

PROCEEDINGS OF SPIE

***Detection and Sensing of
Mines, Explosive Objects,
and Obscured Targets XX***

**Steven S. Bishop
Jason C. Isaacs**
Editors

**20–23 April 2015
Baltimore, Maryland, United States**

Sponsored and Published by
SPIE

Volume 9454

Proceedings of SPIE 0277-786X, V. 9454

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

Detection and Sensing of Mines, Explosive Objects, and Obscured Targets XX,
edited by Steven S. Bishop, Jason C. Isaacs, Proc. of SPIE Vol. 9454, 945401
© 2015 SPIE · CCC code: 0277-786X/15/\$18 · doi: 10.1117/12.2184320

Proc. of SPIE Vol. 9454 945401-1

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 XX*, edited by Steven S. Bishop, Jason C. Isaacs, Proceedings of SPIE Vol. 9454 (SPIE, Bellingham, WA, 2015) Article CID Number.

ISSN: 0277-786X

ISBN: 9781628415704

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 © 2015, 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. 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/15/\$18.00.

Printed in the United States of America.

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

SPIE 
Digital Library

SPIDigitalLibrary.org

Paper Numbering: Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print. Papers are published as they are submitted and meet publication criteria. A unique 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 as 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.

Contents

vii *Authors*
ix *Conference Committee*

SESSION 1 TECHNOLOGY MÉLANGE I

- 9454 02 **Forecasting the soil-dependent performance of ground-penetrating radar by means of a conventional field-moisture sensor [9454-1]**
- 9454 03 **Stand-off explosive detection utilizing low power stimulated emission nuclear quadrupole resonance detection and subwavelength focusing wideband super lens [9454-2]**
- 9454 04 **Minimally disruptive schedule repair for MCM missions [9454-3]**
- 9454 05 **Fusion of iECO image descriptors for buried explosive hazard detection in forward-looking infrared imagery [9454-4]**

SESSION 2 TECHNOLOGY MÉLANGE II

- 9454 06 **Detection of concealed targets using spintronic microwave sensor [9454-5]**
- 9454 07 **Differential excitation spectroscopy for detection of common explosives: ammonium nitrate and urea nitrate [9454-6]**
- 9454 08 **Using a blackboard architecture or expert system to identify obfuscated targets from symptoms [9454-7]**
- 9454 09 **Efficiency of using the spectral dynamics analysis for pulsed THz spectroscopy of both explosive and other materials [9454-8]**

SESSION 3 ELECTROMAGNETIC INDUCTION I

- 9454 0A **Fuzzy logic based sensor performance evaluation of vehicle mounted metal detector systems [9454-9]**
- 9454 0B **Approach to explosive hazard detection using sensor fusion and multiple kernel learning with downward-looking GPR and EMI sensor data [9454-10]**
- 9454 0C **Extended-range electromagnetic induction concepts [9454-11]**

SESSION 4 ELECTROMAGNETIC INDUCTION II

- 9454 0F **Buried threat detection using a handheld ground penetrating radar system [9454-14]**

9454 OG **Multiple instance dictionary learning for subsurface object detection using handheld EMI** [9454-15]

9454 OH **Phase response of high to very high frequency metal/anomaly detector** [9454-16]

SESSION 5 EO/IR TECHNOLOGIES AND SIGNAL PROCESSING I

9454 OI **A queuing model for designing multi-modality buried target detection systems: preliminary results** [9454-17]

9454 OJ **Ground vehicle based ladar for standoff detection of road-side hazards** [9454-18]

9454 OK **Airborne thermal infrared hyperspectral imaging of buried objects** [9454-19]

9454 OL **Extended adaptive mutation operator for training an explosive hazard detection prescreener in forward looking infrared imagery** [9454-20]

9454 OM **Design of a buried explosive hazard pre-screener in forward looking imagery based on shearlet filtering and image post-processing** [9454-21]

SESSION 6 EO/IR TECHNOLOGIES AND SIGNAL PROCESSING II

9454 ON **Near real-time, on-the-move multisensor integration and computing framework** [9454-22]

9454 OO **Near real-time, on-the-move software PED using VPEF** [9454-23]

9454 OP **Real-time buried threat detection and cueing capability in VPEF environment** [9454-25]

SESSION 7 EO/IR TECHNOLOGIES AND SIGNAL PROCESSING III

9454 OQ **Multi-scale HOG prescreening algorithm for detection of buried explosive hazards in FL-IR and FL-GPR data** [9454-26]

9454 OR **An application of log-Gabor filter on road detection in arid environments for forward looking buried object detection** [9454-27]

