residing in our academic institutions take full advantage of this opportunity by following in the footsteps of Stewart Sandberg, thereby benefitting both SAGEEP and the current generation of student geophysicists.

SAGEEP thrives because of the remarkable work performed by volunteer members of our society. I thank John Stowell (General Chair), Charles Stoyer (Technical Chair) and Micki Allen (Exhibits Manager) and all the members of the local planning committee for preparing yet another successful, inspiring and entertaining meeting. Most of all, I thank those of you that, like Stewart, support SAGEEP by simply being there and going out of your way to make it accessible to others engaged in near surface geophysics.

Lee Slater, EEGS President

NOTES FROM EEGS

Renew your EEGS Membership for 2016

Be sure to renew your EEGS membership for 2016! 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.

Lifetime Membership

In a move to enable those who wish to join EEGS once and support the organization and receive benefits without renewal, the EEGS Board of Directors approved the formation of a membership category "Lifetime Member." Longtime EEGS member Professor Oliver Kaufmann became the first Lifetime Member this past January. EEGS President Lee Slater welcomed Prof. Kaufmann and said "learning about our first Lifetime Member was one of the high points of my one-year tenure as president of EEGS." President Slater also commended Prof. Kaufmann for his commitment to EEGS and his role in assuring the long-term health and value of EEGS.

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. Make this the year your company gets involved! Contact Lee Slater (lslater@rutgers.edu) for more information.

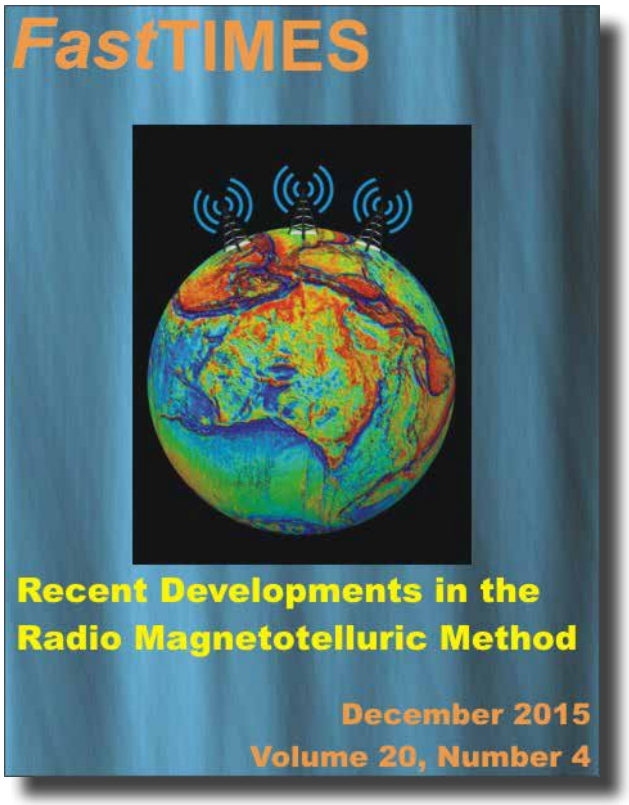
From the *Fast*TIMES Editorial Team

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

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

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

Special thanks are extended to Ron Bell for his leadership in developing this issue of *Fast*TIMES with its focus on the application of drone technology for geophysics.



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 May 15, 2016 to ensure inclusion in the next issue. We look forward to seeing your work in our pages. Note: *Fast*TIMES continues to look for Guest Editors who are interested in organizing a *Fast*TIMES issue around a special topic within the Guest Editor's area of expertise. For more information, please contact Barry Allred (Barry.Allred@ars.usda.gov), if you would like to serve as a *Fast*TIMES Guest Editor.

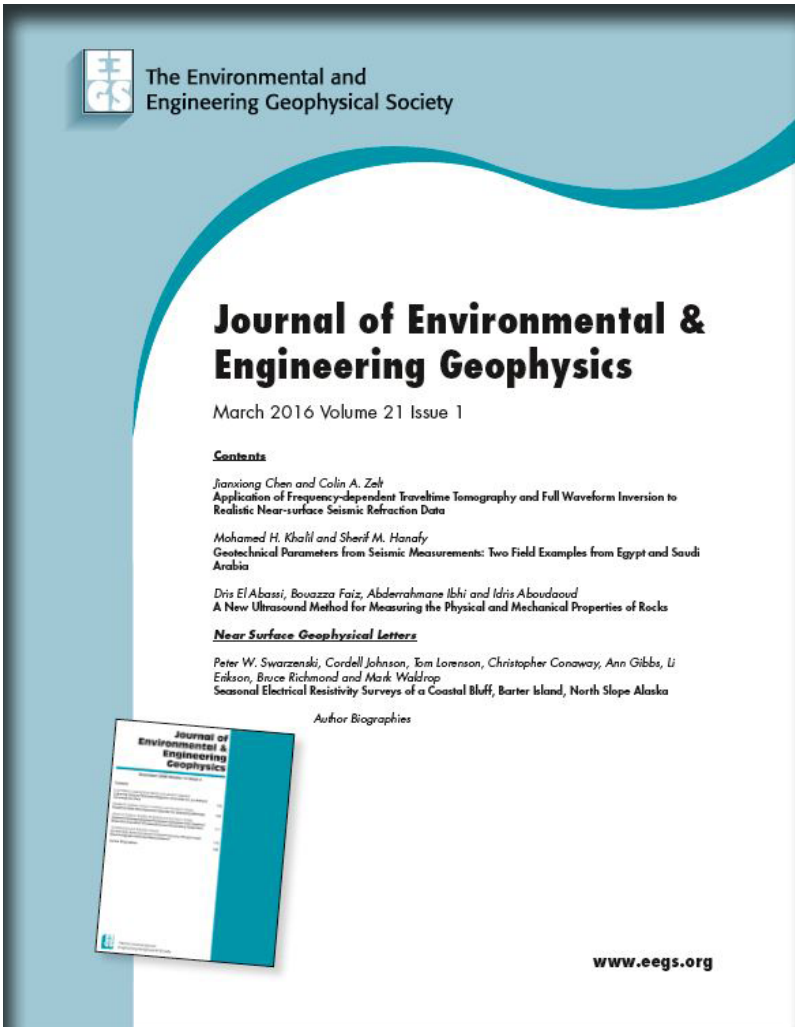
Message from the *Fast*TIMES Editor-in-Chief

I very much appreciate the efforts of Ron Bell (Aerobotic Geophysical Systems, LLC, rbell@igsdenver.com) who served as guest editor for this issue of *Fast*TIMES, which is focused on the application of unmanned aerial vehicle (i.e. drone) technology to geophysics. Since drones are becoming an increasingly important tool for site investigation, the articles in this *Fast*TIMES should be of great interest to our readers. Those that would like to learn more about the use of drones for geophysical investigation are encouraged to attend Ron's short course, **geoDRONEology**, at this year's SAGEEP. In regard to our future plans, the June 2016 *Fast*TIMES will cover forensic geophysics, and if you are interested in submitting a manuscript on this topic, please get in touch with Dan Bigman (dbigman@bigmangeophysical.com). The September 2016 *Fast*TIMES will have articles devoted to karst geophysics, and if you wish to contribute a karst geophysics article, contact Ron Kauffman (ron@spotlightgeo.com). Nedra Bonal (nbonal@sandia.gov) will organize the December 2016 FastTIMES, which is likely to focus on muon measurments for geophysical investigation. We welcome suggestions from our readers concerning potential topics for future issues of *Fast*TIMES. Again, we now encourage our readers to submit letters to the editor regarding comments on articles published in *Fast*TIMES. Letters to the editor responding to articles in past issues should be directed to Barry Allred (Barry.Allred@ars.usda.gov).

Barry Allred, *Fast*TIMES Editor-in-Chief, Barry.Allred@ars.usda.gov

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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Application of Frequency-Dependent Traveltime Tomography and Full Waveform Inversion to Realistic Near-Surface Seismic Refraction Data
Jianxiong Chen and Colin A. Zelt

Geotechnical Parameters from Seismic Measurements: Two Field Examples from Egypt and Saudi Arabia
Mohamed H. Khalil and Sherif M. Hanafy

A New Ultrasound Method for Measuring the Physical and Mechanical Properties of Rocks
Dris El Abassi, Bouazza Faiz, Abderrahmane Ibhi, and Idris Aboudaoud

Near Surface Geophysical Letters

Seasonal Electrical Resistivity Surveys of a Coastal Bluff, Barter Island, North Slope Alaska
Peter W. Swarzenski, Cordell Johnson, Tom Lorenson, Christopher Conaway, Ann Gibbs, Li Erikson, Bruce Richmond, and Mark Waldrop

Editor's Note

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

Search for JEEG Editor in Chief

The Environmental and Engineering Geophysical Society Board of Directors announces its search for a talented individual to join the editorial team of the Journal of Environmental and Engineering Geophysics (JEEG), its flagship publication. The organization seeks a qualified person to fill the senior position of Editor-in-Chief. The current editor, Dr. Janet Simms, is relinquishing the position after more than eight years at the helm of the peer reviewed publication distributed in print and available electronically.

EEGS is an applied scientific organization founded in 1992. The JEEG is published quarterly and features articles on new developments in near-surface geophysics applied to environmental, engineering, and mining issues as well as novel near-surface geophysics case histories. High level duties and responsibilities include managing a team of Associate Editors; managing the publishing process, including the online manuscript submission and review process; and setting and managing publishing guidelines and manuscript acceptance criteria.

EEGS offers staff support, an Editor's Stipend and all the prestige and visibility afforded an Editor-in-Chief and valued member of the EEGS leadership team. Interested individuals should contact the Board by emailing President Lee Slater (lslater@andromeda.rutgers.edu).

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SUCCESS WITH GEOPHYSICS

*Fast*TIMES welcomes short articles on applications of geophysics to the near surface in many disciplines, including engineering and environmental problems, geology, hydrology, agriculture, archaeology, and astronomy. The current issue of *Fast*TIMES is focused on the application of drone technology for geophysics and has four articles devoted to this very timely and important topic. As always, readers are very much encouraged to submit letters to the editor for comments on articles published in previous *Fast*TIMES.

THE RELEVANCY OF SAGEEP & DRONES IN GEOPHYSICS

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In approximately one month, the ***29th Symposium on the Application of Geophysics to Engineering and Environmental Problems, a.k.a. SAGEEP 2016***, will convene. A conference born out of the desire to educate the customers of geophysical technology expressly for the purpose of improving the quality of the data and information deliverables is truly an anomaly in the world of geoscience conferences, and moreover, an unlikely candidate for setting longevity records. It has defied the odds by not adhering to the advice of conventional wisdom.

At the time of its inception, conventional wisdom argued against the existence of a SAGEEP simply on the basis that the "big money" in the geophysics business can only be gained through the exploration for oil and gas and mineral resources. The same argument is put forth by many today even though in recent times thousands in the energy and mining sectors lost their jobs due to low commodity prices and the prospect of a murky, uncertain future for humankind on this planet. Back in the day, few envisioned a SAGEEP nearly 30 years on. Perhaps we should take a moment to collectively ask: *"Why does SAGEEP continue to exist?"* or *"How much longer will it continue to exist?"*

From my perspective, I believe that SAGEEP will continue to exist as long as it is perceived to be relevant. On first glance, that seems like a trivial statement. However, if you pause to take a deeper look into the business of near surface geophysics contrasted against the backdrop of a global economy experiencing disruption and huge uncertainty, you will undoubtedly ask the question *"Is SAGEEP relevant?"*. If your conclusion is that it is no longer relevant, then "*What do you propose as the best course of action that will return SAGEEP to a state of relevancy?*"

I believe that relevancy is a direct function of how many commercial transactions will result from the industry networking conducted at SAGEEP. Or to put it another way, the metric for assessing relevancy is the number of:

(a) employers finding the employee candidates they seek,
(b) vendors engaging with the new as well as current customers they require, and
(c) project managers finding the consultants/contractors they rely on to fulfill their missions.

The analysis is simple. If the numbers are high, SAGEEP is relevant.

Keywords: SAGEEP, Drones, Geology, Geophysics.

At its core, SAGEEP is the bridge between those in the academic\research communities and the customers deriving benefit from the application of geophysics. SAGEEP is and should always be about educating the customers of applied geophysics and promoting its use. Perhaps measuring relevancy should start by first agreeing on what should be considered "*applied geophysics*". The presentations at SAGEEP have traditionally focused on the application of geophysical methods to quantify the subsurface geology and detect anthropomorphic objects buried below the surface. Little attention has been given to the geophysical imaging methods used to map surface of the earth. Perhaps, this is because the vast majority of these methods are categorized as "*remote sensing*". Or, maybe the industry has simply been too busy thinking "*subsurface*" that it has unintentionally ignored the benefits of surface image data.

Drones are changing the definition of "*applied geophysics*" because they are changing how geology is mapped along with the manner in which geophysical data is and will be acquired. The reasons are many, but the bottom line can be stated in one catch phrase: ***higher resolution data in less time at lower cost***. There are limits, of course, to what airborne robots can be tasked to do. However, as society becomes accustomed to tasking robots to do the useful work of data acquisition, there is no doubt that, indeed, the paradigm for geological mapping will experience a dramatic, much needed shift. At this year's SAGEEP, there will be 15 presentations - eleven (11) oral and four (4) poster - on the use of drones for geoscience data gathering. There will be eight (8) oral presentations in the Monday afternoon session titled ***Drones in Geophysics***. Another three (3) oral papers will be presented in the ***Airborne Geophysics*** session on Tuesday. The titles of the presentations along with the names of the presenters and their respective affiliations are listed in Figure 1.

SAGEEP 2016 Denver Marriott City Center - Denver, CO

Drones in Geophysics www.eegs.org/SAGEEP-2106/

Monday - March 21, 2016

#	Title	Author(s) & Affiliation
1	*UAVs for Remote Sensing and Aeromagnetic Surveys -*	J. Zamudio, UASUSA Inc.
2	*UAS Hyperspectral Surveys*	T. Haynie and L. Anderson, Spectrabotics LL
3	*L-Band Soil Moisture Mapping Using Small Unmanned Aerial System*	A. Gasewski, U. of Colorado
4	*The Concept of UAV Magnetometry in Geophysical Exploration*	Johannes Stoll, Mobile Geophysical Technologies
5	*Unmanned Air Vehicles in Earth Sciences, advanced multi-sensor magnetic gradiometer applications*	Blair Walker, GEM Systems
6	*The Concept of UAV Airborne Tensor VLF-EM*	Johannes Stoll, Mobile Geophysical Technologies
7	*Detection of a salt-freshwater transition zone by very low frequency (VLF) measurements carried out with an unmanned aircraft system (UAS)*	Buelent Tezkant, Univ. of Cologne
8	*Using Unmanned Aerial Vehicle (UAV) during Geophysical Surveys*	Aleksey Khamein, Missouri S&T

Poster Sessions

9	*The Rise of the geoDRONE*	R. Bell, Aerobotic Geophysical Systems
10	*New Remote Sensing Technologies Support Geologic Exploration*	Bill Emison, Emison Technologies
11	*Unmanned Agronomic Intelligence for Precision Agriculture*	Christopher Rice, Front Range UAS Services
12	*UAV Imagery and Mapping; What Are the Capabilities and Limitations?*	R. Perez and W. R. Layton , Earth Forensics, M. Cruikshank and C. Hugh, Cal State Univ @ Fullerton

Tuesday - March 22, 2016

13	*Miniature Magnetometer Measurements Relevant to Deployment from Drones*	J. Johnston, Geometrics, Inc.
14	*Rotary Wing UAVs Open New Capabilities in Small Object Detection*	Johannes Stoll, Mobile Geophysical Technologies
15	*Mini Sized Fixed Wing UAV: An Efficient Tool for Airborne Magnetometry*	Johannes Stoll, Mobile Geophysical Technologies

Figure 1: SAGEEP drone relevant presentations.

