

# PROCEEDINGS OF SPIE

## ***Detection and Sensing of Mines, Explosive Objects, and Obscured Targets XIII***

**Russell S. Harmon**

**John H. Holloway, Jr.**

**J. Thomas Broach**

*Editors*

**17–20 March 2008**

**Orlando, Florida, USA**

*Sponsored and Published by*  
**SPIE**

**Volume 6953**

Proceedings of SPIE, 0277-786X, v. 6953

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in *Detection and Sensing of Mines, Explosive Objects, and Obscured Targets XIII*, edited by Russell S. Harmon, John H. Holloway, Jr., J. Thomas Broach, Proceedings of SPIE Vol. 6953 (SPIE, Bellingham, WA, 2008) Article CID Number.

ISSN 0277-786X  
ISBN 9780819471444

Published by  
**SPIE**  
P.O. Box 10, Bellingham, Washington 98227-0010 USA  
Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445  
SPIE.org

Copyright © 2008, Society of Photo-Optical Instrumentation Engineers

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at [copyright.com](http://copyright.com). Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/08/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.



[SPIEDigitalLibrary.org](http://SPIEDigitalLibrary.org)

---

**Paper Numbering:** Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon they are published online, and connects the same identifier to all online, print, and electronic versions of the publication. SPIE uses a six-digit CID article numbering system in which:

- The first four digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc.

The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages. Numbers in the index correspond to the last two digits of the six-digit CID number.

# Contents

ix Conference Committee

---

## SESSION 1 ELECTROMAGNETIC INDUCTION SENSING AND DETECTION I

---

- 6953 02 **Study of the influence of the plastic casing on the electromagnetic induction response of a buried landmine [6953-01]**  
Y. Das, Defence Research and Development Canada-Suffield (Canada)
- 6953 03 **Application of the NSMS model to multi-axis time domain EMI data [6953-02]**  
F. Shubitidze, Dartmouth College (USA) and Sky Research, Inc. (USA); B. E. Barrowes, U.S. Army ERDC Cold Regions Research and Engineering Lab. (USA); I. Shamatava, Sky Research, Inc. (USA) and Dartmouth College (USA); J. P. Fernández, Dartmouth College (USA); K. O'Neill, Dartmouth College (USA) and U.S. Army ERDC Cold Regions Research and Engineering Lab. (USA)
- 6953 04 **Performance comparison of frequency domain quadrupole and dipole electromagnetic induction sensors in a landmine detection application [6953-03]**  
E. B. Fails, P. A. Torrione, Duke Univ. (USA); W. R. Scott, Jr., Georgia Institute of Technology (USA); L. M. Collins, Duke Univ. (USA)
- 6953 05 **Combining dipole and mixed model approaches for UXO discrimination [6953-04]**  
F. Shubitidze, Dartmouth College (USA) and Sky Research, Inc. (USA); E. Demidenko, Dartmouth College (USA); B. E. Barrowes, U.S. Army ERDC Cold Regions Research and Engineering Lab. (USA); I. Shamatava, Sky Research, Inc. (USA) and Dartmouth College (USA); J. P. Fernández, Dartmouth College (USA); K. O'Neill, Dartmouth College (USA) and U.S. Army ERDC Cold Regions Research and Engineering Lab. (USA)

---

## SESSION 2 ELECTROMAGNETIC INDUCTION SENSING AND DETECTION II

---

- 6953 06 **High definition impedance imaging for mines and tunnels [6953-05]**  
A. Wexler, P. A. O'Connor, Quantic Electroscan Inc. (Canada); J. McFee, Defence Research and Development Canada-Suffield (Canada)
- 6953 08 **Detection of buried objects using ultra-wideband radar: newly launched mine detection project in South Korea [6953-07]**  
K. Kam, K. Kim, Gwangju Institute of Science and Technology (South Korea)

---

## SESSION 3 SENSING AND DETECTION POTPOURRI

---

- 6953 09 **Substrate-related effects on molecular and atomic emission in LIBS of explosives [6953-09]**  
C. McEnnis, J. B. Spicer, Johns Hopkins Univ. (USA)

