

# PROCEEDINGS OF SPIE

## **Radioelectronic Systems Conference 2019**

**Piotr Kaniewski**  
**Jan Matuszewski**  
*Editors*

**20–21 November 2019**  
**Jachranka, Poland**

*Organized by*  
Military University of Technology (Poland)  
PIT-RADWAR S.A. (Poland)

*Sponsored by*  
National Security Bureau (Poland), *Honorary Patronage*  
Polish Space Agency (Poland), *Patronage*  
Polska Zbrojna Magazine (Poland), *Medial Patronage*

*Published by*  
SPIE

**Volume 11442**

Proceedings of SPIE 0277-786X, V. 11442

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

Radioelectronic Systems Conference 2019, edited by Piotr Kaniewski, Jan Matuszewski, Proc. of SPIE  
Vol. 11442, 1144201 · © 2020 SPIE · CCC code: 0277-786X/20/\$21 · doi: 10.1117/12.2566591

Proc. of SPIE Vol. 11442 1144201-1

The papers 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. Additional papers and presentation recordings may be available online in the SPIE Digital Library at [SPIDigitalLibrary.org](http://SPIDigitalLibrary.org).

The papers 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 these proceedings:

Author(s), "Title of Paper," in *Radioelectronic Systems Conference 2019*, edited by Piotr Kaniewski, Jan Matuszewski, Proceedings of SPIE Vol. 11442 (SPIE, Bellingham, WA, 2020) Seven-digit Article CID Number.

ISSN: 0277-786X  
ISSN: 1996-756X (electronic)

ISBN: 9781510636712  
ISBN: 9781510636729 (electronic)

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](http://SPIE.org)

Copyright © 2020, 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 \$21.00 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/20/\$21.00.

Printed in the United States of America by Curran Associates, Inc., under license from SPIE.

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

**SPIE. DIGITAL  
LIBRARY**

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

---

**Paper Numbering:** *Proceedings of SPIE* follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of 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 and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five 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.

# Contents

vii	<i>Authors</i>
ix	<i>Conference Committee</i>
xiii	<i>Introduction</i>

---

## OPENING SESSION

---

11442 02	<b>Laser warning system as an element of optoelectronic battlefield surveillance [11442-25]</b>
11442 03	<b>A concept of software extension of 3D low-PRF radar systems to 4D semi-medium-PRF radar systems [11442-6]</b>
11442 04	<b>BIBLOS for simulation of the Earth Observation missions [11442-62]</b>

---

## RADIOLOCATION

---

11442 05	<b>Adaptation of radar software to work with ambiguous distance measurement [11442-14]</b>
11442 06	<b>Analysis of association gates in radar tracking based on Kalman filter [11442-36]</b>

---

## MICROWAVE TECHNIQUE

---

11442 07	<b>A concept of application of dedicated spatially-distributed sources of electromagnetic interference [11442-38]</b>
11442 08	<b>Pulsed power L-band magnetron with increased operating parameters [11442-33]</b>
11442 09	<b>Integrated microwave frequency discriminator with rat-race 3dB hybrids [11442-39]</b>
11442 0A	<b>Transmission parameters of an anisotropic layered structure in the waveguide [11442-49]</b>

---

## RADAR TECHNIQUE I

---

11442 0B	<b>Properties of chosen OFDM-generated radar waveforms [11442-31]</b>
----------	---

- 11442 OC **A method for nonlinear conjugate scales in a multi-position radar system with ambiguous range measurements** [11442-1]
- 11442 OD **An analysis of the influence of the correlation gate shape on the TBD algorithm effectiveness** [11442-58]
- 11442 OE **Implementation of tactical ballistic missile tracking** [11442-35]

---

#### BIOMEDICAL ELECTRONICS

---

- 11442 OF **Multimodal data acquisition set for objective assessment of Parkinson's disease** [11442-21]
- 11442 OG **Selected problems of image data preprocessing used to perform examination in Parkinson's disease** [11442-24]
- 11442 OH **The use of voice processing techniques in the assessment of patients with Parkinson's disease** [11442-20]
- 11442 OI **Human identification based on motoric features** [11442-23]
- 11442 OJ **Radiation standards review concerning non-ionizing radiation** [11442-27]