As of a week ago, there are 342,000 small unmanned aircraft systems (sUAS), each with a maximum takeoff weight (MTOW) of less than 55 lbs. registered with the FAA for use in the National Air Space of the United States. A good percentage of those aircraft will be deployed to do mapping projects. Some will be tasked to map geology. At this point in time, only a minor number of drones will be launched for the purpose of acquiring the type of geophysical data required for sensing the

subsurface. The overwhelming majority of drones will be tasked to acquire data within the visible light electromagnetic spectrum. Some will capture data in the infrared part of the EM spectrum. In short order, the scenario will change. The up swell of interest for using drones in geophysical data acquisition is happening.

Do you wish learn how to integrate drones into your workflow? If you answered "yes", register for the geoDRONEology short course at SAGEEP 2016. At the end of the day, you will know precisely what you need to know in order to put drones to useful work. ***Are you interested in speaking face-to-face with experts in the field of applying drones for geoscience data acquisition?*** If you answered "yes", then register for SAGEEP 2016. You will become "drone enlightened". The bottom line is that the ***Drones in Geophysics*** presentations at SAGEEP 2016 are fundamentally about evolving the business model of near-surface geophysics in order to sustain relevancy in the face of economic uncertainty.

DEVELOPING HIGH SENSITIVITY MAGNETOMETERS FOR UNMANNED AIRCRAFT

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Abstract

Unmanned Aerial Vehicle (UAV) technology has dramatically improved in the last 5 years; cost effective, sophisticated remote control and autonomous UAV's have been fitted with photographic and lidar technology, for a variety of mining applications. It is anticipated that UAV-borne magnetometer systems will replace most ground portable and high resolution airborne magnetometer and magnetic gradiometer surveys. The predicted adoption of UAV-borne magnetic and magnetic gradient systems will only be possible if the data quality is comparable to what is collected with manned systems today, and if the magnetometer systems can be miniaturized, so they can be carried by affordable unmanned vehicles, with suitable range.

When assessing a UAV vehicle for its applicability to carry a geophysical payload, the platform needs to be carefully evaluated for the amount of magnetic interference generated by the vehicle, its available payload for a magnetometer or magnetic gradiometer system, its comparable range to a manned aircraft, and its affordability. An area near the boundary of the Paleozic Salina and Guelph formations, near Caistorville, Ontario, Canada, was surveyed with a customized unmanned aircraft, fitted with a horizontal magnetic gradiometer system at a terrain clearance of 30 m. The survey site was chosen on the basis of its low magnetic gradients. The total magnetic intensity (TMI) and horizontal magnetic gradient data were recorded. The study demonstrates that affordable, autonomous vehicles for collecting high resolution magnetic gradient data, are viable replacements for traditional airborne and ground portable magnetic surveys.

Introduction

Using a UAV to collect magnetic data is more or less universally accepted as a good idea. Developing a machine to carry out a repetitive task is something we humans have been doing throughout our history. In addition to being repetitive, there are places where we want to explore and acquire high resolution magnetic data that may be too dangerous for a manned aircraft, or too remote and expensive to bring a manned aircraft. An autonomous magnetometer or magnetic gradiometer is well suited for these environments. Ground portable magnetometer surveys can't match the rapid data acquisition of a UAV borne survey, and sometimes the magnetometer sensor is a little too close to magnetic sources that are not of interest, so putting a magnetometer sensor on a UAV makes sense for many reasons.

One of the challenges is of course to deliver data quality comparable to what is collected with manned systems today. Another equally important challenge is to develop a magnetometer system that is lightweight enough to be carried by a small, affordable UAV. UAV's with available payload to carry magnetometer systems designed for manned aircraft, are prohibitively expensive, far exceeding the cost of manned aircraft. For 35 years, GEM Systems has been manufacturing magnetometers.

Keywords: Unmanned Aerial Vehicle (UAV), Magnetometer, Magnetic Field.

With the exception of a couple of portable EM receivers (VLF) that is all GEM Systems does. The GSM-19 Overhauser magnetomer, because of it low power consumption, fast sampling and sensitivity became an industry leader. GEM pioneered integrated GPS Navigation for portable magnetometers, in the 1990's. An autonomous magnetometer system is first a GEM Systems magnetometer system. The fact that the magnetometer system is autonomous and has flight capability, is just a feature of the magnetometer from our perspective.

GSMP-35U Ultralight UAV Magnetometer

The GSMP-35U magnetometer with 0.1 pT sensitivity forms the core of GEM's UAV solutions. The sensors are based on GEM's popular optically pumped potassium magnetometer sensor, that offers the highest sensitivity available in the industry. The sensors stream RS-232 or RS-485 data which can be visualized for quality control purposes, if hardware is on board facilitating a down link of data. The GSMP-35U magnetometer is supplied complete with 128 Mb of on board data storage, suitable for long flights. The GSMP-35U magnetometer can be supplied with optional cabling, firmware and post processing software, to facilitate recording the rich data stream from the 3DR Pixhawk autopilot found in so many UAV's, in the magnetometer's memory. A full, multi-parameter database, which includes the magnetometer data and all of the UAV's sensor data, can be created all in 1 step, retrieving the data from the magnetometer. The focus of the GSMP-35U development has been to miniaturize the sensor; GEM Systems' engineers have been able to produce a magnetometer with a sensor (see Figure 1) weighing only 0.43 kg and processing electronics weighing only 0.46 kg.

Figure 1: UAV Sensor in the wing tip pod of the Monarch autonomous gradiometer.

Selecting a UAV

Customizing a UAV to carry a geophysical payload and to minimize magnetic interference can be a significant undertaking. The first step in the process of selecting a UAV is to assess the magnetic interference the UAV of choice generates, using a portable high sensitivity magnetic gradiometer. GEM Systems' magnetic interference test (MIT) involves collecting a 10 Hz time series with a gradiometer array (the gradiometer's position is fixed – see Figure 2). A number of profiles are created by moving points on the aircraft, along a radius from the array, and pausing for 10 seconds at 0.5 m intervals from the array. Multiple profiles are created (engines, servos, on / off) on different

cardinal headings to determine if the aircraft might introduce "heading errors" based on the aircraft's orientation. The data gives a very good sense of how rapidly, the magnetic interference "falls off" as the distance from the source of noise increases, A determination of where to install the sensor on the UAV or how far the magnetometer sensor needs to be away from the vehicle to be exposed to a minimal amount of interference, is made by examining the MIT data. GEM Systems' engineers began assessing unmanned aerial vehicles in 2013 for affordability, available payload, range, magnetic interference and the UAV manufacturer's appetite for customization.

Figure 2 : UAV evaluation process should seek out vehicles that will contribute a minimal amount of magnetic interference.

Multicopter Solutions

Multicopters are affordable and easy to fly, but generally their range is limited (batteries have to be changed) and that can create some operational challenges if there are some long lines to fly. Multicopters generally also generate a great deal of magnetic interference (permanent magnets in the multiple electric motors), which is a major problem to overcome. Magnetic interference testing will reveal that if the magnetometer sensor should be slung 3.0 to 5.0 metres below the multicopter, to escape as much magnetic interference as possible. GEM Systems ultra light weight magnetometer systems for the popular multi rotor class of UAV's (see Figures 3 and 4) feature a single lightweight version of GEM's optically pumped potassium vapour magnetometer sensor, a data acquisition module, GPS navigation and laser altimeter to monitor / control terrain clearance.

Figure 3 : Sensor HEAD is suspended by a 2.0 metre signal cable; the other instrumentation is installed in a stand alone chassis between the skids of the UAV, which can be quickly disconnected if the UAV is to be used for other applications.

Figure 4: Flight testing the autonomous Hoverfly BigSky high endurance quadcopter with a slung magnetometer.

Unmanned Helicopters

ING Robotics popular medium lift Responder R1 helicopter has an available payload of 6 kg for a geophysical system and has a maximum cruise speed of 72 km/hr and a range 40 minutes, making the Responder a good candidate to carry a magnetometer payload. The MIT (see Figure 5) indicated that the GSMP-35U potassium magnetometer sensor will need to be installed at least 2.0 metres from the Responder, to escape most of the magnetic interference generated by the aircraft. The least amount of magnetic interference is present near the tail of the aircraft. The installation of a magnetometer sensor head on a tail boom, using the sensor electronics as a counter weight, is underway.

Figure 5 : ING R1 undergoing testing for magnetic interference.

Fixed-Wing UAV's

GEM Systems Monarch autonomous gradiometer (see Figure 6) is a customized version of the Tempest aircraft developed by UASUSA. The Tempest ET (extended tip) has been fitted with wing tip pods for the magnetometer sensors and changes have been made to the flight control system to minimize magnetic interference. When compared to other UAV vehicles, the Tempest offers an excellent combination of available payload, extended range, affordable price, and most importantly minimal magnetic interference. The Tempest aircraft has extreme weather capability (used in the study of tornado's) and can fly in winds up to 80 km/hr. The aircraft has been deployed from weather balloons at 38,000 ft, so the aircraft and its onboard systems are designed for extreme cold and winds. Soon there will be 3 Monarch autonomous gradiometers flying on 3 continents. In Canada, Abitibi Geophysics have branded surveys with our autonomous gradiometer system AeroVision. GEM also has received orders for our autonomous gradiometer from the African (Burkina Faso) and Australian (branded AUSmag) continents and we will be shipping those systems in Q1 2016. The Monarch has a cruise speed of 70 km/hr (at a 10 Hz sample rate, the gradiometer will be acquiring a data point every 1.9 metres – see Figure 7) and has a range of approximately 1.5 hours. The Monarch should be able to acquire over 100 linear km's of magnetic gradient data per flight and will be able to fly multiple flights per day, as the procedure to change batteries is a trivial matter. The Monarch is launched via catapult in an autonomous mode where it is monitored and commanded by a pilot / primary operator located at the ground control station (GCS – see Figure 8). The combination of an autopilot and onboard computer enables the Monarch to maintain the desired grid pattern / flight plan.

Figure 6 : The Monarch on its catapult launcher.

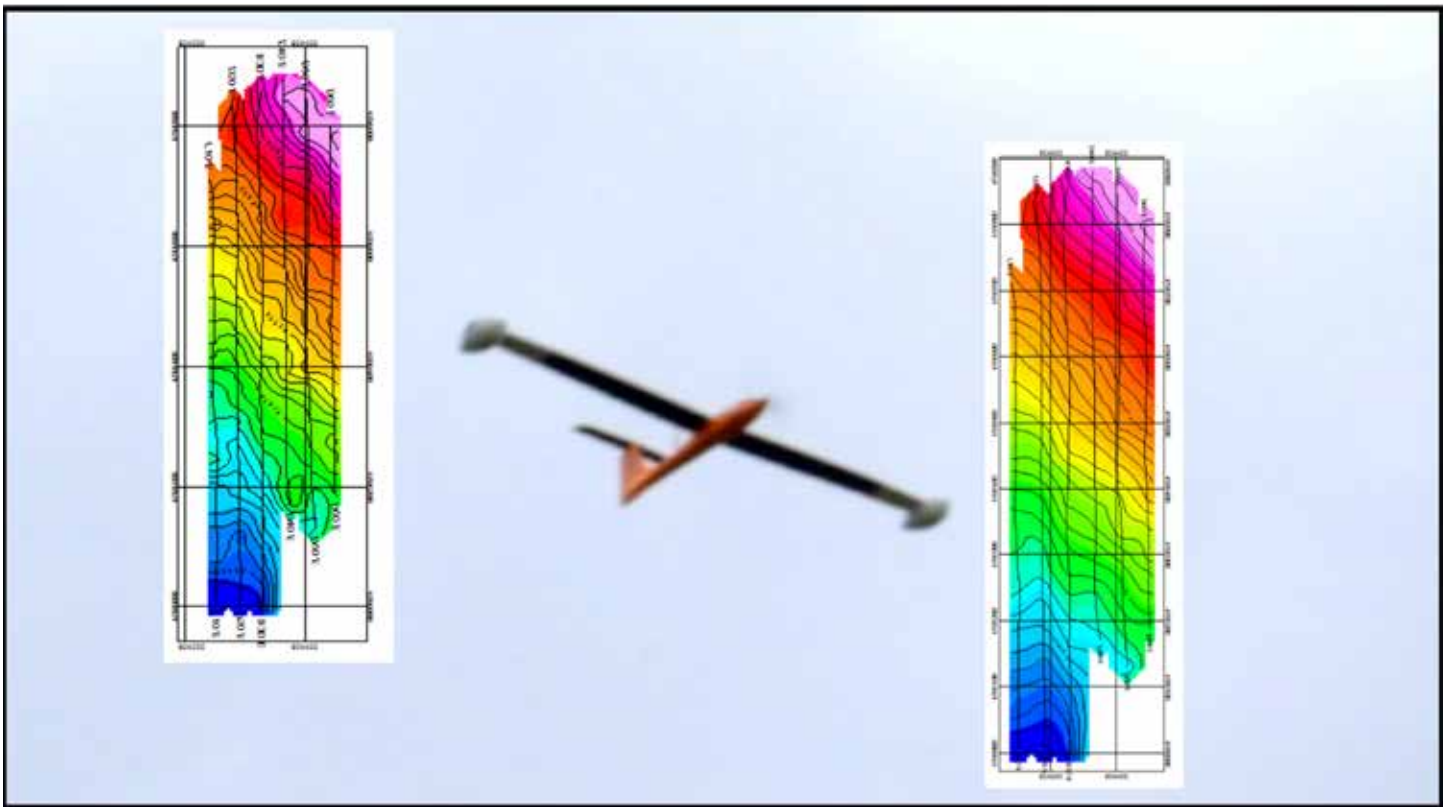

Figure 7: GEM's Monarch autonomous gradiometer in flight shown with data (Total Field) acquired by both wing tip UAV magnetometers (full range of data is 2 nT).

Figure 8: Monitoring and controlling the Monarch with the mission planner ground station.

VLF-EM

GEM Systems' airborne VLF-EM system (see Figure 9) is comprised of two Sensors weighing 1.0 kg each and a control console measuring weighing 2.1 kg. The weight of the entire system with all the interconnect cabling is approximately 6 kg . The VLF-EM subsystem was designed for manned aircraft, but if the UAV has suitable payload capacity, the subsystem can be installed on an unmanned aircraft without any changes to the system. It is possible to provide a system with a single VLF sensor to reduce the payload requirement.

Figure 9: GEM's airborne VLF-EM subsystem with non magnetic air core sensors.

Permits for Flight Tests

To enable the continuous development and improvement of UAV magnetometer system, obtaining the necessary permits from the aviation authorities is an important consideration. In Canada, if the survey area is more than 5 nautical miles from a "built up area" a simple webform can be used to obtain an exemption from Transport Canada. Built-up areas are considered areas with groups of buildings or dwellings including anything from small hamlets to major cities. Anything larger than a farmstead should be considered a built up area. Since there are a couple of houses within 5 nautical miles of GEM Systems' magnetometer test site south of Hamilton, Ontario, Canada, it is necessary to obtain a Special Flight Operating Certificate (SFOC) before commencing UAV operations. Once the UAV operator has and has demonstrated that they can operate safely, it is possible to obtain SFOC's that are valid up to one year. The Tempest (Tempest ET/Monarch) has more Certificates of Authorization (COA's) issued by the FAA in the US than any other commercially available platform.