- 6953 0B **Electron beam injected into ground generates subsoil x-rays that may deactivate concealed electronics used to trigger explosive devices** [6953-11]  
M. Retsky, Electron Optics Development Co., LLC (USA)
- 6953 0C **Humanitarian IED clearance in Colombia** [6953-12]  
J. M. H. Hendrickx, New Mexico Institute of Mining and Technology (USA); A. Molina, D. Diaz, Univ. Nacional de Colombia (Colombia); M. Grasmueck, Univ. of Miami (USA); H. A. Moreno, New Mexico Institute of Mining and Technology (USA) and Escuela de Ingeniería de Antioquia (Colombia); R. D. Hernández, Escuela de Ingeniería de Antioquia (Colombia)
- 6953 0D **Preliminary experimental validation of a landmine detection system based on localized heating and sensing** [6953-56]  
M. Balsi, La Sapienza Univ. (Italy) and Lab. di Sminamento Umanitario (Italy); M. Corcione, P. Dell'Omoo, La Sapienza Univ. (Italy); S. Esposito, La Sapienza Univ. (Italy) and Lab. di Sminamento Umanitario (Italy); L. Magliocchetti, La Sapienza Univ. (Italy)
- 6953 0E **Achievements and bottlenecks in humanitarian demining EU-funded research: final results from the EC DELVE project** [6953-57]  
H. Sahli, Vrije Univ. Brussel (Belgium); C. Bruschini, CBR Scientific Consulting (Switzerland); L. Van Kempen, Vrije Univ. Brussel (Belgium); R. Schleijpen, E. den Breejen, TNO Defence, Security and Safety (Netherlands)

---

#### **SESSION 4 LITTORAL SENSING AND DETECTION I**

---

- 6953 0H **Enhanced ATR algorithm for high resolution multi-band sonar imagery** [6953-15]  
T. Aridgides, M. Fernández, Lockheed Martin (USA)

---

#### **SESSION 5 LITTORAL SENSING AND DETECTION II**

---

- 6953 0J **Target detection from dual disparate sonar platforms using canonical correlations** [6953-18]  
M. R. Azimi-Sadjadji, J. D. Tucker, Colorado State Univ. (USA)
- 6953 0K **A parameterized statistical sonar image texture model** [6953-19]  
J. T. Cobb, Naval Surface Warfare Ctr. (USA); K. C. Slatton, Univ. of Florida (USA)
- 6953 0L **Gaussian Markov random field modeling of textures in high-frequency synthetic aperture sonar images** [6953-20]  
S. Y. Foo, Florida State Univ. (USA); J. T. Cobb, J. R. Stack, Naval Surface Warfare Ctr. (USA)
- 6953 0M **Underwater UXO detection and discrimination: understanding EMI scattering phenomena in a conducting environment** [6953-21]  
F. Shubitidze, Dartmouth College (USA) and Sky Research, Inc. (USA); B. Barrowes, U.S. Army ERDC Cold Regions Research and Engineering Lab. (USA); I. Shamatava, Dartmouth College (USA) and Sky Research, Inc. (USA); J. P. Fernández, Dartmouth College (USA); K. O'Neill, Dartmouth College (USA) and U.S. Army ERDC Cold Regions Research and Engineering Lab. (USA)

- 6953 0N **TACMSI: a novel multi-look multispectral imager for maritime mine detection** [6953-22]  
C. L. Leonard, C. W. Chan, T. Cottis, M. DeWeert, M. Dichner, B. Farm, D. Kokubun, E. Louchard, R. Noguchi, M. Topping, T. Wong, D. Yoon, BAE Systems (USA)
- 6953 0O **Electrical impedance tomography for underwater detection of buried mines** [6953-23]  
G. Bouchette, S. Gagnon, P. Church, T. Luu, Neptec Design Group (Canada); J. McFee, Defence Research and Development Canada-Suffield (Canada)