---

#### OPTOELECTRONICS

---

- 11442 OK **Hybrid wireless communication link** [11442-41]
- 11442 OL **The photonic radar: the situation today and the prospects for the future** [11442-52]
- 11442 OM **Influence of photon energy on conductivity of photoconductive semiconductor switches fabricated from semi-insulating GaP** [11442-34]
- 11442 ON **LIDAR-based SLAM implementation using Kalman filter** [11442-5]
- 11442 OO **Optoelectronic sensor system for recognition of objects and incidents** [11442-26]

---

#### COMMUNICATION DEVICES AND SYSTEMS

---

- 11442 OP **Testing of the impact of dielectric thickness on basic parameters of the microstrip GSM / LTE antenna** [11442-10]
- 11442 OQ **Cryptographic protection of classified information in military radio communication faced with threats from quantum computers** [11442-47]

- 11442 OR **The measurements of the secured voice communication quality in a broadband radio channel** [11442-2]
- 11442 OS **Security of communication in the special communications systems** [11442-44]

---

#### SIGNAL AND DATA PROCESSING

---

- 11442 OT **Acoustoelectronic method of solvents purity evaluation** [11442-4]
- 11442 OU **Application of two classifiers fusion based on support vector machines method and time series comparison DTW to recognize maritime objects upon FLIR images** [11442-11]
- 11442 OV **Designing a mobile application on the example of a system for digital photos watermarking** [11442-30]

---

#### ELECTRONIC WARFARE

---

- 11442 OW **Efficiency of using active interference dedicated to medium range surveillance radar** [11442-32]
- 11442 OX **Detection and classification model of radioelectronic jamming signals with ELINT subsystem included within the Integrated Air Electronic Warfare Range (IAEWR)** [11442-28]

---

#### UNMANNED SYSTEMS

---

- 11442 OY **Advanced protection methods of unmanned aircraft vehicle against attack by radio techniques** [11442-43]
- 11442 OZ **Linear controller design with the use of PSO algorithm for UAV trajectory tracking** [11442-18]
- 11442 IO **The air object tracking in 3D space using distance measurements** [11442-37]

---

#### POSTER SESSION

---

- 11442 I1 **Photoacoustic in remote sensing** [11442-45]
- 11442 I2 **Quantum remote sensing: a challenge in radiolocation** [11442-51]
- 11442 I3 **Computer application for testing Kalman filter** [11442-15]
- 11442 I4 **Recognition analysis issues for tactical unmanned aerial vehicles based on optical photographs and SAR scans** [11442-8]

- 11442 15 **Analysis of possibilities to increase the efficiency of the relative database management system using the methods of parallel processing [11442-54]**
- 11442 16 **Programmable tandem detonator [11442-12]**
- 11442 17 **Classification of helicopter Doppler ambiguous echo signal [11442-53]**
- 11442 18 **The use of machine learning algorithms for image recognition [11442-48]**
- 11442 19 **Recognition of alphanumeric characters using artificial neuron networks and MSER algorithm [11442-46]**
- 11442 1A **Results of research of the eight-channel sensor for the defectoscopy of railway rails [11442-56]**
- 11442 1B **Use of track-before-detect algorithm to reduce settling period of Kalman filter [11442-61]**
- 11442 1C **Unscented Kalman filter application in personal navigation [11442-7]**
- 11442 1D **Thermal impact of the environment on the cables supplying electronic firefighting devices [11442-17]**
- 11442 1E **Determination of co-site work conditions of selected wideband radio station by measurement method [11442-57]**
- 11442 1F **Range cell migration compensation in inverse synthetic aperture radar [11442-60]**
- 11442 1G **Methods of automatic vegetation encroachment detection for high voltage power lines [11442-63]**
- 11442 1H **Microwave frequency detector using a 4x4 Butler matrix [11442-42]**
- 11442 1I **Work disruptions of electronics devices in hospital objects [11442-3]**
- 11442 1J **Microwave delay lines for analogue signal correlation [11442-13]**
- 11442 1K **Measurement method for construction of the radio environment maps supporting cognitive radios [11442-29]**

## Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five 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.