Conclusion

The study demonstrates that affordable, autonomous vehicles for collecting high resolution magnetic gradient data, are viable replacements for traditional airborne and ground portable magnetic surveys, and can be used in environments that may be too dangerous for a manned vehicle, or too costly / remote for manned vehicles.

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HYPERSPECTRAL IMAGING FROM A UAS PUTS DATA SCIENTISTS AT THE CONTROLS

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Until now, the only way to get aerial Hyperspectral Imagery (HSI) was from either a satellite system or an aircraft, largely due to the size, complexity, and power requirements of the sensors. However, the increased reliability and improved flight performance of small Unmanned Aerial Systems (UAS) coupled with the introduction of new hyperspectral sensor technologies suitable for UAS platforms has now given scientists a new capability for data collection. But this comes with new requirements and demands on the scientist. While the combination of these technologies represents a new era in data collection, the versatility and access of the UAS brings with it the need for increased cooperation between sensor operators, platform developers, and data scientists for a successful hyperspectral program. Unlike the satellite and the airplane, the use of a UAS can put the data scientist at the controls (literally!), with additional responsibilities that require a more thorough understanding of all technical and operational components of the program. For those considering incorporating HSI sensor data from a UAS as part of their program, here are a few key considerations to ensure you not only get suitable data for your analysis effort, but also all of your equipment back!

1. Be Prepared to Manage the Data!

Those familiar with hyperspectral data understand a few things from the moment you analyze your first cube: 1) It's a large data-set!, and 2) Analysis of the data requires experience with hypercubes to understand the nuances of the dataset. For most efforts, post-flight processing of the datacube is satisfactory since the data will likely be studied for month or years to refine techniques or develop new insights. The data will likely require significant processing to account for environmental conditions during collection (e.g. atmospheric, solar illumination) and correction for UAS attitude and ground registration.

It's easy (and perhaps ill-conceived) to think that real-time on-board image processing is both available and accurate enough to integrate into a UAS program at the moment. This is not to say the capability cannot be developed; however, it is worth noting that the processing demands typically require additional hardware and power demands that tax the UAS platform into shorter flight times. The truth is that with sensor technologies where they are today it is better to save that capability for a future goal. In the short term, development funding is better spent on improving post-flight processing than real-time analysis. That said, if real-time analysis is required, then be prepared to focus the analysis on selected bands and/or signature features rather than signature matching across the spectrum. The goal is to limit the amount of data to analyze in flight and conduct a more thorough analysis on computing systems designed for optimized speed and memory. High-performance computing is reducing in size, weight, and power and, while it is an encouraging trend, credit-card sized processors are not quite to where they need to be in order to integrate with a UAS and perform the type of analysis that makes the expense of a HSI sensor an effective, economical tool.

Keywords: Hyperspectral Imagery (HSI), Unmanned Aerial Vehicle (UAV), Hypercube, Sensor-Stabilizing Gimbal, Inertial Measurement Unit (IMU).

2. To Gimbal or Not to Gimbal?

Since we are so concerned about Size, Weight, and Power (SWaP), careful consideration must be applied to every decision that adds components to the UAS. One of the more complicated SWaP demand considerations is the use of a sensor-stabilizing gimbal. A gimbaled sensor will not only improve the quality of the sensor data, but also allow sensor-pointing options independent of the UAS's orientation. And here is where tough decision gets made because of trade-offs between data quality and flight performance. It is possible to mount a HSI (or other spectral sensors) on the UAS without a gimbal and save the SWaP burdens on the UAS in order to extend the flight-time which comes as a relief for those trying to optimize the integration. Like most engineer trade-offs, this option comes with some costs.

Firstly, mounting the sensor to the airframe means all of the attitude-orientations (pitch, yaw, roll) are transferred directly to the data since the focal plane is directly affected by the UAS's orientation. Conversely if your sensor is fixed to a gimbal then you can dictate sensor orientation and maintain that orientation for the duration of the flight regardless of the UAS's orientation. Secondly, real-time sensor orientation information is required in order to correct the data during processing (rectify the data to the Earth) which requires the sensor system to incorporate what is typically called IMU-data (Inertial Measurement Unit - data). IMU-data is composed of a body's 3-dimensional forces and/or angular rate as measured by a combination of accelerometers and gyroscopes. When aligned with the recorded HSI data via Global Positioning System (GPS) timestamps, post-processing can have the attitude affects removed from the datasets.

IMU devices typically add a sizeable cost to the sensor package, but are reliable and highly accurate since they are usually affixed to the sensor/focal-plane. Of note, the UAS's flight controller also generates IMU attitude information which can be correlated with the sensor data via timestamps. Since the flight control is separate from the HSI sensor (and typically not oriented "forward-facing" in relation to the flight control system), additional steps are required to program the imagery correction to account for the offsets. The decision to use a gimbal really comes down to the how the data will be used and the importance of flight-duration. Given that much of the processing will be done post-flight, there could be adequate time for rectification and data analysis with other data-sets that enable correlations for ground accuracy, which can eliminate the need for a gimbal.

3. What's the Best Platform to Host the Sensor, Fixed Wing or Multicopter?

As usual, it depends on your sensor. Line scanners work similarly to a "push broom" or "wisk broom" whereby a linear array detector advances with the UAS's motion, producing successive lines of image data (analogous to the forward sweep of a push broom) recording an entire line across the FOV before returning to the start of the next line. A line-scanner (such as the Headwall Photonic's Nano-Hyperspec™) requires a very precise aircraft speed to balance light conditions with sensor performance to ensure you have adequate exposure and coverage of the target area. This is very similar to balancing shutter speed and aperture settings on digital frame cameras. Fly too fast and you get "skips" in coverage (the scanner cannot keep-pace with the ground movement); fly too slowly and your ground coverage gets "compressed" where you are essentially recording the same pixel multiple times. For this, multicopters are a convenient choice since pilots can dictate the flight speed with precision and can balance light-conditions with sensor exposure requirements.

Other sensor technologies that incorporate "Frame Grabbers" as part of their design are not encumbered by this particular flight requirement. These systems typically record an entire image datacube at once similar to a digital frame camera taking a snapshot. The cost is that a frame grabber typically requires frame-capture cards which place increased SWaP requirements on the UAS. However, since these systems can capture an entire frame, flight speeds are not as restrictive and introduce fixed-wing platforms as potential options for collection.

4. Is there an Optimum HSI Sensor for a UAS?

It is unlikely in the near-term that industry will effectively build a sensor that does it all and this has more to do with physics than with good sensor design. Generally speaking, HSI sensors are categorized by which bands they collect which is largely based on how current sensors are able to capture and interpret light-data. There are various sensor design methodologies that conform to electromagnetic properties that ultimately drive sensor design and include features such as diffraction gratings, optical band-pass filters, photodiodes, and liquid-cooled detector arrays. Today's sensors are generally categorized by the bands they collect using one of the sensor design methodologies and fall into the following categories: Visible and Near Infrared (VNIR) sensors detect electro-magnetic energy at wavelengths between approximately 400 and 1400 nanometers, Shortwave Infrared (SWIR) sensors detect energy from 1400-3000 nanometers, and Mid and Longwave Infrared (MWIR-LWIR) sensor detect between 3000-15000 nanometers.

Since objects on the ground reflect, absorb, transmit or radiate energy across the entire spectrum you must choose a detector able to collect within your region of interest. The particular material you are looking for may have distinguishing spectral features that sensors and/or processing can detect in a localized region more predominantly in one region over another and this largely drives the type of sensor needed for the mission. As a general guideline, VNIR sensors are compact and low-power, utilizing diffraction gratings and band-pass filters which make them suitable for UAS platforms. SWIR, MWIR, and LWIR sensors often require cooling and higher power requirements which may exclude smaller UAS frames. Many of today's UAS-HSI ventures utilize VNIR sensors which require innovative data-analytic techniques to finding materials or features of interest. The reality, however, is that many of the more interesting and/or definitive spectral features exist within the SWIR and LWIR bands because of their resistance to atmospheric influences. There remains a significant market-demand for small sensors that are able to collect within these regions of the spectrum and integrate with small UAS frames. Given all of the details that often limit (or even dictate) the direction, capabilities, and performance of a UAS-HSI program, there are a number of significant decisions that involve every aspect of engineering, data analysis, integration, and platform design that require extensive experience and professionalism within these disciplines.

5. Here is Why the Team Needs to Collaborate (or, Why the Scientist May Likely Be at the Controls.)

Despite all the complexities discussed above, HSI detection from a small UAS is still an option but only after a team comes together to design the right solution. It's a balance between what the scientist needs for analysis and what the platform crew can provide to meet that need. To illustrate the point, I'll use a recent example where our team accepted an invitation to demonstrate the capabilities of a small UAS for chemical agent detection using a VNIR hyperspectral sensor. The mission was to correctly identify and locate a sample of methyl salicylate (oil of wintergreen) in an urban setting from a low-flying UAS. These types of missions inevitably encounter challenges from the environment (clouds, rain, temperatures), integration of the sensor and platform, data analysis, and piloting of the system so it was apparent from the beginning that our greatest chance of success would come from a collaborative effort to address each of these areas by subject matter experts. The UAS platform consisted of a carbon fiber commercial frame controlled with the open-source 3D Robotics Pixhawk flight control system (Figure 1). To reduce weight and complexity, the team elected to mount the sensor directly to the frame and utilize the sensor's integrated Inertial Measuring Unit and software to correct for the UAS's attitude effects on the data.

Figure 1: A commercial UAS carbon fiber frame with an open source flight control system hosting the Headwall Photonics Nano-Hyperspec ™ hyperspectral sensor. The sensor is a Visible - Near Infrared (VNIR, 400-1000nm) 270-band, diffraction-grating, push-broom imaging system with an integrated Inertial Measuring Unit.

To address the sensor selection, data analysts from Exogenesis Solutions, Inc., with years of experience in spectral data analytics and (equally important) sensor design, determined that this particular chemical had spectral signature features within the VNIR spectrum that could be detected using conventional analysis methods but only in post flight analysis. Given that the VNIR was our spectrum of choice we selected the Headwall Photonics Nano-Hyperspec ™ because of its low SWaP requirements as well as a fully integrated IMU device for image rectification. We further went with a custom multicopter platform from Spectrabotics and Autonomous Avionics because of the precise speed requirements the push broom sensor required and the reliability of a platform hand-built by UAS designers. The NanoHyperspec ™ sensor was mounted directly to the hexacopter's frame to save weight and complexity and the sensor's IMU was able to provide detailed attitude information to rectify the data for analysis. We conducted a total of six flight tests for sensor-platform integration to ensure the sensor data was suitable for analysis, none of which included the methyl salicylate within the hypercubes (our data analysts were confident they could develop a methodology on-site to locate the material).

Central to nearly all of the integration and flight-profile methodologies was the quality of the data we collected so each test resulted in modifications to flight plans, sensor operations, data management, and sensor mounting techniques to ensure the right balance of flight performance and data quality. As seems to be typical, weather conditions on the day of the exercise were challenging with a low ceiling (<500 feet), temperatures in the mid-40s and the occasional passing of light rain. This had the effect of lowering the ambient lighting for exposure calculations; however, adjustments to the UAS's speed were manageable. The target area was a two-acre urban terrain setting within an US Army training facility that included a wide array of both construction and natural materials (wood, concrete, soil, vegetation) as well as physical objects (roof tops, walls, streets) breaking up the landscape (Figure 2). The flight speed was set for five-meters per second and the flight altitude was set for 100-meters above ground-level which gave us a swath-width of about 10-meters. The multicopter was programmed to fly an autonomous "lawnmower-pattern" over target area from a remote distance of about 150 meters and all maneuvers (except for takeoff) were performed autonomously. The flight lasted seven minutes without any abnormalities; while not environmentally sealed, both the multicopter and the sensor performed well under misty conditions.

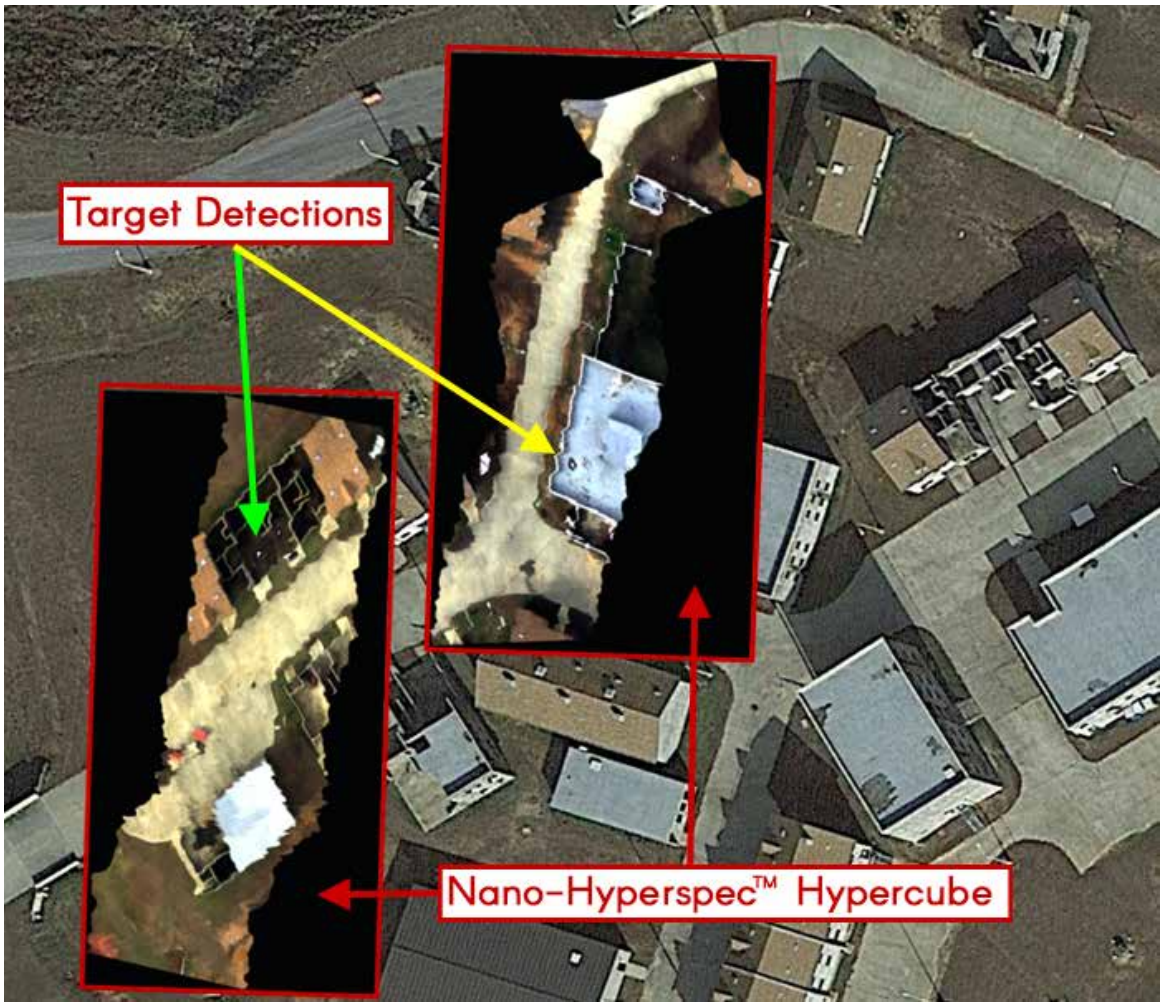

Figure 2. Target Detection Locations. Spectral imagery analysis identified target chemical locations within an urban terrain setting using spectral signature matching. Imagery strips represent a data-collection pass by the UAS and target materials were assessed during post-flight analysis of the hypercube.