SESSION 8 LASER BASED CHEMICAL SENSING TECHNOLOGIES

9454 OS **A method for detecting ultra-low quantities of explosives with use a picosecond laser FAIMS analyzer** [9454-28]

9454 OT **Raman detection of improvised explosive device (IED) material fabricated using drop-on-demand inkjet technology on several real world surfaces** [9454-29]

9454 OU **Detection of homemade explosives using Raman excitation at 1064 nm** [9454-30]

SESSION 9 FORWARD LOOKING GPR TECHNOLOGIES

- 9454 0V **Clutter and target discrimination in forward-looking ground penetrating radar using sparse structured basis pursuits** [9454-31]
- 9454 0W **Deep belief networks for false alarm rejection in forward-looking ground-penetrating radar** [9454-32]
- 9454 0X **An apodization approach for processing forward-looking GPR for buried target detection** [9454-33]
- 9454 0Y **A synthetic aperture acoustic prototype system** [9454-34]
- 9454 0Z **Explosive hazard detection using MIMO forward-looking ground penetrating radar** [9454-35]

SESSION 10 GPR TECHNOLOGIES I

- 9454 11 **Automatic target detection and discrimination algorithm applicable to ground penetrating radar data** [9454-37]
- 9454 12 **Design and validation of inert homemade explosive simulants for ground penetrating radar** [9454-38]
- 9454 13 **Deep convolutional neural networks for classifying GPR B-scans** [9454-39]
- 9454 14 **GPR anomaly detection with robust principal component analysis** [9454-40]
- 9454 15 **A layer tracking approach to buried surface detection** [9454-41]

SESSION 11 GPR TECHNOLOGIES II

- 9454 16 **Target signature localization in GPR data by jointly estimating and matching templates** [9454-42]
- 9454 17 **Fast 3D subsurface imaging with stepped-frequency GPR** [9454-43]
- 9454 18 **Fusion of forward-looking infrared camera and down-looking ground penetrating radar for buried target detection** [9454-44]
- 9454 19 **Detection of deeply buried non-metal objects by ground penetrating radar using non-negative matrix factorization** [9454-45]
- 9454 1A **Recognizing subsurface target responses in ground penetrating radar data using convolutional neural networks** [9454-46]
- 9454 1B **Anomaly detection of subsurface objects using handheld ground-penetrating radar** [9454-49]

SESSION 12 GPR TECHNOLOGIES III

- 9454 1C **Improving buried threat detection in ground-penetrating radar with transfer learning and metadata analysis** [9454-47]
- 9454 1D **Leveraging robust principal component analysis to detect buried explosive threats in handheld ground-penetrating radar data** [9454-48]

SESSION 13 NEUTRON BEAM

- 9454 1E **Tagged neutron capabilities for detecting hidden explosives** [9454-51]

SESSION 14 MARITIME SIGNAL PROCESSING I

- 9454 1F **Information surfing with the JHU/APL coherent imager** [9454-52]
- 9454 1G **Multiple pass collaborative search in the presence of false alarms** [9454-53]
- 9454 1H **Optimal relative view angles for an object viewed multiple times** [9454-54]
- 9454 1I **Possibilistic context identification for SAS imagery** [9454-55]

SESSION 15 MARITIME SIGNAL PROCESSING II

- 9454 1K **Investigation of measurable parameters that correlate with automatic target recognition performance in synthetic aperture sonar** [9454-57]
- 9454 1L **Unsupervised 3D scene understanding and prediction to enable adaptable solutions to the art gallery problem and watchman route problem** [9454-58]
- 9454 1N **Automated area segmentation for ocean bottom surveys** [9454-60]