Baczewski, Dariusz, 08  
Bareła, Jarosław, 00  
Barrios Garcia, Pedro A., 04  
Białek, Kamila, 0F, 0G, 0H  
Bielecki, Z., 0K  
Bieszczad, Grzegorz, 00  
Blazejewicz, Mariusz, 08  
Borowski, Mariusz, 0Q  
Borowski, Tomasz, 0L, 11, 12  
Buda, Wojciech, 06  
Bugaj, Jarosław, 0P  
Camps, Adriano, 04  
Chmielińska, Jolanta, 0F, 0G, 0H  
Czopik, Grzegorz, 10  
Dobrowolski, Andrzej, 0F, 0G, 0H  
Dukata, Andrzej, 0A  
Fatek, Patrycja, 13  
Florczak, Jarosław, 0X  
Gibalski, Dariusz, 07, 16  
Gil, Fabian, 0I  
Golan, Edward, 1K  
Grochowina, B., 0K  
Gromada, Krzysztof, 14  
Gruszka, Ireneusz Marek, 15  
Handzel, Kacper, 0X  
Jakubowski, Jacek, 0F, 0G, 0H  
Jaroś, Krzysztof, 06  
Jarzemski, Józef, 07  
Jasek, K., 0T  
Jędrusik, Piotr, 0W  
Kaczmarek, Paweł, 0V  
Kamiński, P., 0M  
Kaniewski, Piotr, 0C, 0N, 13, 1C  
Kawalec, Adam, 0B, 0D, 17  
Kędzierawski, Robert, 04  
Kniota, Michał, 0B  
Kołcon, Andrzej, 0X  
Konatowski, Stanisław, 0I, 0Z  
Kopczyński, Krzysztof, 02  
Kostera-Pruszczyk, Anna, 0F, 0G, 0H  
Kozłowski, R., 0M  
Kraszewski, Tomasz, 10  
Kuczerski, Tomasz, 16  
Laskowski, Dariusz, 08, 0Y  
Łata, Krystian, 0P  
Leśnik, Czesław, 17, 1F  
Lewandowski, Zbigniew, 16  
Ligienza, Andrzej, 00  
Lubkowski, Piotr, 0R  
Łuszczczyk, Mariusz, 07  
Majda-Zdancewicz, Ewelina, 0F, 0G, 0H  
Majewski, Paweł, 08  
Masiewicz, Mariusz, 0X  
Matiieshyn, Yuriy, 1A  
Matuszewski, Jan, 18, 19  
Matyszek, R., 0K  
Meller, Michał, 03, 05  
Mikołajczyk, J., 0K  
Miskiv, Volodymyr-Myron, 0C  
Nalewajko, Piotr, 14  
Nichoha, Vitalij, 1A  
Nojszewska, Monika, 0F, 0G, 0H  
Okoń-Fafara, M., 0D, 0E, 1B  
Oryszczak, Wojciech, 04  
Park, Hyuk, 04  
Pasek, Przemysław, 1C  
Pasternak, Mateusz, 0C, 0L, 0T, 12  
Pawłowski, Piotr, 0Z  
Perka, Bogdan, 0M, 1D  
Pietkiewicz, Tadeusz, 0U  
Pietrański, Jerzy, 0L, 0W, 12  
Piotrowski, Zbigniew, 0J, 0V  
Piwowarski, Karol, 0M, 1D  
Polak, Rafał, 0R, 0Y, 1E  
Potulska-Chromik, Anna, 0F, 0G, 0H  
Prokopiuk, A., 0K  
Prudyus, Ivan, 0C  
Rajkowski, Adam, 18  
Romanik, Janusz, 1K  
Różański, Grzegorz, 0S  
Różycki, Andrzej, 08  
Rutkowski, Adam, 09  
Rychlewski, Michał, 08  
Serafin, Piotr, 17, 1F  
Sierpułowski, Robert, 0R, 0Y  
Sikorska-Łukasiewicz, K., 1G  
Skibko, Z., 1I  
Słowak, Paweł, 0N  
Sosnowski, Tomasz, 00  
Stachno, A., 1I  
Stadnik, Hubert, 09, 1H  
Stawiarski, Kamil, 03, 05  
Stec, B., 1H  
Storozh, Volodymyr, 1A  
Suproniuk, Marek, 0M, 1D, 1I  
Susek, Waldemar, 0A, 1J  
Szabra, D., 0K  
Szczepaniak, Zenon, 07, 1J