Once the UAS landed, the data (about 2.5 Gbytes in size) was collected from the sensor via Ethernet port to a laptop and orthorectified to the ground using the Headwall Photonics HySpy software against digital elevation models and IMU/GPS data collected by the UAS platform. Spectral signature and feature-matching was performed using ENVI as the analytic toolset. Within the data each pixel in a hyperspectral image contains a "fingerprint of light" that can be matched to libraries of chemically diagnostic spectral signatures. To develop a "library signature" for methyl salicylate we took sample collections on site of the target material with various backgrounds (wood, straw, concrete) in order to catalog a known spectral signature with the sensor. In the post-collection workflow, HSI data processing routines were performed to extract or "detect" a signature of the methyl salicylate including (Figure 3):

- Radiance Calibration: Ls = (DN – Dark Current) * Gain
  where Ls is the at-sensor radiance value.
- Orthorectification: Performed using Headwall HySpy software against digital elevation models and IMU/GPS data collected by the UAS platform.
- Atmospheric Correction: Performed using a modified flat fielding technique.
- Target Detection: Performed using a lab spectral signature of methyl salicylate using four target detection algorithms: matched filter, spectral angle mapper, constrained energy minimization and adaptive coherent estimator.

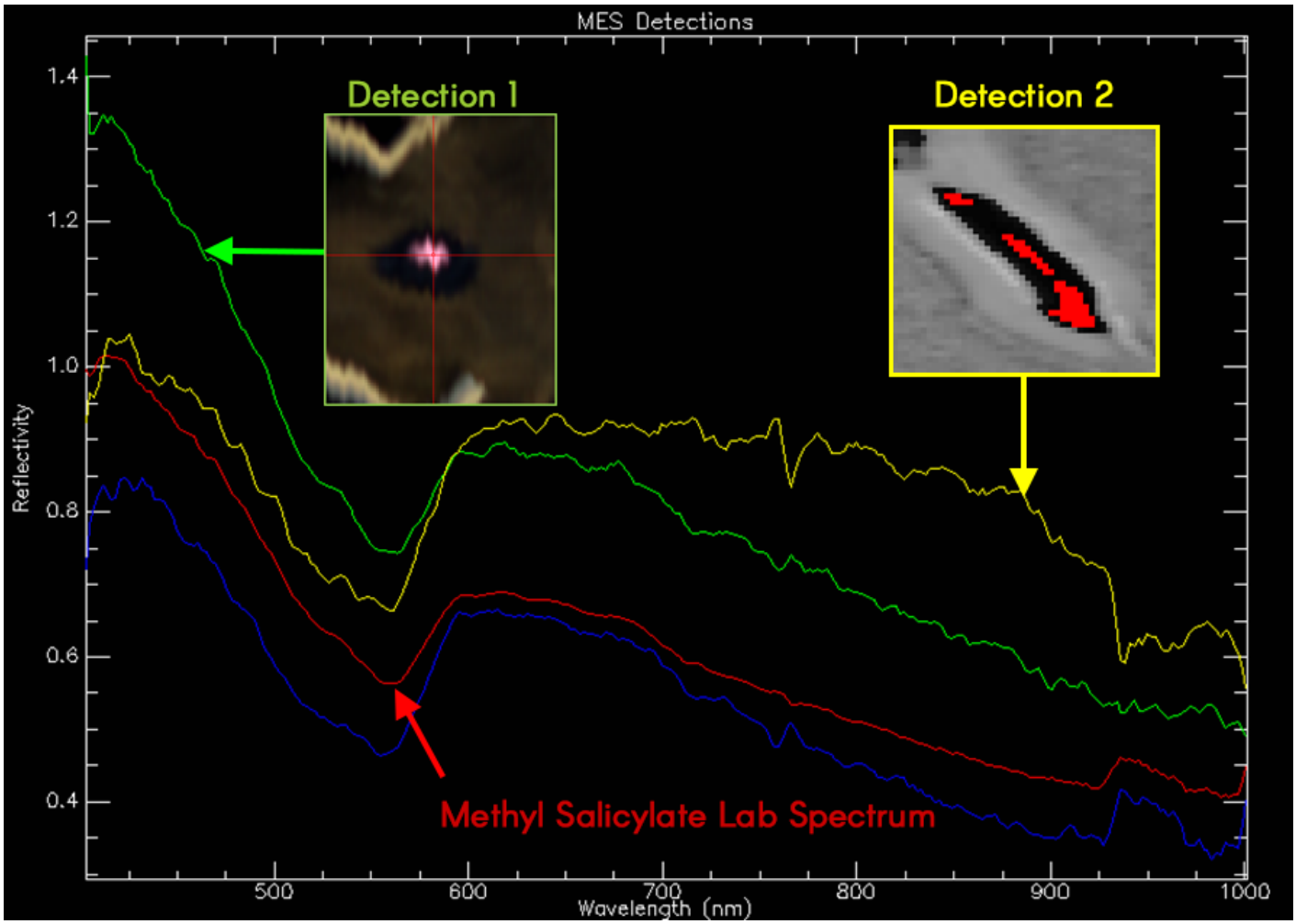

Figure 3: Methyl salicylate signature matches from remotely sensed hyperspectral datacube. The reference signature (red) was used to identify similar material signatures at the pixel-level across the entire data sample using a matched filter, spectral angle mapper, constrained energy minimization and adaptive coherent estimator.

Each algorithm has strengths and weaknesses because some of the algorithms perform better in poor lighting conditions and some perform better at un-mixing pixels and determining chemical concentration. Results from each algorithm were weighted and synthesized into a final detection result with no false positives or missed targets. Happy to say, we found the material in all of the target locations plus the spot where a tester accidentally spilled some on the way to the target areas!

What made this effort a success in terms of successfully conducting HSI data collection from a small UAS platform and positively identifying a chemical substance on the ground was the combination of talent and experience spread across the integration team comprised from four separate companies, integrated into a single program. Given the rapid development of technologies across each of the disciplines as a result of UAS-development, it was apparent to us early in the mission-analysis that the ability to employ cutting-edge technologies across multiple disciplines was best left to those deeply involved in those disciplines. Central to the effort and perhaps the one holding the final decision is the data scientist who must ultimately turn the raw values into a final product, balancing all of the technical demands of the program with the utility of data that's ultimately the determining factor of program success. ***Find your team and safe flying out there!***

THE BUREAU OF LAND MANAGEMENT & THE USE OF UNMANNED AIRCRAFT SYSTEMS (UAS) FOR RESOURCE MANAGEMENT

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Disclaimer: The following comments and observations are solely mine and should be construed as an interpretation of the content contained in a power point presentation provided by Lance Brady as well as the conversations that I have had with him. It is not an official document that has been reviewed and approved for release by the U.S. Bureau of Land Management (BLM). I am presenting it to you because I think it is worthy enough to be shared with the readers of the *Fast*Times. Please do not send in the lawyers for whatever reason. If I get something wrong or offend you in anyway, I apologize.

I first met Mr. Lance Brady in the winter of 2013 at a Denver area meeting of the Rocky Mountain UAS Professionals. A few weeks prior, I had just returned from a ground geophysical field project in western Nevada brim full with a desire to learn more about unmanned aircraft systems (UAS) and how they might be tasked to acquire low altitude geophysical data. Lance was the speaker for the evening. His presentation about the use of drones at the BLM was inspirational. I did not realize it at the time, but that evening I experienced what is best described as an epiphany.

A few months ago, I asked Lance if he would write an article for the *Fast*TIMES about how drones were presently being used at the BLM. His replied that he was very supportive of the concept but that when it came down to it, he simply did not have any time that he could allocate to authoring an article. He went on to share that he was too busy in the field conducting drone projects. As we discussed the dilemma, he suggested that I use the contents of a slide deck for a talk he had recently presented to staffers from various agencies within the U.S. Department of Interior. Included in the following paragraphs are what I consider to be the salient details about the BLM's use of drones that I extracted from the Lance's slide deck. In addition, I included snippets of information gleaned from several conversations that I have had with Lance over the course of the last 12 months. Before I continue, I am grateful to Lance for his generosity in providing this information about using drones.

The BLM has been operating unmanned aircraft since 1998-1999 to test the efficacy of radio controlled (RC) model aircraft for data gathering. From 2000-2004, they used an Aerial Camera Blimp System. They began using drones in earnest soon after taking possession of a cache of Raven fixed wing UAS made by AeroViroment and T-Hack RQ-16 rotary wing UAS made by Honeywell. These surplus aircraft were originally used by the US military. During the past 2 years, the BLM has replaced the military drones with the Falcon UAS (fixed wing – see Figure 1a) and the Falcon Hover (multi-copter – see Figure 1b) made by Falcon Unmanned (http://www.falconunmanned.com/). In addition, they acquired a Pulse Vapor 55 (see Figure 1c), a single rotor helicopter made by Pulse Aerospace (http://pulseaero.com/).

Keywords: Unmanned Aircraft Systems (UAS), Bureau of Land Management (BLM), Photogrammetry.

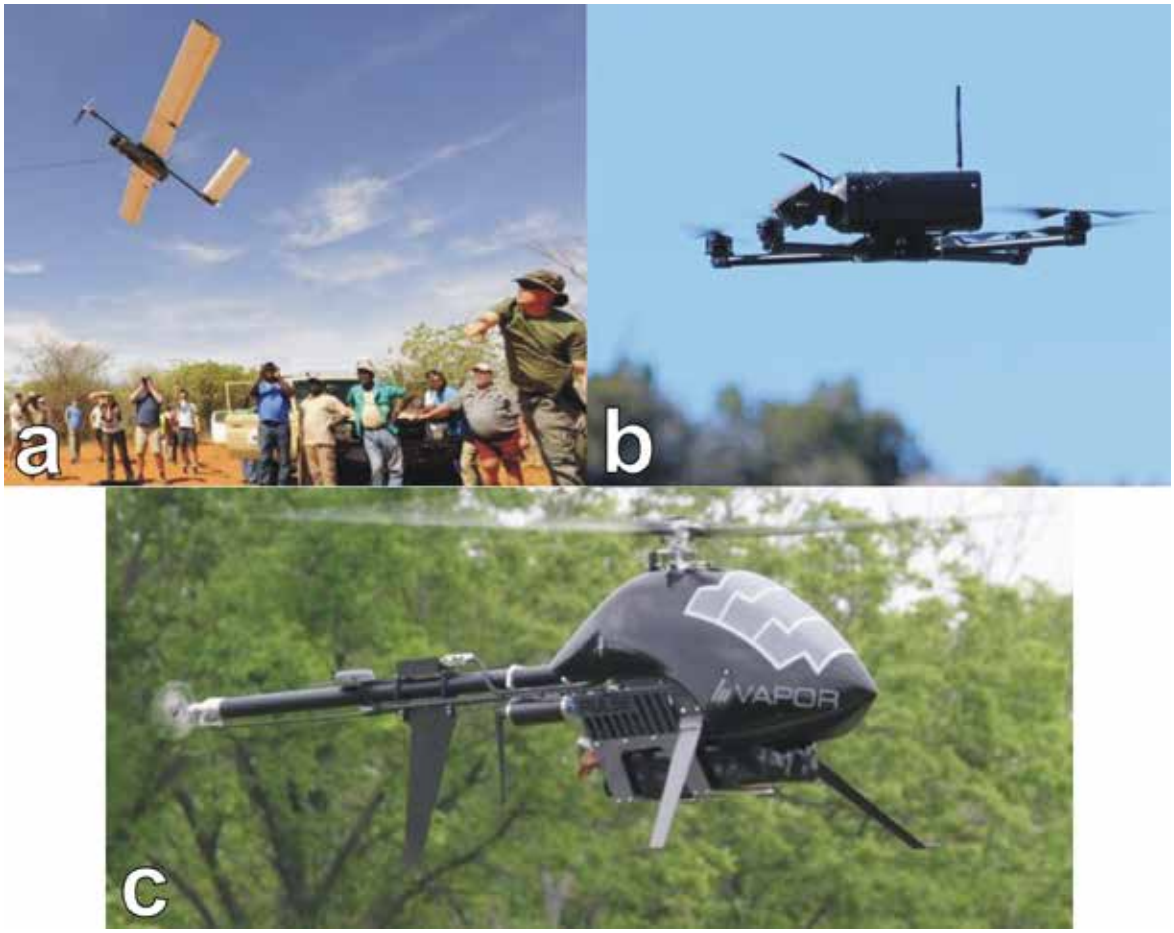


Figure 1: Unmaned aircraft systems commonly employed by the U.S. Bureau of Land Management; (**a**) Falcon UAS, (**b**) Falcon Hover, and (**c**) Pulse Vapor 55.

The BLM manages more than 245 million square surface acres of federal land located in the Western U.S. The primary objective of the BLM small UAS program is to provide low cost, high quality data and information in timely fashion to BLM field personnel and staff as well as to interagency clients within the Department of Interior. The agency has applied for and received numerous public Certificates of Authorization (COA) from the FAA. In December of 2013, the BLM signed a Memorandum of Agreement (MOA) with the FAA that significantly streamlines and shortens the process of obtaining a COA. In December, 2015 the MOA was updated. As a result, the BLM is able to file an application for a COA and fly within 24 hours.

The BLM has created a set of standard operating procedures that are used for every UAS project and every UAS flight. The primary emphasis is placed on public safety and conducting safe operations. In addition, all of the stakeholders to the project from the field staff and project management at the BLM to the adjacent land owners and local public authorities are notified and kept informed about the UAS operations.

The BLM UAS field operations are typically 3 to 4 days long. A minimum of two (2) UAS operators are deployed, but three (3) operators are typical. Most of the BLM UAS projects involve color photography or photogrammetry. They have flown some projects using a near infrared (NIR) and thermal infrared sensors (TIR). The BLM is presently looking for other sensors, in particular, those capable of subsurface geophysical measurements. .

For a photogrammetry project, the data are checked in the field for completeness after each flight. The photogrammetry processing software, Photoscan, is used to verify alignment and coverage at low resolution. Full resolution data processing is done in the office. Any necessary GPS/RTK ground control and scale measurements are taken in the field on the same day as flight operations occur.

The BLM has deployed UAS for a variety of applictions including:

. Rangeland Health
Vegetation Monitoring
Habitat Monitoring
Fuels Projects
Fire Rehab
Noxious Weeds
Wildlife Surveys
Stream Channel Morphology
Archaeological Site Inventories
Recreation Use and Inventories
Transportation Planning/OHV Management
Hazardous Materials
Trespass / ROW Compliance

Figures 2, 3, 4, and 5 provide some specific examples of BLM UAS projects.