---

**SESSION 6    OPTICAL SENSING AND DETECTION**

---

- 6953 0P **UXO detection, characterization, and remediation using intelligent robotic systems**  
[6953-24]  
S. Amer, A. Shirkhodaie, H. Rababaah, Tennessee State Univ. (USA)
- 6953 0Q **Phenomenology of thermal signatures of disturbed and undisturbed soils** [6953-25]  
G. Koenig, Y. Koh, U.S. Army ERDC Cold Regions Research and Engineering Lab. (USA); S. Howington, U.S. Army ERDC Coastal and Hydraulics Lab. (USA); C. Scott, U.S. Army ERDC Cold Regions Research and Engineering Lab. (USA)
- 6953 0R **Spectral methods to detect surface mines** [6953-26]  
E. M. Winter, Technical Research Associates, Inc. (USA); M. Schatten Silvious, U.S. Army RDECOM CERDEC Night Vision & Electronic Sensors Directorate (USA)
- 6953 0S **Exposure effects on the optical properties of building materials** [6953-27]  
S. Lane, J. M. Cathcart, J. T. Harrell, Georgia Institute of Technology (USA)
- 6953 0T **Adaptive spatial sampling schemes for the detection of minefields in hyperspectral imagery** [6953-28]  
A. M. Thomas, J. M. Cathcart, Georgia Institute of Technology (USA)
- 6953 0U **Comparative performance between compressed and uncompressed airborne imagery**  
[6953-29]  
C. Phan, R. Rupp, U.S. Army RDECOM CERDEC NVESD (USA); S. Agarwal, Missouri Univ. of Science and Technology (USA); A. Trang, U.S. Army RDECOM CERDEC NVESD (USA); S. Nair, Missouri Univ. of Science and Technology (USA)
- 6953 0V **Automated determination of scale and orientation of mine field grid** [6953-30]  
A. M. Thomas, J. M. Cathcart, Georgia Institute of Technology (USA)

---

**SESSION 7    ENVIRONMENTAL EFFECTS ON SENSING AND DETECTION**

---

- 6953 0W **Investigation of soil processes on radar signature of landmines** [6953-31]  
D. T. Abrams, Univ. of Puerto Rico at Mayagüez (Puerto Rico) and U.S. Army Engineer Research and Development Ctr. (USA); N. J. Lamie, G. Koh, U.S. Army Engineer Research and Development Ctr. (USA)
- 6953 0X **Radar attenuation in desert soil** [6953-32]  
G. Koh, U.S. Army Engineer Research and Development Ctr. (USA)

- 6953 0Y **Global prediction of thermal soil regimes** [6953-33]  
J. M. H. Hendrickx, New Mexico Institute of Mining and Technology (USA); H. Xie, Univ. of Texas, San Antonio (USA); J. B. J. Harrison, B. Borchers, New Mexico Institute of Mining and Technology (USA); J. Simunek, Univ. of California, Riverside (USA)
- 6953 0Z **Toward a model for predicting magnetic susceptibility of bedrock regolith and soils** [6953-34]  
R. L. van Dam, Michigan State Univ. (USA); J. M. H. Hendrickx, J. B. J. Harrison, New Mexico Institute of Mining and Technology (USA); R. S. Harmon, Army Research Lab. (USA)
- 6953 10 **Improving detection and discrimination of buried metallic objects in magnetic geologic settings by modeling the background soil response** [6953-35]  
L. R. Pasion, Univ. of British Columbia (Canada) and Sky Research, Inc. (Canada); S. D. Billings, Sky Research, Inc. (Canada); D. W. Oldenburg, Univ. of British Columbia (Canada)