Szczepankiewicz, Karolina, 04  
Szkop, Emil, 08  
Teodorczyk, M., 0M  
Wajszczyk, Bronisław, 0E, 15, 1B  
Wicik, Robert, 0Q  
Wilgucki, Kamil, 1K  
Wojtczak, Marta, 0J  
Wojtyra, Damian, 0Y  
Woźniak, Martyna, 08  
Zajac, Marcin, 19  
Zieliński, Kacper, 1F  
Zubel, Krzysztof, 1K  
Zygmunt, Marek, 02



# Conference Committee

## *Conference Chair*

**Piotr Kaniewski**, Military University of Technology (Poland)

## *Deputy Conference Chairs*

**Krzysztof S. Kulpa**, Warsaw University of Technology (Poland)

**Robert Szelebaum**, PIT-RADWAR S.A. (Poland)

## *Secretary*

**Stanislaw Konatowski**, Military University of Technology (Poland)

## *Program Committee*

**Zbigniew Bielecki**, Military University of Technology (Poland)

**Tadeusz Brenner**, PIT-RADWAR S.A. (Poland)

**Andrzej P. Dobrowolski**, Military University of Technology (Poland)

**Jacek Jakubowski**, Military University of Technology (Poland)

**Pawel Kabacik**, Wrocław University of Science and Technology (Poland)

**Piotr Kaniewski**, Military University of Technology (Poland)

**Ryszard J. Katulski**, Gdansk University of Technology (Poland)

**Michal Kedzierski**, Military University of Technology (Poland)

**Stanislaw Konatowski**, Military University of Technology (Poland)

**Krzysztof Kopczynski**, Military University of Technology (Poland)

**Krzysztof S. Kulpa**, Warsaw University of Technology (Poland)

**Dariusz Laskowski**, Military University of Technology (Poland)

**Czeslaw Lesnik**, Military University of Technology (Poland)

**Mateusz Malanowski**, Warsaw University of Technology (Poland)

**Jerzy Milosz**, PIT-RADWAR S.A. (Poland)

**Jacek Misiurewicz**, Warsaw University of Technology (Poland)

**Marek Nałęcz**, Warsaw University of Technology (Poland)

**Stephen D. O'Regan**, U.S. Embassy in The Czech Republic  
(Czech Republic)

**Mateusz Pasternak**, Military University of Technology (Poland)

**Jerzy Pietrasinski**, Military University of Technology (Poland)

**Zbigniew Piotrowski**, Military University of Technology (Poland)

**Witold A. Pleskacz**, Warsaw University of Technology (Poland)

**Ivan Prudyus**, Lviv Polytechnic National University (Ukraine)

**Piotr Samczynski**, Warsaw University of Technology (Poland)

**Edward Sędek**, UTP University of Science and Technology (Poland)

**Piotr Slobodzian**, Wrocław University of Science and Technology (Poland)

**Bogusław Smólski**, Committee of Electronics and Telecommunications,  
Polish Academy of Sciences (Poland)  
**Cezary Specht**, Gdynia Maritime University (Poland)  
**Bronisław Stec**, Military University of Technology (Poland)  
**Marek Suchanski**, Military Communication Institute (Poland)  
**Jarosław Sulkowski**, Air Force Institute of Technology (Poland)  
**Waldemar Susek**, Military University of Technology (Poland)  
**Zenon Szczepaniak**, Military University of Technology (Poland)  
**Robert Szelenbaum**, PIT-RADWAR S.A. (Poland)  
**Ryszard Szpleć**, Military University of Technology (Poland)  
**Piotr Szymański**, PIT-RADWAR S.A. (Poland)  
**Ewa Świercz**, Białystok University of Technology (Poland)  
**Zbigniew Watral**, Military University of Technology (Poland)  
**Wojciech Wojtasiak**, Warsaw University of Technology (Poland)