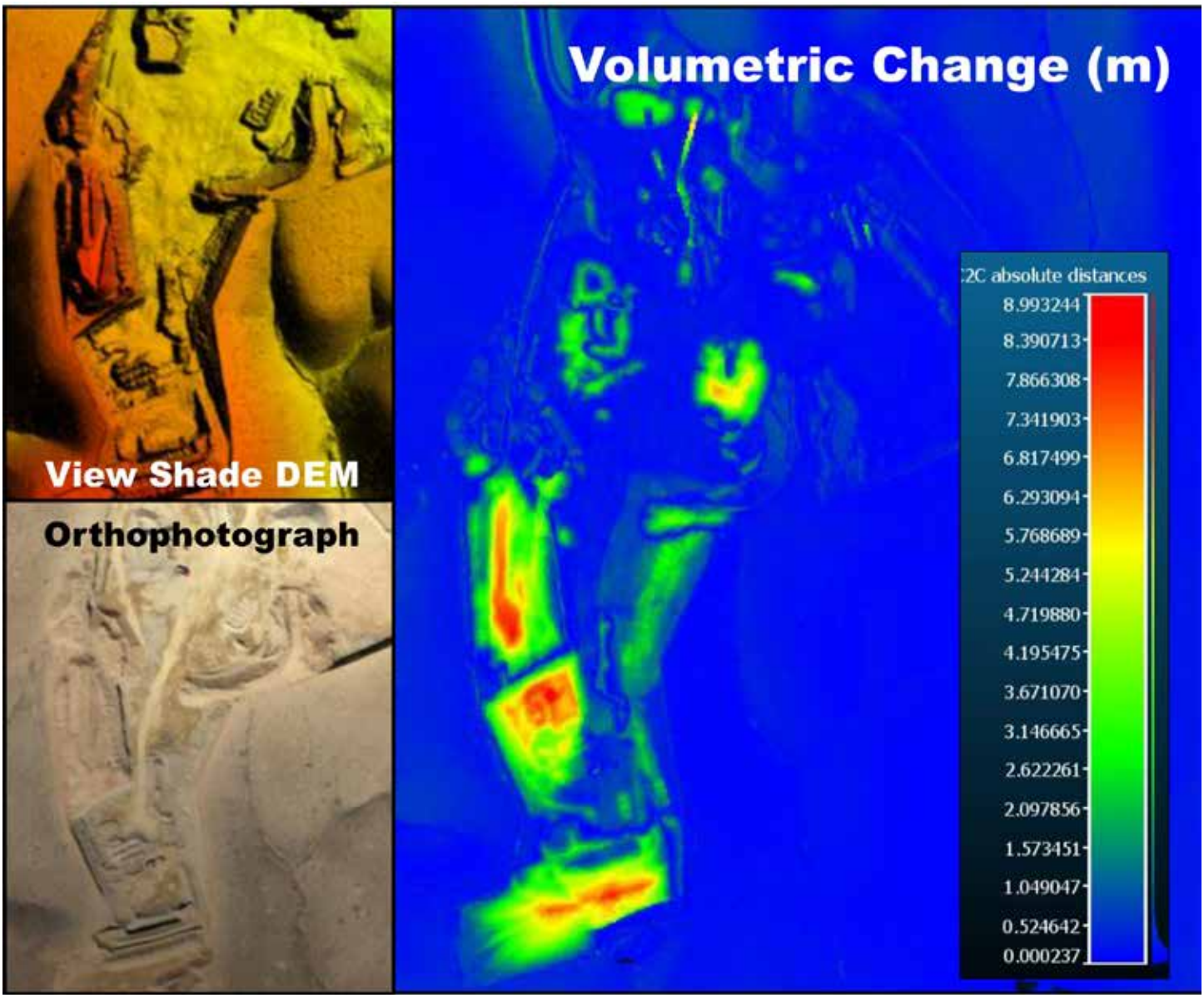


Figure 2: Photogrammetry for volumetric change detection at a gravel pit in Grand Junction, Colorado.

Figure 3: Photogrammetric monitoring of the Debeque Landslide (Debeque, Colorado) – June and October 2013.

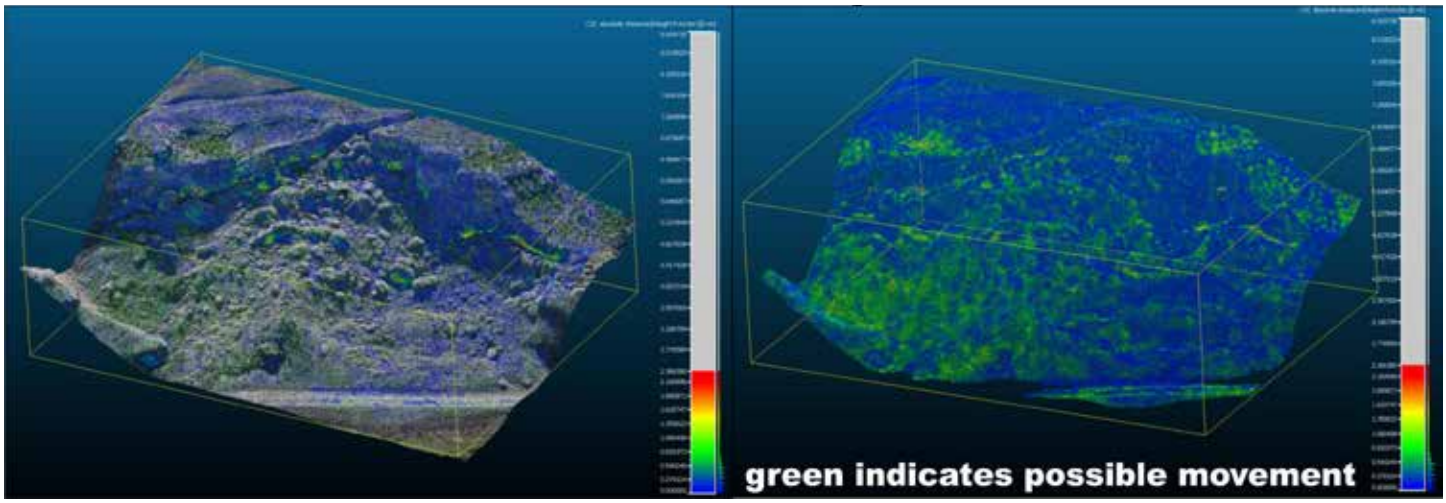


Figure 4: 3D digital surface model differencing in area of Debeque Landslide (Debeque, Colorado) to identify areas of possible landslide movement

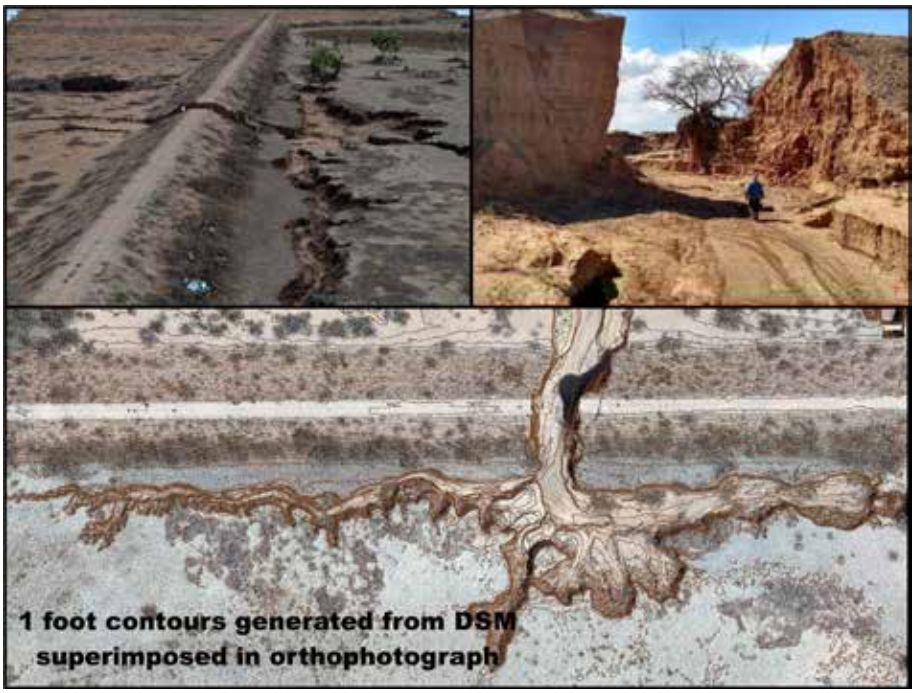
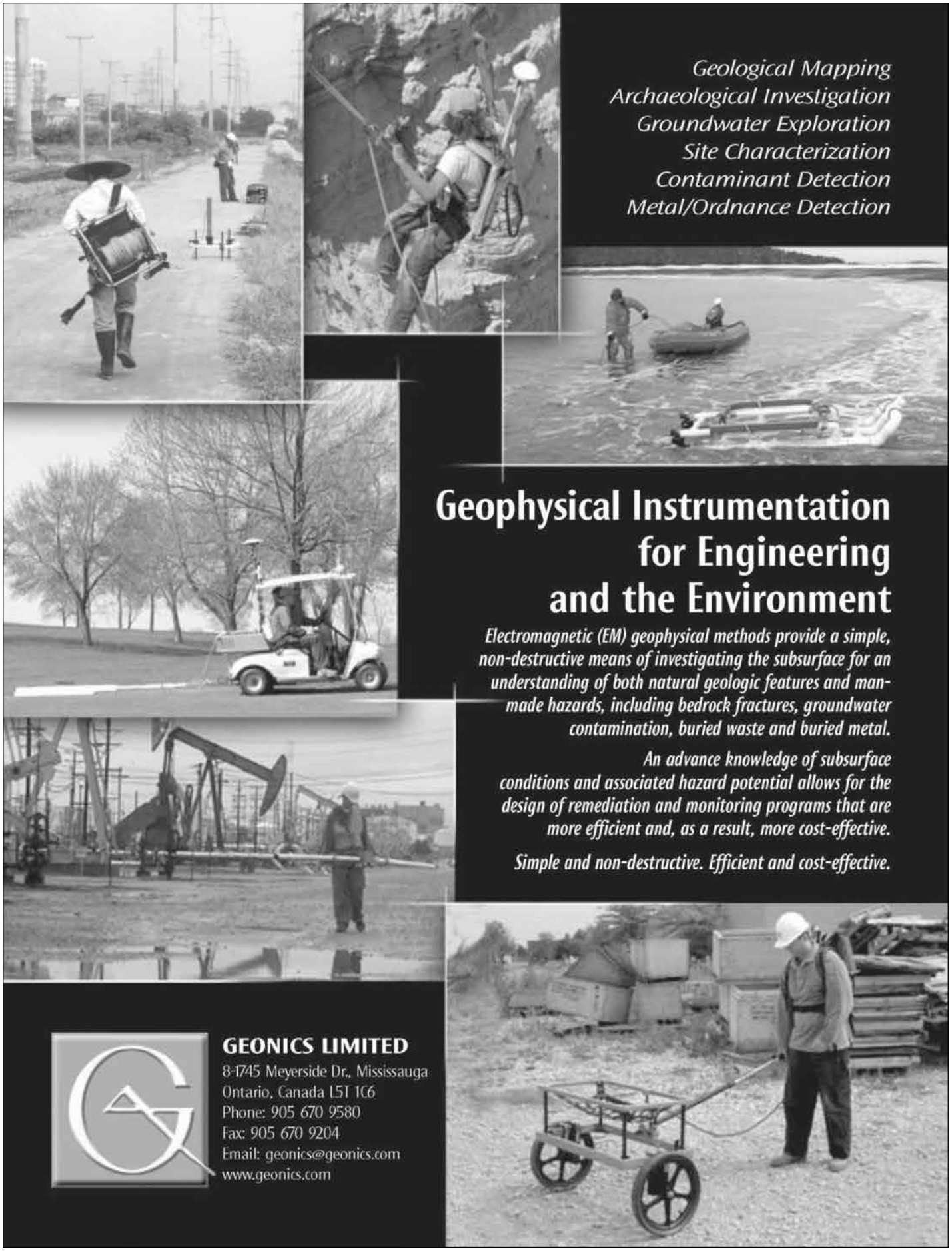


Figure 5: Analysis of HX Dam Breach (Safford, Arizona) using UAS photogrammetry.

The UAS program development team will be continuing to procure aircraft as they move forward with implementing the goal of establishing three (3) regional crews trained to execute flight operations, process the data, and deliver an end product.

BLM Contact Information: Lance Brady, BLM NOC UAS Lead - (303) 236-4242 - lrbrady@blm.gov


Geological Mapping
Archaeological Investigation
Groundwater Exploration
Site Characterization
Contaminant Detection
Metal/Ordnance Detection
Geophysical Instrumentation for Engineering and the Environment
Electromagnetic (EM) geophysical methods provide a simple, non-destructive means of investigating the subsurface for an understanding of both natural geologic features and man-made hazards, including bedrock fractures, groundwater contamination, buried waste and buried metal.
An advance knowledge of subsurface conditions and associated hazard potential allows for the design of remediation and monitoring programs that are more efficient and, as a result, more cost-effective.
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www.geonics.com

geoDRONE Report

by Ron Bell Aerobotic Geophysical Systems, LLC
e-mail: rbell@igsdenver.com tel: 720-220-3596

15 February 2016

3300+ Exemption 333 Certificate of Authorization (COA) permits have been awarded to individuals and companies by the Federal Aviation Administration (FAA) since the institution of the process for legal operation of an unmanned aircraft system (UAS) for civil use in the National Air Space of the United States commenced nearly one year ago. 300,000+ hobbyist drones have been registered with the FAA since late December of 2015 when agency issued rules requiring registration of ***all*** small UAS weighing more than 0.55 lbs. (250 g) and less than 55 lbs. (25 kg).

The cost of an off-the-shelf, ready-to-fly quadcopter equipped with all of the accessories needed to conduct a UAS photogrammetric survey is less than USD $3000.00. The weight and power specifications and, *more importantly*, the price for a multi-spectral imager has been reduced dramatically. During the past year, the UAS industry has rapidly ramped up to meet the surging demand for aircraft and sensors capable of useful work.

It simply does not make sense for companies to continue operating with a "wait and see" mentality. Rather, it makes much more sense to add a drone to the "geo-tool box" or contract with UAS mission services company to acquire - in nearly real-time- site specific basic mapping data and information. The consequence of management inaction simply means having, at some point, to play catch up in order to remain in business.

However, the lack of off-the-shelf UAS compatible geophysical data acquisition instrumentation or UAS fitted with geophysical sensors capable of sensing variations in subsurface geology is a gaping hole in the presently available UAS offerings. Those companies and individuals equipped with the entrepreneurial willingness to take on the risk and significant challenges of developing and bringing to market UAS geophysical systems have the very real possibility of enjoying high profits. Who will have the courage and the sufficient financial strength in the current downtrodden and uncertain economy to bring a geophysical solution to the market? Perhaps, a more fundamental question that should be answered first and foremost is: "*What is a UAS geophysics solution?"*

Late last summer, I began soliciting drone relevant technical content for the upcoming **SAGEEP 2016**. The companies that I presented in my previous **geoDRONE Report** along with those listed below were insightful and thoughtful enough to accept the invitation to present their respective work in the ***Drones in Geophysics*** technical session that will be held on Monday, March 21st, 2016. My heartfelt gratitude goes out to each of these companies for their willingness to share their knowledge and experience that they have accumulated using UAS for geoscientific investigations.

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spectrabotics

contact: Tim Haynie, President & CEO
tel: 719-428-1590
e-mail: info@spectrabotics.com
location: Colorado Springs, CO
website: http://www.spectrabotics.com
UAS Operated: multi-rotor copters
Sensors: a) high definition RGB camera
b) near infrared (NIR)

INDUSTRY NEWS

Spectrabotics is a geospatial data consulting and services firm specializing in the application of UAS. The heart of the company is a team of innovative geospatial data scientists dedicated to providing the highest quality, purpose-built data sets for solving real world problems in a timely, customer-centric fashion. Their customers are as varied as the solutions they provide. Whether the customer is interested basic topographic mapping for construction projects or sophisticated NDVI analysis of imagery for precision agriculture or exploring the complexities that come with the hyperspectral imaging for mineral species mapping, they can do it all. Check out their website at www.spectrabotics.com.