---

#### SESSION 8 MULTISYSTEM SENSING

---

- 6953 11 **Hand-held dual-sensor ALIS and its evaluation tests** [6953-36]  
M. Sato, Tohoku Univ. (Japan); K. Takahashi, Tohoku Univ. (Japan) and Federal Institute for Materials Research and Testing (Germany)
- 6953 13 **Estimating object depth using a vertical gradient metal detector** [6953-39]  
J. Marble, I. McMichael, U.S. Army Night Vision & Electronic Sensors Directorate (USA); D. Reidy, BRTRC (USA)
- 6953 14 **On the registration of FLGPR and IR data for a forward-looking landmine detection system and its use in eliminating FLGPR false alarms** [6953-40]  
K. Stone, J. Keller, K. C. Ho, M. Busch, Univ. of Missouri, Columbia (USA); P. D. Gader, Univ. of Florida (USA)
- 6953 15 **Sensor management for landmine detection using correlated sensor observations** [6953-41]  
M. P. Kolba, L. M. Collins, Duke Univ. (USA)

---

#### SESSION 9 EOIR SIGNAL PROCESSING

---

- 6953 16 **FastKRX: a fast approximation for kernel RX anomaly detection** [6953-42]  
S. Tiwari, Migma Systems Inc. (USA); S. Agarwal, Missouri Univ. of Science and Technology (USA); A. Trang, U.S. Army RDECOM CERDEC NVESD (USA)
- 6953 17 **Exploiting "mineness" for scatterable minefield detection** [6953-43]  
A. Trang, U.S. Army RDECOM CERDEC NVESD (USA); S. Agarwal, Missouri Univ. of Science and Technology (USA); T. Broach, T. Smith, U.S. Army RDECOM CERDEC NVESD (USA)
- 6953 18 **HAMD: a software system for surface and buried mine detections** [6953-44]  
B. Ling, M. Liu, U. Venkataraman, Migma Systems, Inc. (USA); A. H. Trang, U.S. Army RDECOM CERDEC NVESD (USA)

- 6953 19 **Application of context-based classifier to hyperspectral imagery for mine detection**  
[6953-45]  
J. Bolton, P. Gader, Univ. of Florida (USA)

---

**SESSION 10 GPR FOR DETECTION AND ALGORITHM FUSION I**

---

- 6953 1B **Application of Markov random fields to landmine detection in ground penetrating radar data** [6953-47]  
P. A. Torrione, L. Collins, Duke Univ. (USA)
- 6953 1C **Landmine detection with ground penetrating radar using discrete hidden Markov models with symbol dependent features** [6953-48]  
H. Frigui, O. Missaoui, Univ. of Louisville (USA); P. Gader, Univ. of Florida (USA)
- 6953 1D **Subspace processing of GPR signals for vehicle-mounted landmine detection system**  
[6953-49]  
K. C. Ho, Univ. of Missouri, Columbia (USA); P. D. Gader, J. N. Wilson, Univ. of Florida (USA);  
H. Frigui, Univ. of Louisville (USA)

---

**SESSION 11 GPR FOR DETECTION AND ALGORITHM FUSION II**

---

- 6953 1E **Use of rank-based decision level fusion in landmine discrimination** [6953-50]  
J. N. Wilson, Univ. of Florida (USA)
- 6953 1F **A generic framework for context-dependent fusion with application to landmine detection**  
[6953-51]  
H. Frigui, Univ. of Louisville (USA); P. D. Gader, Univ. of Florida (USA);  
A. Chamseddine Ben Abdallah, Univ. of Louisville (USA)
- 6953 1G **The generalized SEA and a statistical signal processing approach applied to UXO discrimination** [6953-53]  
I. Shamatava, F. Shubitidze, Sky Research, Inc. (USA) and Dartmouth College (USA);  
B. Barrowes, U.S. Army ERDC Cold Regions Research and Engineering Lab. (USA);  
E. Demidenko, Dartmouth College (USA); J. P. Fernández, Sky Research, Inc. (USA);  
K. O'Neill, Sky Research, Inc. (USA) and U.S. Army ERDC Cold Regions Research and Engineering Lab. (USA)
- 6953 1H **A data-derived time-domain SEA for UXO identification using the MPV sensor** [6953-54]  
J. P. Fernández, Dartmouth College (USA); B. Barrowes, U.S. Army Corps of Engineers, ERDC-CRREL (USA); K. O'Neill, Dartmouth College (USA) and U.S. Army Corps of Engineers, ERDC-CRREL (USA); I. Shamatava, F. Shubitidze, Dartmouth College (USA); K. Sun, Dartmouth College (USA) and Schlumberger-Doll Research (USA)
- 6953 1I **Inversion of frequency domain data collected in a magnetic setting for the detection of UXO** [6953-55]  
N. Lhomme, L. R. Pasion, Sky Research, Inc. (Canada) and Univ. of British Columbia (Canada); S. D. Billings, Sky Research, Inc. (Canada); D. W. Oldenburg, Univ. of British Columbia (Canada)

