

PROCEEDINGS OF SPIE

Radar Sensor Technology XV

Kenneth I. Ranney
Armin W. Doerry
Editors

25–27 April 2011
Orlando, Florida, United States

Sponsored and published by
SPIE

Volume 8021

Proceedings of SPIE, 0277-786X, v. 8021

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 *Radar Sensor Technology XV*, edited by Kenneth I. Ranney, Armin W. Doerry, Proceedings of SPIE Vol. 8021 (SPIE, Bellingham, WA, 2011) Article CID Number.

ISSN 0277-786X

ISBN 9780819485953

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 © 2011, 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/11/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the 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 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 as 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 SYSTEMS AND APPLICATIONS

- 8021 02 **Ground penetration radar using free-electron maser** [8021-01]
A. D. McAulay, Lehigh Univ. (United States)
- 8021 03 **A computer simulation of a long-range CWFM radar showing the tradeoffs of performance as a function of range** [8021-02]
R. S. Gordy, S. Zoledziowski, Global Technical Systems (United States)
- 8021 04 **Augmented reality using ultra-wideband radar imagery** [8021-03]
L. Nguyen, F. Koenig, K. Sherbondy, U.S. Army Research Lab. (United States)

SESSION 2 PHENOMENOLOGY I

- 8021 06 **Human polarimetric micro-doppler** [8021-10]
D. Tahmouh, J. Silvius, U.S. Army Research Lab. (United States)
- 8021 08 **Polarization dynamics and interference analysis for wideband signals** [8021-07]
G. Stratis, G. Maalouli, D. Manzi, R. Ihly, Raytheon Missile Systems (United States)
- 8021 09 **Phenomenology of fully polarimetric imaging radars** [8021-08]
J. V. Geaga, Consultant (United States)
- 8021 0A **Visualizing and displaying radar micro-doppler data** [8021-11]
D. Tahmouh, J. Silvius, U.S. Army Research Lab. (United States)

SESSION 3 PHENOMENOLOGY II

- 8021 0C **Polarisation transform analysis for detection of shallow buried non-metallic landmines in microwave X-band region** [8021-09]
K. C. Tiwari, D. Singh, M. Arora, Indian Institute of Technology Roorkee (India)
- 8021 0D **Radar cross section statistics of dismounts at Ku-band** [8021-12]
A. M. Raynal, B. L. Burns, Sandia National Labs. (United States); T. J. Verge, General Atomics Aeronautical Systems, Inc. (United States); D. L. Bickel, Sandia National Labs. (United States); R. Dunkel, General Atomics Aeronautical Systems, Inc. (United States); A. W. Doerry, Sandia National Labs. (United States)
- 8021 0E **Radar cross section statistics of ground vehicles at Ku-band** [8021-13]
A. M. Raynal, D. L. Bickel, M. M. Denton, W. J. Bow, A. W. Doerry, Sandia National Labs. (United States)

- 8021 OF **Human activity classification using Hilbert-Huang transform analysis of radar Doppler data** [8021-14]
D. P. Fairchild, R. M. Narayanan, The Pennsylvania State Univ. (United States)

SESSION 4 THROUGH THE WALL RADAR

- 8021 OH **Comparison of three radar systems for through-the-wall sensing** [8021-16]
X. Wang, J. Li, The Univ. of Texas-Pan American (United States); Y. Yang, C. Lu, Towson Univ. (United States); C. Kwan, B. Ayhan, Signal Processing, Inc. (United States)
- 8021 OI **A fast data acquisition and processing scheme for through-the-wall radar imaging** [8021-17]
F. Soldovieri, Institute for Electromagnetic Sensing of the Environment (Italy); R. Solimene, Seconda Univ. di Napoli (Italy); F. Ahmad, Villanova Univ. (United States)
- 8021 OJ **Target localization with a single-antenna monostatic radar via multipath exploitation** [8021-18]
P. Setlur, G. E. Smith, F. Ahmad, M. G. Amin, Villanova Univ. (United States)
- 8021 OK **Real-time subsurface imaging algorithm for intra-wall characterization** [8021-19]
W. Zhang, A. Hoorfar, C. Thajudeen, Villanova Univ. (United States)
- 8021 OM **Wave propagation through complex wall structures** [8021-21]
B. Anderton, R. White, E. Williams, J. Hess, S. Manson, G. Stratis, Raytheon Missile Systems (United States)