GEM SYSTEMS
Celebrating 35 Years
Leading the World of Magnetics

Contact: D. Blair Walker, B.Sc.
Tel: 905-752-2202 x 260
Mobile: 416-627-7996
e-mail: blair.walker@gemsystems.ca
location: Markham, ON Canada
website: www.gemsystems.ca

UAS: GEM Monarch
Sensors: a) gradient magnetometer system

GEM Systems is the first geophysical instrumentation manufacturer to offer a ready-to-fly, off-the-shelf fixed wing UAS gradient magnetometer solution. A custom built version of the ***Tempest*** fixed wing UAV from UASUSA (see below) along with two GEM GSMP-35UAV optically pumped potassium magnetometers specially designed for use on a UAV are the core of their **GEM Monarch Magnetic Gradiometer** UAS geophysical solution.

The sensitivity of the magnetometer is 0.3 picoTesla. The data sampling rate is operator selectable at 1, 5, 10, and 20 Hz. The aircraft has been modified to reduce the level of noise interference with the measurement.

The **GEM Monarch Magnetic Gradiometer** has a cruise speed of 70 km/hour (43.4mph) and a stall speed of 50 km/hr (31.0 mph). It is capable of up to 1.5 hours per single flight and can be flown in autonomous mapping mode. The standard system can be controlled at range of 13.0 km from the base control station and is upgradeable to a range of 80 km. A daily acquisition rate of 100's of line kilometers per day is typical.

To learn more, contact Blair Walker at: blair.walker@gemsystems.ca
or visit: www.gemsystems.ca

UASUSA

The technical experts at UASUSA have more than 20 years of experience in designing and manufacturing high performance, small UAS tasked to gather scientific data.

Their flagship UAV, ***Tempest***, was developed, in part, to support the atmospheric scientific researchers at the University of Colorado who required a robust, durable UAV capable of high altitude missions at the edge of space. NASA deployed a ***Tempest*** to study and map subterranean wild fires in the Great Dismal Swamp located in southern Virginia. GEM Systems selected the ***Tempest*** as their preferred UAV platform for their **GEM Monarch Magnetic Gradiometer.**

Contact: Skip Miller, CEO
tel: (303) 990 -79001-720-608-1827
e-mail: info@uasusa.com
location: Longmont, CO
website: www.uasusa.com
AS Operated: a) Tempest
b) Recon
c) V-tail (in development)
Sensors: a) visible light camera
b) near infrared
c) thermal infrared
d) multi-spectral
e) magnetometer

The company also offers the ***Recon*** UAS and is presently developing a V-tail UAS. In addition, the company provides UAS design and engineering services along with customized UAS manufacturing services.

To learn more, visit: www.uasusa.com

Dear Reader –

The world of small UAS is expanding at a rapid pace. Innovative new approaches to making productive use of these devices are being developed and tested all over the globe. Drones will change how we think about and do the business of exploring for resources, characterizing the environment, and measuring the engineering properties of soil and rock. *Will you become a "drone head"? Are you one already?*

I am seeking news about drone relevant technology or drone services or, perhaps, the business of applying drones for geological and other "geo-"investigations. I also invite you to send along your comments and suggestions. My goal is to convey timely and relevant information about drones and their use for geological and geospatial mapping.

If you wish the readers of ***FastTIMES*** to know what you are "droning on" about, perhaps as a way of attracting the notice of a potential customer, take a few moments to email to me the information that you wish to have included in the next edition of the **geoDRONE Report.**

Thank you for reading. I look forward to hearing from you.

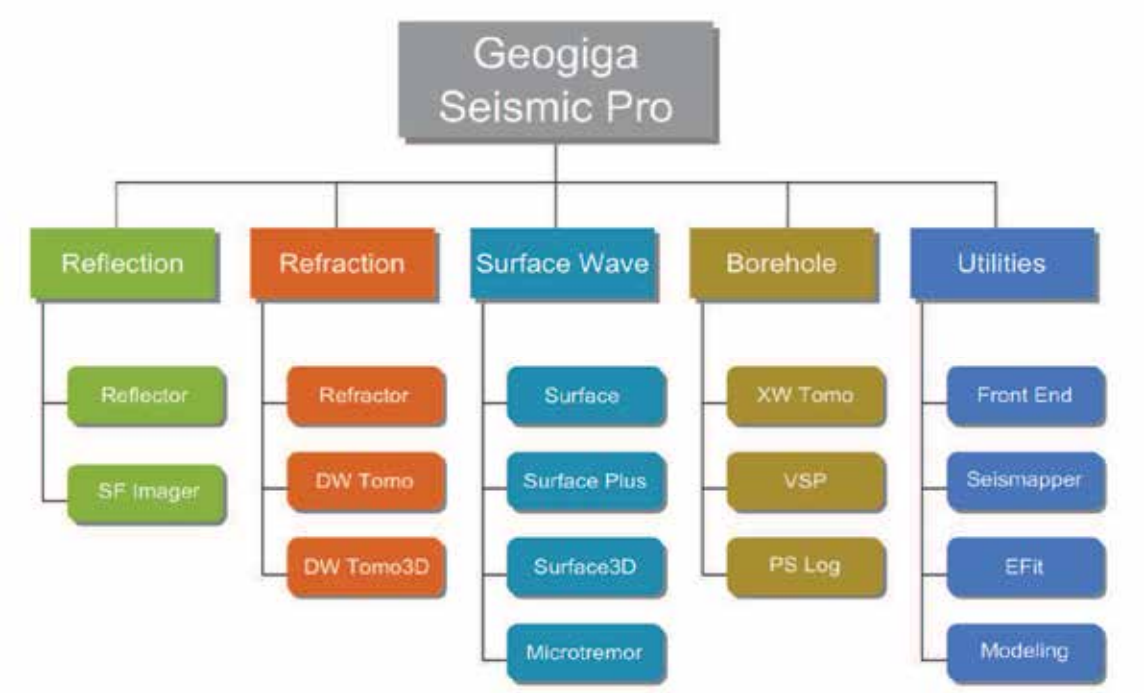
Ron Bell

rbell@igsdenver.com.

INDUSTRY NEWS

Geogiga Technology Corp. will release *Seismic Pro* 8.1 and *RTomo* 6.0 during SAGEEP 2016.

Geogiga Seismic Pro is a complete seismic data processing and interpretation software package adapted to near-surface geophysics. It contains 16 standalone applications handling the full range of seismic survey methods from Reflection, Refraction, and Surface Wave to Borehole Seismic. There are also Utilities for wavefield modeling, velocity model plotting, and much more.



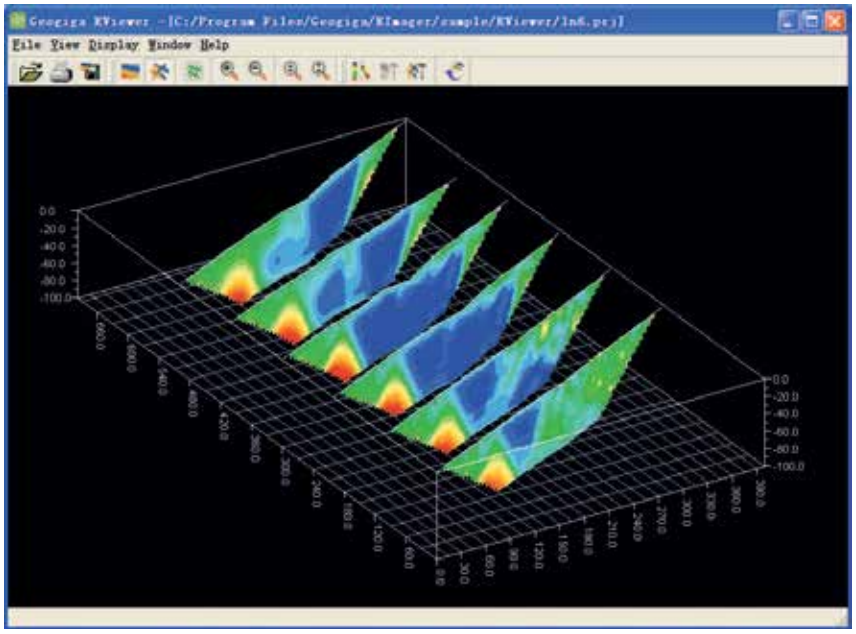
In *Seismic Pro* version 8.1, the following new features have been added:

- Data Format – Support GPR data formats.
- Elevation Input – Automatically sort coordinates and remove duplicate points.
- File Integration – Allow repeated coordinates.
- Batch Commands – Extract traces in batch in *Front End*.
- Initial Model – Improve the automatic initial model building for the dispersion curve inversion in Surface and Surface Plus.
- TX Curves – Enable merging TX curves in *DW Tomo*.
- Ray Coverage – Trim velocity model based on the ray coverage in *DW Tomo3D*.
- Friction Angle – Calculate the friction angles in *PS Log*.
- Two-way Traveltime – Output upgoing and downgoing waves in two-way traveltimes in *VSP*.
- Section Display – Plot well locations on a color section.

There are also minor updates and bug fixes on *Seismic Pro* 8.1. To read the release notes, go to www.geogiga.com.

Geogiga RImager is a 2D resistivity and IP data processing and interpretation software package. It includes two applications:

- *RTomo* – Resistivity and IP Tomography Software. It supports Wenner, Dipole Dipole, Pole Dipole, Pole Pole, Schlumberger, and other general arrays. The accurate topographic correction and robust tomography are applied.
- *RViewer* – Resistivity and IP Data Mapping Software. It plots resistivity and IP data in 2D section and 3D fence with colors, contours, and editable lithologic symbols. The adjacent data sections are automatically joined.



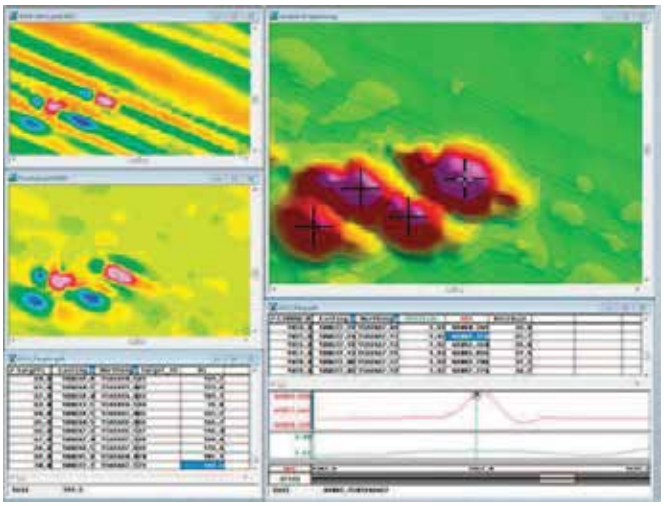
Some of the most important updates in *RImager* version 6.0 are listed as follows:

- Data Format – Fully support third-party data formats.
- IP data – Handle Polarizability (ŋ), Chargeability (m), Percent Frequency Effect (PFE), Phase Angle (Φ) , and Metal Factor (MF).
- Color Section – Enable reversing color section and color map; select contours to be plotted.
- Well Locations – Plot well locations on a color section.
- Curves – Change the foreground and background colors; define the type of tick mark for axis annotations.

To find out more about updates on *RImager* 6.0, visit us at booth 32 in Denver.

Geosoft previews new modelling and analysis capabilities in UXO Marine

Geosoft will preview new modelling and analysis capabilities in UXO Marine, a specialized geophysical software solution for underwater site investigations, at the Oceanology International 2016 and SAGEEP 2016 conferences being held in March. The enhancements are part of a major software update that will be released in Spring 2016.



Building on UXO Marine's existing capabilities for magnetic data processing, analysis and visualization the update will include tools that make it easier and more efficient to process data from large gradient sensor arrays, and model targets from magnetic data.

Highlights in the upcoming release include:

- Improved, automated batch modelling of magnetic data that supports the sparse data commonly seen in many marine magnetic and gradiometer surveys – including output of magnetic moment;
- Expanded tools for working with data from gradient sensor arrays that accommodate any number of sensors and configurations;
- The ability to calculate the Analytical Signal directly from measured vertical magnetic gradients in surveys where magnetic gradient measurements are dense enough to be gridded;
- An interactive "Add Target" tool to automatically find the closest peak to the picked location when picking targets from profile data in the database; and
- Additional lag and offset tools to correct the path or location of your survey data.

With the new features, UXO Marine will provide a more comprehensive workflow for marine geophysics and address industry requirements for tools to rapidly and reliably process, analyze and map high volumes of magnetic data for accurate target detection within subsea environments.

About UXO Marine

International seabed and Unexploded Ordnance (UXO) survey companies and consultants utilize UXO Marine to effectively detect and classify cables, pipelines and unexploded ordnance in underwater environments. Available as an extension to Geosoft's Oasis montaj software, UXO Marine provides a comprehensive solution for processing and visualizing magnetic data for marine surveys. To find out more about the capabilities of UXO Marine, visit http://www.geosoft.com/uxo-marine.

About Geosoft Near Surface Solutions

Geosoft provides market-leading technology for the detection and classification of unexploded ordnance (UXO) and marine geophysics. Geosoft software solutions help surveyors to remove doubt in UXO investigations and manage large-scale land and marine UXO projects more cost effectively. The company's Near Surface solutions team is focused on serving the business and technical needs of clients within the UXO, environmental and marine industries.
Visit www.geosoft.com.

COMING EVENTS AND ANNOUNCEMENTS

Pre-Registration Ends March 4, 2016

MARCH 20-24

Marriott City Center I Downtown Denver

www.EEGS.org/Annual Meeting/SAGEEP 2016

Register Now and Assure Attendance at this Important Educational Symposium:

- Agricultural Geophysics
- Airborne Geophysics
- Archaeological Geophysics
- Engineering Geophysics
- Geophysics and Geologic Hazards
- Hydrogeophysics
- Geophysics for Water Resources Critical Zone Geophysics
- Borehole Geophysics
- Geophysics for Contaminant and Site Remediation
- Geophysics in the Oilfield
- Highway Geophysics
- Integrated Near Surface
- Mining and Reclamation
- Transportation and Infrastructure Geophysics
- UXO and UXO Sensor Technology
- Drones in Geophysics
- Electromagnetics and Magnetotellurics
- GPR and EMI in Complex Environments
- Gravity & Magnetics
- HVSR and Passive Seismology
- Near Surface Data Analysis
- Novel Environmental/NS Geophysics Methods
- Geophysics Case Histories
- Surface Waves/Shallow Seismic
- Surface-wave Seismology for Engineering and Environmental Geophysics
- Resistivity/Induced Polarization/Self-Potential Methods and Applications
- Shallow Marine and Underwater Geophysics

Short Courses Sunday, March 20 (Full Day)

SC-1: **geoDRONEology**
Presenters: Ronald S. Bell, Aerobotic Geophysical Systems, LLC; Rene A. Perez, PG, CHG, Senior Consultant, Hydrogeology, earthforensics, inc.

SC-2: **Ground Penetrating Radar - Principles, Practices and Processing**
Presenter: Greg Johnston, Sensors & Software, Inc.

Short Courses Thursday, March 24 (Full Day)

SC-3: **Satellite InSAR Data: Surface Deformation Monitoring from Space**
Presenter: Alessandro Ferretti (special EAGE-sponsored EET course)

W-1: **Summit on Dams and Levees**
Presenters: William Doll, Tetratech; Phil Sirles, Olson Engineering Mike Powers, U. S. Geological Survey; Craig Hickey, University of Mississippi; Mark Dunscomb, Schnabel Engineering; Justin Rittgers, Colo. School of Mines; Todd Roberts, Roctest, Ltd.; Tomio Inazaki Public Works Research Institute (Japan); Nate Snorteland, U.S. Army Corps of Engineers; Juan Lorenzo, Louisiana State University; Gianfranco Morelli, Geostudi Astier (Italy); Richard Lee, Gannett Fleming; Koichi Hayashi, Geometrics; Ernst Niederleithinger, Bundesanstalt für Materialforschung und –prüfung

COMING EVENTS AND ANNOUNCEMENTS

Environmental and Engineering Geophysical Society

Announcing…..