Authors

Numbers in the index correspond to the last two digits of the six-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first four digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Abeynayake, Canicious, 0A, 11
Abou-Rachid, H., 06
Agarwal, Sanjeev, 0N, 0O, 0P
Akar, Gozde Bozdagi, 18
Alvey, Brendan, 0G
An, Vatana, 1L
Anderson, Derek T., 05, 0L, 0M, 0Z
Apostolos, John, 03
Auslander, Bryan, 04
Bassani, Chet, 0C
Batyayev, V. F., 1E
Baylog, John G., 1G
Beagley, Nathaniel, 1F
Becker, John, 0B, 0W
Belichenko, S. G., 1E
Besaw, Lance E., 13
Bestaev, R. R., 1E
Bishop, Steven S., 0Y
Bogdanov, Artem S., 0S
Brennan, Michael L., 0H
Burnette, Chris, 0N, 0O
Burns, Brian, 0Z
Burns, Joseph, 0B, 14, 17
Camilo, Joseph A., 0V
Chamberland, Martin, 0K
Chan, Aaron M., 0Y
Chase, Walter, 03
Chistyakov, Alexander A., 0S
Close, Ryan, 0J
Cobb, J. Tory, 1I, 1K
Collins, Leslie M., 0F, 0I, 0V, 16, 1A, 1C, 1D
Colwell, Kenneth A., 1C
Cook, Matthew, 0G, 1B
Cox, Jason M., 07
Cua, John T., 0H
Dentinger, Claire, 0U
Deterline, Diane, 0N, 0O
Dobbins, Peter J., 15
Donzelli, Thomas P., 0Y
Du, Xiaoxiao, 1I
Farley, Vincent, 0K
Farrell, Mikella E., 0T
Faust, Anthony A., 12
Feng, Judy, 03
Fu, Lei, 06
Gagnon, Jean-Philippe, 0K
Gagnon, Marc-André, 0K
Gavryuchenkov, A. V., 1E
Gazagnaire, Julia, 1K
Geyer, Chris, 0N, 0O, 0P
Gilani, Syed Uzair, 1H
Green, Kevin, 0N, 0O
Gugino, Peter M., 0Y
Gui, Y. S., 06
Guo, H., 06
Gupta, Kalyan Moy, 04
Guyot, Éric, 0K
Harris, Samuel, 1B
Harrison, Paul, 07
Havens, Timothy C., 05, 0B, 0W, 0X, 14
Heinz, Daniel C., 0H
Ho, Dominic K., 0G, 0Z, 19, 1B
Hollinger, Jim, 0J
Holthoff, Ellen L., 0T
Hu, C.-M., 06
Hunter, Boyd V., 07
Hunter, Richard V., 07
Hyland, John C., 1N
Igel, J., 02
Isaacs, Jason, 1K
Jaidann, M., 06
Johnson, Bruce A., 1L
Kalika, Dmitry, 1D
Karetnikov, M. D., 1E
Keller, James M., 0M, 0Q, 0R, 0Z
Kelly, Jack, 14
Knox, Mary T., 0F, 1D
Kotkovskii, Gennadii E., 0S
Lagueux, Philippe, 0K
Ling, Bo, 0P
Loewer, M., 02
Luke, Robert H., 0Y, 0Z
Lydic Jr., Richard M., 0N
Malof, Jordan M., 0I, 0V, 16
Masarik, Matthew P., 0B, 14, 17
McFee, John E., 12
Melber, Adam W., 0H
Miller, Jonathan S., 0C
Miller, Michael A., 07
Molineaux, Matthew, 04
Moore, Philip G., 04
Morton Jr., Kenneth D., 0F, 0I, 0V, 16, 1A, 1C, 1D
Mouyos, William, 03
Nabelek, Daniel, 19
Nguyen, Bao, 1H
Odulo, Ivan P., 0S
Olivera, Santiago, 0P
Ozturk, Serhat, 18

Pellegrino, Paul M., 0T
Perederiy, Anatoly N., 0S
Phan, Chung D., 0N, 0O, 0P
Pinar, Anthony, 0B, 0W
Plodpradista, P., 0R
Popescu, Mihail, 0R, 0Z
Price, Stanton R., 05, 0L, 0M
Qi, Hairong, 1L
Ratto, Christopher R., 1F
Reichman, Daniël, 16
Robotham, Claude, 0U
Roy, Eric G., 0U
Russell, Kevin L., 12
Sakaguchi, Rayn T., 1A
Savary, Simon, 0K
Schneider, Matt, 0N
Schultz, Gregory, 0C
Schulz, Timothy J., 0W, 0X
Shaw, Darren, 0Q, 0Z
Shende, Apoorva, 1H
Shestakov, Alexander V., 0S
Shipley, Kara R., 1F
Singh, Ravinder, 0L
Smith, Cheryl M., 1N
Smock, Brandon, 15
Soumekh, Mehrdad, 0Y
Spitsyn, Evgeny M., 0S
Steer, Michael B., 0H
Stilwell, Daniel J., 1H
Stimac, Philip J., 13
Stone, Kevin, 0Q, 0Z
Straub, Jeremy, 08
Sutter, Lena, 17
Swett, Bruce, 0N, 0O
Sychev, Alexey V., 0S
Thelen, Brian T., 0B, 14, 17
Torrione, Peter A., 0F, 0I, 0V, 16, 1A, 1C, 1D
Tran, Minh Dao-Johnson, 0A, 11
Tremblay, Pierre, 0K
Trofimov, Vyacheslav A., 09
Van Bastian, Levi, 07
VanderGaast, Brian W., 12
Varentsova, Svetlana A., 09
Vasilkoski, Zlatko, 0P
Walters, William P., 07
Webb, Adam, 0X
Wettergren, Thomas A., 1G
Wilson, Joseph N., 15
Wolfe, Kevin C., 1F
Xiao, Y., 06
Yuksel, Seniha Esen, 18
Zare, Alina, 0G, 1B, 1I