SESSION 5 METAMATERIALS FOR RADAR

- 8021 ON **Novel antennas based upon extraordinary transmission metamaterial lenses** [8021-22]
M. Navarro-Cía, M. Beruete, F. Falcone, M. Sorolla, Univ. Pública de Navarra (Spain)
- 8021 OO **Transformation optics compressed rotman lens implemented with complementary metamaterials** [8021-23]
J. Hunt, Duke Univ. (United States); N. Kundtz, Duke Univ. (United States) and Intellectual Ventures (United States); B. Sun, D. R. Smith, Duke Univ. (United States)
- 8021 OR **Metamaterial-driven lens optics for new beam forming patterns** [8021-26]
A. I. Zaghoul, U.S. Army Research Lab. (United States) and Virginia Polytechnic Institute and State Univ. (United States); S. J. Weiss, U.S. Army Research Lab. (United States)

SESSION 6 APPLICATIONS AND TECHNIQUES I

- 8021 OS **Super-resolution technologies for all-weather sense and avoidance (SAA) radar** [8021-27]
Y. R. Zhang, Z. Li, S. Wang, Y. Pan, H. Suarez, The Univ. of Oklahoma (United States)
- 8021 OU **SAR vibrometry using the pseudo-subspace approach based on the discrete fractional Fourier transform** [8021-29]
Q. Wang, B. Santhanam, M. Pepin, The Univ. of New Mexico (United States); T. Atwood, Sandia National Labs. (United States); M. M. Hayat, The Univ. of New Mexico (United States)

- 8021 0V **Generation of FM signals with quasi-chirp behavior using three-dimensional chaotic flows** [8021-30]
B. C. Flores, C. S. Pappu, B. Verdin, The Univ. of Texas at El Paso (United States)
- 8021 0W **PADF RF localization criteria for multimodel scattering environments** [8021-31]
M. Gates, C. Barber, R. Selmic, Louisiana Tech Univ. (United States); H. Al-Issa, R. Ordonez, Univ. of Dayton (United States); A. Mitra, Air Force Research Lab. (United States)

SESSION 7 APPLICATIONS AND TECHNIQUES II

- 8021 0Y **Clutter locus equation for more general linear array orientation** [8021-33]
D. L. Bickel, Sandia National Labs. (United States)
- 8021 11 **Quick signal detection and dynamic resource allocation scheme for ultra-wideband radar** [8021-36]
X. Kong, A. Mohin, HRL Labs., LLC (United States)
- 8021 12 **Adaptive detection of range-spread targets by the generalized detector** [8021-38]
V. Tuzlukov, Kyungpook National Univ. (Korea, Republic of)

SESSION 8 SIGNAL PROCESSING IN NOISE RADAR

- 8021 13 **Radar signature acquisition using an indigenously designed noise radar system** [8021-39]
A. P. Freundorfer, Queen's Univ. (Canada); J. Y. Siddiqui, Y. M. M. Antar, Royal Military College of Canada (Canada); T. Thayaparan, Defence Research and Development Canada (Canada)
- 8021 14 **High-resolution noise radar using slow ADC** [8021-40]
K. Lukin, P. Vyplavin, O. Zemlyanyi, S. Lukin, V. Palamarchuk, Institute of Radiophysics and Electronics (Ukraine)
- 8021 15 **Direct digitization of ultra-wideband (UWB) noise signals using frequency band folding** [8021-41]
R. Vela, The Pennsylvania State Univ. (United States); G. Woodington, M. R. Deluca, Raytheon Co. (United States); R. M. Narayanan, The Pennsylvania State Univ. (United States)
- 8021 16 **Cross-correlation analysis of noise radar signals propagating through lossy dispersive media** [8021-42]
S. Smith, R. M. Narayanan, The Pennsylvania State Univ. (United States)
- 8021 17 **Super-resolution techniques for velocity estimation using UWB random noise radar signals** [8021-43]
M. Dawood, N. Quraishi, New Mexico State Univ. (United States); A. V. Alejos, New Mexico State Univ. (United States) and Univ. of Vigo (Spain)

SESSION 9 ADAPTIVE GENERATION OF NOISE AND NOISE-LIKE WAVEFORMS

- 8021 18 **A technique for the generation of customizable ultra-wideband pseudo-noise waveforms** [8021-45]
R. Vela, The Pennsylvania State Univ. (United States); D. Erisman, X-COM Systems (United States); R. M. Narayanan, The Pennsylvania State Univ. (United States)
- 8021 19 **Brillouin precursor waveforms pertaining to UWB noise radar signals propagating through dispersive media** [8021-46]
M. Dawood, New Mexico State Univ. (United States); A. V. Alejos, New Mexico State Univ. (United States) and Univ. de Vigo (Spain)
- 8021 1A **A technique for the extraction of ultra-wideband (UWB) signals concealed in frequency band folded responses** [8021-48]
R. Vela, R. M. Narayanan, The Pennsylvania State Univ. (United States); D. Erisman, X-COM Systems (United States)