SAGEEP 2016 Short Courses/Workshops

Registration information available soon! Access the SAGEEP website for rates and online registration links.

Sunday, March 20, 2016

SC-1: geoDRONEology© 2015 Aerobotic Geophysical Systems, LLC **A ONE DAY SHORT COURSE ON INTEGRATING DRONES INTO THE GEOSCIENTIFIC AND ENGINEERING WORKFLOW**

Presenters: Ronald S. Bell, Senior Geophysicist, President, Aerobotic Geophysical Systems, LLC; Rene A. Perez, PG, CHG, Senior Consultant, Hydrogeology, earthforensics, inc.

Multi-rotor and fixed-wing autonomous robotic aircraft, commonly known as "drones", are the latest technical innovation being applied to the acquisition of geospatial and geoscientific data for asset management, geological investigations, and environmental monitoring. This short course will provide you with up-to-date information on how to begin using small unmanned aircraft systems (sUAS) equipped with visible light and infrared cameras for surface investigations and magnetometers for subsurface site characterization. A strong emphasis is placed on the practical implementation of drones for photogrammetry, infrared and spectral imaging, and magnetometry through the use of numerous case histories. Recent changes in the rapidly evolving regulatory framework governing sUAS including the recommended best practices for legally operating drones for profit will be reviewed.
There will be a "wrap up discussion" on the several issues of concern including but not limited to a) the implementation of detect and avoid technologies, b) beyond line of site operations, c) night time flights, and d) drone swarms.

SC-2: GROUND PENTETRATING RADAR - PRINCIPALS, PRACTICES AND PROCESSING
Presenter: Greg Johnston, Sensors & Software, Inc.

Ground Penetrating Radar (GPR) is a non-invasive subsurface exploration technique that has found widespread application in areas including near-surface geology (<100 meters), geotechnical and environmental surveys, mine safety, forensics, archaeology, utility location, concrete inspection, snow thickness measurements and glaciology. This one day course will introduce the principles of GPR and GPR instrumentation, discuss survey design, provide hands-on data acquisition with a GPR system and explore data interpretation (including common pitfalls), data processing and data visualization in 2D and 3D. The course also includes case studies of common and not-so-common applications of the

SAGEEP 2016 Short Courses/Workshops - continued

technology. No prerequisites required. Students will receive printed course notes and a memory stick with a PDF copy of a GPR textbook written by Dr. Peter Annan, the CEO and founder of Sensors & Software. Attendees need to come prepared to work for 2-3 hours outside and, if interested, bring a PC-based laptop for the data processing portion of the course. The laptop should have GoogleEarth installed, if possible.

THURSDAY, March 24, 2016

SC-3: SUMMIT ON DAMS AND LEVEES
Presenters: William Doll, Tetratech; Phil Sirles, Olson Engineering

It is now widely recognized that the infrastructure in the US is in poor condition, and this is but one example of a larger global problem for public safety. Dams and levees, often constructed in an era of less stringent design and construction requirements, are among the infrastructure elements that are of great concern; particularly, as populations increase and relocate in proximity to formerly remote dam and/or levee structures. Geophysics offers many tools that can be used for large-scale assessment and internal imaging, as well as more localized subsurface material characterization of problem areas. Many geophysical and advanced monitoring methods have been developed and deployed and in countries throughout the world.

This forum on dams and levees is designed to bring together geophysicists from many countries to a common venue to share knowledge and experience, as well as discuss the future needs that our industry can provide for addressing this critical problem. The forum includes speakers from leaders in industry, government, and commercial application of state-of-the-practice methods and advancements to stat-of the-art for imaging and monitoring small and large structures with remote/satellite, heliborne, driven, and handheld instruments, which can be deployed once or installed for monitoring these structures.

SC-4: SATELLITE INSAR DATA: SURFACE DEFORMATION MONITORING FROM SPACE
Presenter: Alessandro Ferretti, TeleRilevamento Europa Milan, Italy (special EAGE-sponsored EET course)

Satellite radar data for surface deformation monitoring are gaining increasing attention, and not only within the oil and gas community. They provide a powerful tool for remotely measuring extremely small surface displacements over large areas and long periods of time, without requiring the installation of in-situ equipment. However, apart from remote sensing and radar specialists, only a relatively small number of geoscientists and engineers understand how a radar sensor orbiting the Earth at about 7 km/s from 700km above the Earth's surface can actually measure ground displacements of a fraction of a centimeter.

This course provides a step-by-step introduction to satellite radar sensors, SAR imagery, SAR interferometry and advanced InSAR techniques. Rather than a tutorial for remote sensing specialists, the course starts from very basic concepts and explain in plain language the most important ideas related to

SAGEEP 2016 Short Courses/Workshops - continued

SAR data processing and why geoscientists and engineers should take a vested interest in this new information source.

Instead of providing a thorough analysis of InSAR algorithms, the main aim of the course is to diffuse the news about the potential impact of InSAR results on many real-life applications, highlighting where and when they can provide effective solutions. Participants will learn that InSAR is not only an information source for research and development activities, but also a reliable tool that can be applied successfully to many different applications, spanning from sinkhole detection to reservoir optimization.

Special attention will be paid to oil and gas applications where surface deformation data can provide valuable constraints on reservoir dynamics, enabling time lapse monitoring of volumetric strains at depth. Volume changes in the reservoir induced by fluid extraction and injection can induce both subsidence and uplift. Stress changes may then trigger the reactivation of faults and threaten well integrity. Depending on the depth of the reservoir and the characteristics of the cap rock, deformation may also be detectable at the surface.

COMING EVENTS AND ANNOUNCEMENTS

SECOND ANNOUNCEMENT FOR THE

International School "GEOPHYSICS AND REMOTE SENSING FOR ARCHAEOLOGY"

Pompei, 9-13 May 2016

The School aims at giving the opportunity to scholars, PhD students, researchers and specialists in Geophysics, Remote Sensing and Archaeology to deepen their knowledge and expertise with geophysical and remote sensing techniques for archaeology and cultural heritage documentation and management.

The school consists of **lectures** and on-field **practical work** at the prestigious site of Pompei. The course will provide the basics about data collection, processing and interpretation for geophysical techniques (GPR, magnetic, ERT), passive and active remote sensing and low-cost approaches based on the use of UAV.

The school is organized by two Institutes of the Consiglio Nazionale delle Ricerche, i.e., CNR-IBAM and CNR-IREA, and Soprintendenza Speciale Beni Archeologici Pompei, Ercolano e Stabia.

The course will be held from Monday May 9 to Friday May 13, 2016, and we will foresee lectures/practical work on morning and afternoon (8 hours) for the first four days and only the morning for the last day.

COMING EVENTS AND ANNOUNCEMENTS

Preliminary programme

- Sunday, 8/5: Arrival and icebreaking party
- Monday, 9/5: Lectures: Introduction and description of the course; Remote sensing and UAV for archaeology; Magnetic and Electrical Resistivity Tomography for Archaeology. Ground Penetrating Radar (GPR).
- Tuesday, 10/5: Lectures: Non-invasive diagnostics of monuments and artifacts; Integrated approaches and strategies for archaeology and cultural heritage. Data Acquisition with GPR on the earth and on a wall, ERT, Magnetic, and IR camera. Part 1.
- Wednesday ,11/5: Data Acquisition with GPR on the earth and on a wall, ERT, Magnetic, and IR camera. Part 2.
- Thursday, 12/5: Tutorial regarding the processing and integration of the collected data (magnetic, ERT, GPR and IR) . Processing of UAV data previously gathered in the area of Pompeii.
- Friday, 13/5 (only the morning): Presentation of the data processing results (in charge of the students), Wrap-up and conclusions.

Chairs

Francesco Soldovieri IREA-CNR, Nicola Masini IBAM-CNR, Raffaele Persico, IBAM-CNR

Lecturers

- Giovanni Leucci, Nicola Masini and Raffele Persico CNR-IBAM
- Francesco Soldovieri, Ilaria Catapano CNR/IREA
- Rosa Lasaponara, Enzo Rizzo CNR-IMAA
- Bruno De Nigris SS-PES

Tutors (to be finalized)

- Antonio Pecci, Maria Sileo CNR/IBAM
- Gianluca Gennarelli CNR/IREA

Administrative/Economic Organization

- Generoso Sole CNR/IREA

Venue

The location of the school is the archaeological area of Pompeii, 15 km south of Naples (Italy). Pompeii can be easily reached by car or train. The closest international airport is Naples. The event will take place in the Auditorium inside the archaeological area. The on-field activities will be carried out at the archaeological site of Pompeii.

Registration fee and Participation

The registration fee for the participation is 300 Euros (VAT excluded).

The fee includes: lecture material, entrance and guided visit in the archaeological area of Pompeii, welcome party, social dinner.

The number of admissible students is about 30.

For the participation, please express your interest by sending a CV to archeoschool@irea.cnr.it . The participant selection will be done according to the CV and order of arrival of the request.

Payment Method only by Wire Transfer

NAME of BANK: **BANCA NAZIONALE DEL LAVORO (BNL gruppo BNP Paribas)**

ACCOUNT HOLDER: **Consiglio Nazionale delle Ricerche, "Incassi giornalieri da altre dipendenze"**

SWIFT/BIC: **BNLIITRR**

IBAN: **IT57S0100503392000000218155**

REF: **CDR 072, *NAME SURNAME*, Registration for GEOPHYSICS AND REMOTE SENSING FOR ARCHAEOLOGY SCHOOL**

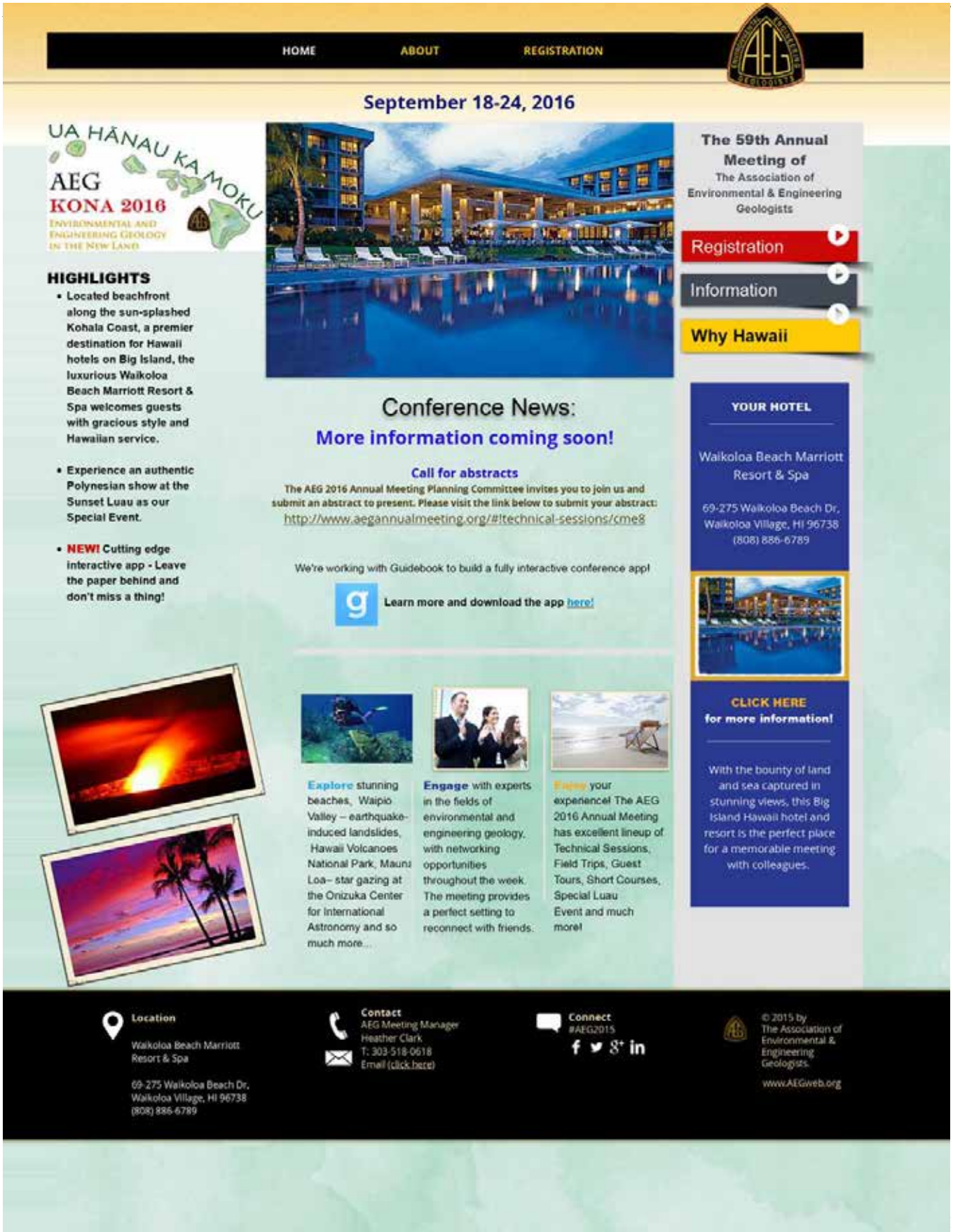
After sending your registration payment by bank wire transfer, scan the bank receipt and attach the PDF file in an email to amministrazione@irea.cnr.it and archeoschool@irea.cnr.it

For any information request and expression of interest to attend, please contact us at the address archeoschool@irea.cnr.it

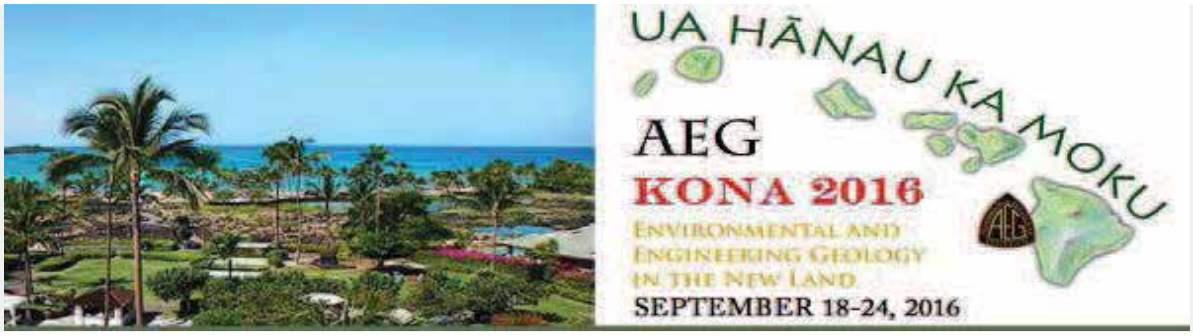
COMING EVENTS AND ANNOUNCEMENTS

email: staff@rmag.org | phone: 303.573.8621 | fax: 303.476.2241 | web: www.rmag.org
910 16th Street #1214, Denver, CO, 80202 | follow: @rmagdenver

COMING EVENTS AND ANNOUNCEMENTS



COMING EVENTS AND ANNOUNCEMENTS



Call for Abstracts

The AEG 2016 Annual Meeting Planning Committee invite you to join us by submitting an abstract to present in Kona, Hawaii.

Abstract submission deadline is May 1, 2016.

VERY IMPORTANT: Please be sure to read the instructions prior to submitting your abstract.