Conference Committee

Symposium Chair

Nils R. Sandell Jr., Strategic Technology Office, DARPA
(United States)

Symposium Co-chair

David A. Logan, BAE Systems (United States)

Conference Chairs

Steven S. Bishop, U.S. Army Night Vision & Electronic Sensors
Directorate (United States)

Jason C. Isaacs, Naval Surface Warfare Center Panama City Division
(United States)

Conference Program Committee

Benjamin E. Barrowes, U.S. Army Engineer Research and
Development Center (United States)

Ryan R. Close, U.S. Army Night Vision & Electronics Sensors Directorate
(United States)

Leslie M. Collins, Duke University (United States)

Gerald J. Dobeck, Naval Surface Warfare Center Panama City
Division (United States)

Anthony A. Faust, Defence Research and Development Canada,
Suffield (Canada)

Tesfaye G-Michael, Naval Surface Warfare Center Panama City
Division (United States)

Gregory Garcia, Naval Surface Warfare Center Panama City Division
(United States)

James M. Keller, University of Missouri-Columbia (United States)

Aaron LaPointe, U.S. Army Night Vision & Electronic Sensors
Directorate (United States)

Henric Östmark, Swedish Defence Research Agency (Sweden)

Motoyuki Sato, Tohoku University (Japan)

Waymond R. Scott Jr., Georgia Institute of Technology (United States)

Richard C. Weaver, U.S. Army Night Vision & Electronic Sensors
Directorate (United States)

Session Chairs

- 1 Technology Mélange I
Leslie M. Collins, Duke University (United States)
- 2 Technology Mélange II
Zeke Topolosky, U.S. Army Night Vision & Electronic Sensors Directorate (United States)
Joe Keranen, White River Technologies, Inc. (United States)
- 3 Electromagnetic Induction I
Rajiv Suri, U.S. Army Research, Development and Engineering Command (United States)
Alina Zare, University of Missouri-Columbia (United States)
- 4 Electromagnetic Induction II
Frank Navish III, U.S. Army Night Vision & Electronic Sensors Directorate (United States)
Gregory Schultz, White River Technologies, Inc. (United States)
- 5 EO/IR Technologies and Signal Processing I
Christopher Geyer, EOIR Technologies (United States)
Kevin K. Green, EOIR Technologies (United States)
- 6 EO/IR Technologies and Signal Processing II
Sanjeev Agarwal, U.S. Army Night Vision & Electronic Sensors Directorate (United States)
Bruce Swett, EOIR Technologies (United States)
- 7 EO/IR Technologies and Signal Processing III
Robert H. Luke III, U.S. Army Night Vision & Electronic Sensors Directorate (United States)
Mark P. Kolba, Signal Innovations Group, Inc. (United States)
- 8 Laser Based Chemical Sensing Technologies
Ken E. Yasuda, U.S. Army Night Vision & Electronic Sensors Directorate (United States)
Mikella E. Farrell, U.S. Army Research Laboratory (United States)
- 9 Forward Looking GPR Technologies
Brian P. Burns, U.S. Army Night Vision & Electronic Sensors Directorate (United States)
Matthew P. Masarik, Michigan Tech Research Institute (United States)

- 10 GPR Technologies I
Brian C. Barlow, U.S. Army Night Vision & Electronic Sensors Directorate
(United States)
Peter A. Torrione, Duke University (United States)
- 11 GPR Technologies II
Brian C. Barlow, U.S. Army Night Vision & Electronic Sensors Directorate
(United States)
Matthew P. Masarik, Michigan Tech Research Institute (United States)
- 12 GPR Technologies III
Brian C. Barlow, U.S. Army Night Vision & Electronic Sensors Directorate
(United States)
Lance E. Besaw, Applied Research Associates, Inc. (United States)
- 13 Neutron Beam
Anthony A. Faust, Defence Research and Development Canada,
Suffield (Canada)
J. Paul Farrell, Brookhaven Technology Group, Inc. (United States)
- 14 Maritime Signal Processing I
Julia Gazagnaire, Naval Surface Warfare Center Panama City
Division (United States)
John G. Baylog, Naval Undersea Warfare Center (United States)
- 15 Maritime Signal Processing II
John G. Baylog, Naval Undersea Warfare Center (United States)
Julia Gazagnaire, Naval Surface Warfare Center Panama City
Division (United States)