SESSION 10 IMAGING AND DETECTION USING NOISE RADAR

- 8021 1B **SAR imagery using chaotic carrier frequency agility pulses** [8021-49]
X. Xu, X. Feng, BeiHang Univ. (China)
- 8021 1D **Target discrimination technique utilizing noise waveforms** [8021-51]
G. Woodington, M. DeLuca, R. Moro, D. Lemus, Raytheon Co. (United States); R. Vela, R. Narayanan, The Pennsylvania State Univ. (United States)
- 8021 1E **Design and implementation of random noise radar with spectral-domain correlation for moving target detection** [8021-52]
J. P. Kim, C. H. Jeong, C. H. Kim, Chung-Ang Univ. (Korea, Republic of)
- 8021 1F **Passive radar imaging of moving targets using distributed apertures** [8021-53]
L. Wang, Nanjing Univ. of Aeronautics and Astronautics (China); B. Yazici, Rensselaer Polytechnic Institute (United States)

SESSION 11 CHAOTIC AND NOISE-LIKE RADAR SYSTEMS

- 8021 1H **Concept for low-cost chaos radar using coherent reception** [8021-55]
J. N. Blakely, N. J. Corron, U. S. Army Aviation and Missile Research, Development, and Engineering Ctr. (United States)
- 8021 1I **Nonlinear dynamics method for target identification** [8021-56]
T. L. Carroll, F. J. Rachford, U.S. Naval Research Lab. (United States)

SESSION 12 POSTER SESSION

- 8021 1K **ECCM performance analysis of chaotic coded orthogonal frequency division multiplexing (COFDM) SAR** [8021-58]
X. Feng, X. Xu, BeiHang Univ. (China)

- 8021 1L **Noise radar with broadband microwave ring correlator** [8021-59]
W. Susek, B. Stęć, Military Univ. of Technology (Poland)
- 8021 1M **Interference suppression in noise radar systems** [8021-60]
S. Djukanović, M. Daković, Univ. of Montenegro (Montenegro); T. Thayaparan, Defence Research and Development Canada (Canada); L. Stanković, Univ. of Montenegro (Montenegro)
- 8021 1N **Detection and identification of concealed weapons using matrix pencil** [8021-61]
R. S. Adve, Univ. of Toronto (Canada); T. Thayaparan, Defence Research and Development Canada (Canada)
- 8021 1O **Through-the-wall detection of human activity** [8021-62]
T. Johansson, J. Rahm, J. Gustavsson, S. Nilsson, A. Sume, A. Örbom, Swedish Defence Research Agency (Sweden)
- 8021 1P **Some comments on GMTI false alarm rate** [8021-63]
A. W. Doerry, Sandia National Labs. (United States)
- 8021 1Q **Optimal antenna beamwidth for stripmap SAR** [8021-64]
A. W. Doerry, Sandia National Labs. (United States)
- 8021 1R **Synthetic aperture radar for disaster monitoring** [8021-65]
R. Dunkel, R. Saddler, General Atomics Aeronautical Systems, Inc. (United States);
A. W. Doerry, Sandia National Labs. (United States)
- 8021 1S **Design and implementation of a digital impulse generator for a 24GHz UWB radar** [8021-66]
S.-D. Kim, J.-H. Lee, Daegu Gyeongbuk Institute of Science & Technology (Korea, Republic of)
- 8021 1T **DC-offset effect cancelation method using mean-padding FFT for automotive UWB radar sensor** [8021-67]
Y. Ju, S.-D. Kim, J.-H. Lee, Daegu Gyeongbuk Institute of Science & Technology (Korea, Republic of)
- 8021 1U **Integrated radar-camera security system: experimental results** [8021-68]
M. Życzkowski, N. Pałka, T. Trzciński, R. Dulski, M. Kastek, P. Trzaskawka, Military Univ. of Technology (Poland)
- 8021 1V **Resolution analysis of bistatic SAR** [8021-69]
G. Garza, Z. Qiao, The Univ. of Texas-Pan American (United States)
- 8021 1W **Side-looking image formation with a maneuvering vehicle-mounted antenna array** [8021-70]
K. Ranney, L. Nguyen, F. Koenig, G. Kirose, A. Martone, G. Mazzaro, K. Sherbondy, C. Tran, K. Kappra, U.S. Army Research Lab. (United States)
- 8021 1X **Wideband fiber optic vector modulator using 8-tap all-optical Hilbert transformer** [8021-71]
R. Tucker, S. C. Granieri, A. Siahmakoun, Rose-Hulman Institute of Technology (United States)