Username: AEG
Password: Kona2016
(Note: The Username/Password are *not* your member Username/Password)

Submit your abstract

Below is a listing of planned Symposia and proposed Technical Sessions:

Technical Sessions

- Dams: Repair and Removal Projects
- Transportation and Infrastructure Project: Rebuilding our Pipelines, Tunnels, Bridges, Highways and Railways
- Slope Movements: Landslides and Rockfall Hazard Remediation and Mitigation Projects
- Geologic Hazards, Communication and Mitigation of Volcanic, Seismic, Liquefaction and Tsunami Hazards
- Geophysics and Remote Sensing in Engineering Geology: Case Studies and Advances using geophysics, drones and satellites
- Subsidence/Sinkhole Hazards in Karst and other Terrains
- Climate Change and Engineering Geology: Coast Line effects and Mitigation Projects
- Habitat Restoration and Improvement Projects: Stream Remediation, Culvert Replacement, Hatchery Reconstructions
- Groundwater and Hydrogeologic Projects

- Environmental Remediation Projects
- Rock Mechanics
- Materials Test and Ground Improvement
- Careers in Geosciences
- Lifeline Engineering and Special Tech
- Unique Engineering Geology Projects
- Volcanic and Seismic Hazards of the Circum-Pacific Region

Invited Symposia

- Rock Engineering-Rock Mechanics Symposium
- Engineering Geology for Tunnels and Underground Construction
- Reaching the Last Mile: Our Responsibility to effectively Communicate to those in Harms Way what Geohazards they Face and Implement Disaster Mitigation Strategies
- Environmental Impacts and Cleanup for Military Bases
- Application of Geophysics to Geotechnical Investigations
- Coastal and Harbor Projects
- Archeology and Engineering Geology
- Dam Safety Projects
- Landslide Symposia

Full Annual Meeting details can be found at www.aegannualmeeting.org.
We are looking forward to receiving your Abstract!

Have Questions?

Please contact Heather Clark by email or call 303-518-0618 for show questions.

If you need help with registration, please contact the AEG office from 8 am to 5 pm Eastern at 844-331-7867 (toll free) or use our Contact Form.

About AEG

The Association of Environmental & Engineering Geologists (AEG) contributes to its members' professional success and the public welfare by providing leadership, advocacy, and applied research in environmental and engineering geology.

Environmental and Engineering Geophysical Society

2016 Individual Membership Application

Renew or Join Online at www.EEGS.org

Individual Membership Categories

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

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

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

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

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Individual	$90	$130

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

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Retired *(Must be Approved by EEGS Board of Directors)*	$50	$130

Introductory Members If you have not been a member of EEGS before, we offer a reduced rate (electronic JEEG option) for new members to enjoy all the benefits of individual membership (except vote or hold office) for one year.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Introductory	$50	$130

Lifetime Members New! Support EEGS, receive benefits on an ongoing basis and never renew again! Members of this category enjoy all the benefits of Individual membership.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Lifetime Member	$995	$995

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

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Developing World *(List of qualifying countries next page)*	$50	$130

Student Members Students represent EEGS' future and we offer complimentary membership subsidized by Corporate Student Sponsor Members and those who sponsor students. Student members enjoy all the benefits of individual membership (except to vote or hold office). Available for all students in an accredited university up to one year post-graduation. Please submit a copy of your student ID and indicate your projected date of graduation: ___ /____ (Month/Year). New! Students in year two beyond graduation are offered a special rate for 1 year.

Category	Electronic *JEEG* Available Online	Printed *JEEG* Mailed to You
Student up to 1 Year Post Graduation	$ 0	$90
Student - Year Two Post Graduation **(Grad Date: Mo/Yr.: ___/___)**	$50	$90

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 $130.00 if you would like the printed, quarterly *Journal of Environmental & Engineering Geophysics* (*JEEG*) mailed to you). To receive a printed *JEEG* as a benefit of membership, select the Developing World Printed membership category on the membership application form.

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

1720 South Bellaire Street | Suite 110 | Denver, CO 80222-4303
(p) 001.1.303.531.7517 | (f) 001.1.303.820.3844 | staff@eegs.org | www.eegs.org

Environmental and Engineering Geophysical Society

2016 EEGS Membership Application

Renew or Join Online at www.EEGS.org

CONTACT INFORMATION

Salutation | First Name | Middle Initial | Last Name

Company/Organization | Title

Street Address | City | State/Province | Zip Code | Country

Direct Phone | Mobile Phone | Fax

Email | Website

ABOUT ME: INTERESTS & EXPERTISE

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

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

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Environmental and Engineering Geophysical Society

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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: $ _____

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Corporate Contribution Total: $ _____

Foundation Total: $ _____

PAYMENT INFORMATION

☐ Check/Money Order ☐ VISA ☐ MasterCard

☐ AmEx ☐ Discover

Subtotals

Membership: $ _____

Student Sponsorship: $ _____

Foundation Contributions: $ _____

Grand Total: $ _____

Card Number **Exp. Date** **CVV #:**

Name on Card

Signature

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

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

Return this form with payment to: EEGS, 1720 South Bellaire Street, Suite 110, Denver, CO 80222 USA

Credit card payments can be faxed to EEGS at 001.1.303.820.3844

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

QUESTIONS? CALL 001.1.303.531.7517

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

Category	2016 Electronic JEEG	2016 Basic Rate (print JEEG)	2016 Basic + Web Ad Package
Corporate Student Sponsor *Includes one (1) individual membership, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES and Sponsorship of 10 student memberships*	$310	$340	$840
Corporate Donor *Includes one (1) individual EEGS membership, one (1) full conference registration to SAGEEP, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES*	$660	$690	$1190
Corporate Associate *Includes two (2) individual EEGS memberships, an exhibit booth and registration at SAGEEP, the ability to insert marketing materials in the SAGEEP delegate packets, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES*	$2410	$2440	$2940
Corporate Benefactor *Includes two (2) individual memberships to EEGS, two (2) exhibit booths and registrations at SAGEEP, the ability to insert marketing materials in the SAGEEP delegate packets, a company profile and linked logo on the EEGS Corporate Members web page, a company profile in FastTIMES and the SAGEEP program, recognition at SAGEEP and a 10% discount on advertising in JEEG and FastTIMES*	$4010	$4040	$4540
Website Advertising	Purchase Separately		
One (1) Pop-Under, scrolling marquee style ad with tag line on Home page, logo linked to Company web site	$600/yr.	$600/yr.	Package Rates include both website ad locations
One (1) Button sized ad, linked logo, right rail on each web page	$250/yr.	$250/yr.	

Environmental and Engineering Geophysical Society **2016 EEGS Corporate Membership Application**	Renew or Join Online at www.EEGS.org

CONTACT INFORMATION

Salutation | First Name | Middle Initial | Last Name

Company/Organization | Title

Street Address | City | State/Province | Zip Code | Country

Direct Phone | Mobile Phone | Fax

Email | Website

ABOUT ME: INTERESTS & EXPERTISE

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

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☐ Geophysical Contractor	☐ Geotechnical	☐ Gravity	☐ AWWA	☐ Student
☐ Equipment Manufacturer	☐ Geo. Infrastructure	☐ Ground Penetrating Radar	☐ AGU	
☐ Software Manufacturer	☐ Groundwater	☐ Magnetics	☐ EAGE	
☐ Research/Academia	☐ Hazardous Waste	☐ Marine Geophysics	☐ EERI	
☐ Government Agency	☐ Humanitarian Geo.	☐ Remote Sensing	☐ GeoInstitute	
☐ Other	☐ Mining	☐ Seismic	☐ GSA	
	☐ Shallow Oil & Gas	☐ Other	☐ NGWA	
	☐ UXO		☐ NSG	
	☐ Aerial Geophysics		☐ SEG	
	☐ Other		☐ SSA	
			☐ SPWLA	

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Environmental and Engineering Geophysical Society	Renew or Join Online at www.EEGS.org
2016 EEGS Corporate Membership Application	

FOUNDATION CONTRIBUTIONS

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Corporate Contribution Total: $ _____

Foundation Total: $ _____

PAYMENT INFORMATION

☐ **Check/Money Order** ☐ **VISA** ☐ **MasterCard**

☐ **AmEx** ☐ **Discover**

Subtotals

Membership: $ _____

Student Sponsorship: $ _____

Foundation Contributions: $ _____

Grand Total: $ _____

Card Number **Exp. Date**

Name on Card **CVV#**

Signature

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

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

Return this form with payment to: EEGS, 1720 South Bellaire Street, Suite 110, Denver, CO 80222 USA

Credit card payments can be faxed to EEGS at 001.1.303.820.3844

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QUESTIONS? CALL 001.1.303.531.7517

EEGS CORPORATE MEMBERS

Corporate Benefactor

Your Company Here!

Corporate Associate

Advanced Geosciences, Inc.
www.agiusa.com

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

CGG Canada Services Ltd.
www.cgg.com

Exploration Instruments LLC
www.expins.com

Geogiga Technology Corporation
www.geogiga.com

Geomar Software Inc.
www.geomar.com

Geometrics, Inc.
www.geometrics.com

Geonics Ltd.
www.geonics.com

Geophysical Survey Systems, Inc.
www.geophysical.com

Geosoft Inc.
www.geosoft.com

Geostuff
www.geostuff.com

GeoVista Ltd.
www.geovista.co.uk

Interpex Ltd.
www.interpex.com

Mount Sopris Instruments
www.mountsopris.com

Ontash & Ermac, Inc.
www.ontash.com

Petros Eikon Incorporated
www.petroseikon.com

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

Sensors & Software Inc.
www.sensoft.ca

Vista Clara Inc.
www.vista-clara.com

Zonge international, Inc
www.zonge.com

Corporate Donor

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

Northwest Geophysics
www.northwestgeophysics.com

Quality Geosciences Company, LLC
www.quality-geophysics.com

Spotlight Geophysical Services
www.spotlightgeo.com

Corporate Student Sponsor

Geo Solutions Limited, Inc.
www.geosolutionsltd.com

Spotlight Geophysical Services
www.spotlightgeo.com

EEGS STORE

Environmental and Engineering Geophysical Society

2016 Publications Order Form

ALL ORDERS ARE PREPAY

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

Sold To:

Name: _____

Company: _____

Address: _____

City/State/Zip: _____

Country: _____ Phone: _____

E-mail: _____ Fax: _____

Ship To (If different from "Sold To":

Name: _____

Company: _____

Address: _____

City/State/Zip: _____

Country: _____ Phone: _____

E-mail: _____ Fax: _____

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

SAGEEP PROCEEDINGS

			Member	Non-Member
		2015 (CD-ROM)	$75	$100
	0036	2014 (CD-ROM)	$75	$100
	0034	2013 (CD-ROM)	$75	$100
	0033	2012 (CD-ROM)	$75	$100
	0030	2011 (CD-ROM)	$75	$100
	0029	2010 (CD-ROM)	$75	$100
	0026	2009 (CD-ROM)	$75	$100
	0025	2008 (CD-ROM)	$75	$100

			Member	Non-Member
	0023	2007 (CD-ROM)	$75	$100
	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—PROEEDINGS ISSUES ORDERED		

SAGEEP Short Course Handbooks

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

Miscellaneous Items

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

MISCELLANEOUS ITEMS CONTINUED ON NEXT PAGE...

EEGS STORE

Publications Order Form (Page Two)

		EEGS T-shirts in two colors (circle color/size): Gray: L, M & XLarge I White: L & XL	$10	$10
		EEGS Lapel Pin	$3	$3
		SUBTOTAL—SHORT COURSE/MISC. ORDERED ITEMS:		

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

Qt.	Year	Issue
	1995	JEEG 0/1 - July
		JEEG 0/2 - January
	1996	JEEG 1/1 - April
		JEEG 1/2 - August
		JEEG 1/3 - December
	1998	JEEG 3/2 - June
		JEEG 3/3 - September
		JEEG 3/4 - December
	1999	JEEG 4/1 – March
		JEEG 4/2 - June
		JEEG 4/3 - September
		JEEG 4/4 - December
	2000	JEEG 5/3 - September
		JEEG 5/4 - December
	2001	JEEG 6/1 - March
		JEEG 6/3 - September
		JEEG 6/4 - December
	2003	JEEG 8/1- March
		JEEG 8/2 - June
		JEEG 8/3 - September
		JEEG 8/4 - December
	2004	JEEG 9/1- March
		JEEG 9/2 - June

Qt.	Year	Issue
	2004	JEEG 9/3 - September
		JEEG 9/4 - December
	2005	JEEG 10/1 - March
		JEEG 10/2 - June
		JEEG 10/3 - September
		JEEG 10/4 - December
	2006	JEEG 11/1 - March
		JEEG 11/2 - June
		JEEG 11/3 - September
		JEEG 11/4 - December
	2007	JEEG 12/1 - March
		JEEG 12/2 - June
		JEEG 12/3 - September
		JEEG 12/4 - December
	2008	JEEG 13/1 - March
		JEEG 13/2 - June
		JEEG 13/3 - September
		JEEG 13/4 - December
	2009	JEEG 14/1 - March
		JEEG 14/2 - June
		JEEG 14/3 - September
		JEEG 14/4 - December
	2010	JEEG 15/1 - March

Qt.	Year	Issue
	2010	JEEG 15/2 - June
		JEEG 15/3 - September
		JEEG 15/4 - December
	2011	JEEG 16/1 - March
		JEEG 16/2 - June
		JEEG 16/3 - September
		JEEG 16/4 - December
	2012	JEEG 17/1 - March
		JEEG 17/2 - June
		JEEG 17/3 - September
		JEEG 17/4 - December
	2013	JEEG 18/1 - March
		JEEG 18/2 - June
		JEEG 18/3 - September
		JEEG 18/4 - December
	2014	JEEG 19/1 - March
		JEEG 19/2 - June
		JEEG 19/3 - September
		JEEG 19/4 - December
	2015	JEEG 20/1 - March
		JEEG 20/2 - June
		JEEG 20/3 - September
		JEEG 20/4 - December

SUBTOTAL—JEEG ISSUES ORDERED

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

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

Payment Information:

☐ Check #: _____ (Payable to EEGS)

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

☐ Visa ☐ MasterCard ☐ AMEX ☐ Discover

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

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

Cardholder Name (Print) _____
Signature: _____

EEGS STORE

Environmental and Engineering Geophysical Society

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

2016 Merchandise Order Form

ALL ORDERS ARE PREPAY

Sold To:

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

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

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

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

Merchandise Order Information:

ITEM DESCRIPTION	QTY	EEGS T-SHIRT COLOR WHITE OR GRAY/Size	MEMBER RATE	NON-MEMBER RATE	TOTAL
EEGS Mug			$10	$10	
SAGEEP 2015 T-shirt (Medium)			$18	$18	
SAGEEP 2015 T-shirt (Large)			$18	$18	
***SAGEEP 2015** T-shirt (XLarge)*			$18	$18	
***SAGEEP 2015** T-shirt (XXLarge)*			$18	$18	
EEGS T-shirt Gray: L, M & XLarge			$10	$10	
EEGS T-shirt White: L & XL			$10	$10	
EGS Lapel Pin			$3	$3	

SUBTOTAL – MERCHANDISE ORDERED:

TOTAL ORDER:

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

GRAND TOTAL:

Payment Information:

☐ Check #: _____ (Payable to EEGS)

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

☐ Visa ☐ MasterCard ☐ AMEX ☐ Discover

Card Number: _____CVV# ____ Cardholder Name (Print): _____

Exp. Date: _____ Signature: _____

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

THANK YOU FOR YOUR ORDER!

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