Author Index



# Conference Committee

## Symposium Chair

**Larry B. Stotts**, Defense Advanced Research Projects Agency (USA)

## Symposium Cochair

**Ray O. Johnson**, Lockheed Martin Corporation (USA)

## Program Track Chairs

**John H. Holloway, Jr.**, Naval Surface Warfare Center Panama City Division (USA)

**Patrick J. Gardner**, West Carolina University (USA)

## Conference Chairs

**Russell S. Harmon**, U.S. Army Research Office (USA)

**John H. Holloway, Jr.**, Naval Surface Warfare Center Panama City Division (USA)

**J. Thomas Broach**, U.S. Army Night Vision & Electronic Sensors Directorate (USA)

## Program Committee

**Leslie M. Collins**, Duke University (USA)

**Yogadhis Das**, Defence Research and Development Canada (Canada)

**Gerald J. Dobeck**, Naval Surface Warfare Center Panama City Division (USA)

**Paul D. Gader**, University of Florida (USA)

**John E. McFee**, Defence Research and Development Canada (Canada)

**Nicola A. Playle**, Defence Science and Technology Laboratory (United Kingdom)

**James M. Sabatier**, The University of Mississippi (USA)

**Motoyuki Sato, IV**, Tohoku University (Japan)

**Miranda A. Schatten**, U.S. Army Night RDECOM CERDEC NVESD (USA)

**Waymond R. Scott, Jr.**, Georgia Institute of Technology (USA)

**Richard C. Weaver**, U.S. Army RDECOM CERDEC NVESD (USA)

Session Chairs

- 1 Electromagnetic Induction Sensing and Detection I  
**Al Wexler**, Quantic EMC Inc. (Canada)  
**Francis Navish III**, U.S. Army Night Vision & Electronic Sensors Directorate (USA)
- 2 Electromagnetic Induction Sensing and Detection II  
**Fridon Shubitidze**, Dartmouth College (USA)
- 3 Sensing and Detection Potpourri  
**James B. Spicer**, Johns Hopkins University (USA)
- 4 Littoral Sensing and Detection I  
**John H. Holloway, Jr.**, Naval Surface Warfare Center Panama City Division (USA)  
**James T. Cobb**, Naval Surface Warfare Center Panama City Division (USA)
- 5 Littoral Sensing and Detection II  
**Tom Ardigides**, Lockheed Martin Corporation (USA)
- 6 Optical Sensing and Detection  
**J. Michael Cathcart**, Georgia Institute of Technology (USA)  
**Peter Howard**, U.S. Army Night Vision & Electronic Sensors Directorate (USA)
- 7 Environmental Effects on Sensing and Detection  
**Russell S. Harmon**, U.S. Army Research Office (USA)
- 8 Multisystem Sensing  
**Motoyuki Sato, IV**, Tohoku University (Japan)
- 9 EOIR Signal Processing  
**George G. Keonig**, U.S. Army Engineer Research and Development Center (USA)
- 10 GPR for Detection and Algorithm Fusion I  
**Paul D. Gader**, University of Florida (USA)  
**Richard C. Weaver**, U.S. Army RDECOM CERDEC NVESD (USA)
- 11 GPR for Detection and Algorithm Fusion II  
**Peter A. Torrione**, Duke University (USA)  
**Anh H. Trang**, U.S. Army Night Vision & Electronic Sensors Directorate (USA)