- 8021 1Y **Far-field scattering of random electromagnetic fields from particulate media** [8021-73]
Z. Tong, O. Korotkova, Univ. of Miami (United States)
- 8021 1Z **Stereo matching: performance study of two global algorithms** [8021-74]
S. Arunagiri, V. J. Jordan, P. J. Teller, The Univ. of Texas at El Paso (United States); J. C. Deroba, U.S. Army CERDEC Intelligence and Information Warfare Directorate (United States); D. R. Shires, S. J. Park, L. H. Nguyen, U.S. Army Research Lab. (United States)
- 8021 20 **On the use of the Shark antenna for radar detection techniques** [8021-75]
L. Desrumaux, M. Lalande, J. Andrieu, XLIM/OSA, IUT-GEII (France); V. Bertrand, CISTEME-ESTER (France); B. Jecko, XLIM/OSA, Univ. de Limoges (France)
- 8021 21 **Attenuation of front-end reflections in an impulse radar using high-speed switching** [8021-76]
G. J. Mazzaro, M. A. Ressler, G. D. Smith, U.S. Army Research Lab. (United States)
- 8021 23 **Exploiting spatial diversity in MIMO radars with colocated antennas** [8021-78]
G. Maalouli, D. Rosser, G. Stratis, Raytheon Missile Systems (United States)
- 8021 24 **Sidelobe minimization in MTI processing** [8021-79]
K. Ranney, A. Martone, R. Innocenti, L. Nguyen, U.S. Army Research Lab. (United States)

Author Index

Conference Committee

Symposium Chair

William Jeffrey, HRL Laboratories, LLC (United States)

Symposium Cochair

Kevin P. Meiners, Office of the Secretary of Defense (United States)

Conference Chairs

Kenneth I. Ranney, U.S. Army Research Laboratory (United States)

Armin W. Doerry, Sandia National Laboratories (United States)

Program Committee

Fauzia Ahmad, Villanova University (United States)

Sean M. Buckley, Jet Propulsion Laboratory (United States)

Joseph C. Deroba, U.S. Army CERDEC Intelligence and Information Warfare Directorate (United States)

Doreen M. Dyck, Defence Research and Development Canada (Canada)

Benjamin C. Flores, The University of Texas at El Paso (United States)

John E. Gray, Naval Surface Warfare Center Dahlgren Division (United States)

Majeed M. Hayat, The University of New Mexico (United States)

Todd A. Kastle, Air Force Research Laboratory (United States)

Seong-Hwoon Kim, Raytheon Space & Airborne Systems (United States)

James L. Kurtz, University of Florida (United States)

Changzhi Li, Texas Tech University (United States)

Jenshan Lin, University of Florida (United States)

David G. Long, Brigham Young University (United States)

Jia-Jih Lu, General Atomics Aeronautical Systems, Inc. (United States)

Anthony F. Martone, U.S. Army Research Laboratory (United States)

Atindra K. Mitra, Air Force Research Laboratory (United States)

George J. Moussally, Mirage Systems (United States)

Lam H. Nguyen, U.S. Army Research Laboratory (United States)

Hector A. Ochoa-Gutierrez, The University of Texas at Tyler (United States)

Meppalli K. Shandas, dB Control (United States)

Jerry Silvius, U.S. Army Research Laboratory (United States)

Brian Smith, U.S. Army Armament Research, Development and Engineering Center (United States)

Helmut H. Suess, Deutsches Zentrum für Luft- und Raumfahrt e.V.
(Germany)
David Tahmoush, U.S. Army Research Laboratory (United States)
Lars M. Wells, Sandia National Laboratories (United States)
Steven J. Weiss, U.S. Army Research Laboratory (United States)

Session Chairs

- 1 Systems and Applications
James L. Kurtz, University of Florida (United States)
- 2 Phenomenology I
Meppalli K. Shandas, dB Control (United States)
Gregory J. Mazzaro, U.S. Army Research Laboratory (United States)
- 3 Phenomenology II
Lam H. Nguyen, U.S. Army Research Laboratory (United States)
Anthony F. Martone, U.S. Army Research Laboratory (United States)
- 4 Through the Wall Radar
Atindra K. Mitra, Air Force Research Laboratory (United States)
Jerry Silvius, U.S. Army Research Laboratory (United States)
- 5 Metamaterials for Radar
Steven J. Weiss, U.S. Army Research Laboratory (United States)
- 6 Applications and Techniques I
Seong-Hwoon Kim, Raytheon Space & Airborne Systems (United States)
David Tahmoush, U.S. Army Research Laboratory (United States)
- 7 Applications and Techniques II
John E. Gray, Naval Surface Warfare Center Dahlgren Division (United States)
Fauzia Ahmad, Villanova University (United States)
- 8 Signal Processing in Noise Radar
Ram M. Narayanan, The Pennsylvania State University (United States)
- 9 Adaptive Generation of Noise and Noise-Like Waveforms
Thayananthan Thayaparan, Defence Research and Development Canada (Canada)
- 10 Imaging and Detection Using Noise Radar
Konstantin A. Lukin, Usikov Institute of Radiophysics and Electronics (Ukraine)

- 11 Chaotic and Noise-Like Radar Systems
Russell Vela, The Pennsylvania State University (United States)