#### *Session Chairs*

Opening Session

**Jerzy Miłosz**, PIT-RADWAR S.A. (Poland)

1A Radiolocation

**Jerzy Pietrasinski**, Military University of Technology (Poland)

1B Microwave Technique

**Waldemar Susek**, Military University of Technology (Poland)

2A Radar Technique I

**Tadeusz Brenner**, PIT-RADWAR S.A. (Poland)

2B Biomedical Electronics

**Andrzej P. Dobrowolski**, Military University of Technology (Poland)

3A Radar Technique II

**Jacek Misiurewicz**, Warsaw University of Technology (Poland)

3B Optoelectronics

**Krzysztof Kopczynski**, Military University of Technology (Poland)

4A Communication Devices and Systems

**Marek Suchanski**, Military Communication Institute (Poland)

4B Signal and Data Processing

**Zbigniew Watral**, Military University of Technology (Poland)

5A Electronic Warfare

**Zbigniew Piotrowski**, Military University of Technology (Poland)

5B Unmanned Systems  
**Dariusz Laskowski**, Military University of Technology (Poland)

Poster Session  
**Zenon Szczepaniak**, Military University of Technology (Poland)



## Introduction

For fourteen years, the scientific-technical Radioelectronic Systems Conference (RSC) has provided a national forum for the radioelectronics community, facilitating networking and the exchange of knowledge and experience between representatives of academies, research institutes, industry, and national institutions involved in the use and construction of devices and systems using radio waves. Its main purpose is to assess and present the current state and trends in the development of radioelectronic devices and systems, with a special focus on the achievements of Polish scientific and industrial entities.

This year's conference was the Tenth Jubilee edition, which motivated me to give a brief review of its history. The RSC conference was originally organized by the Institute of Radioelectronics of the Faculty of Electronics of the Military University of Technology, Warsaw, Poland, in the year 2005, in Soczewka, near Plock. In terms of content, it was a continuation of a conference entitled "Problems of Contemporary Radiolocation" organized in the years 1978, 1981, 1988, 1993, and 1998 by the Institute of Radiolocation (the previous name for the Institute of Radioelectronics). It also drew from a tradition of seminars on "Radar Signal Processing" led by the Telecommunications Research Institute, as well as on a conference called, "Control in Radiolocation and Aerial Objects" organized in Jelenia Gora by the Higher Military School of Radioelectronics and the Military University of Technology.

As the names of the sources of the RSC conference indicate, one of its most important scientific fields from the very beginning was radiolocation. This scientific field was also featured in another national conference, highly renowned among the Polish radar community, the Scientific-Technical Conference on Radiolocation, organized annually by the Telecommunications Research Institute. Due to the similar scope and circle of participants, in 2011 it was decided that both conferences would be organized jointly with a fresh approach and under the common name "Days of Radiolocation". This edition is the seventh time the RSC conference has been organized in this way. The conference locations so far have been Soczewka (three times in 2005, 2007, and 2009), Rynia (2011), Sobienie Szlacheckie (2012), and Jachranka (five times in 2013, 2014, 2015, 2017, and 2019).

Although the RSC conference has always been strongly connected to radiolocation, since the beginning its ambition has also been to present a wider scope of subjects of contemporary radioelectronics and complementing fields. This scope has gradually expanded and currently includes acoustics and acoustoelectronics, antennas and microwaves, biomedical electronics, measurement devices and systems, optoelectronics, radar technology, radionavigation, radioelectronics for space applications, signal and data processing in radioelectronics, special devices and systems, telecommunication devices and systems, and unmanned systems.

The group of institutions interested in actively participating in the conference is also systematically expanding, which encourages the integration of the community dealing with the issues of radioelectronic devices and systems.

The 10th RSC conference was supported once again by the International Society for Optics and Photonics (SPIE), ensuring high review standards and resulting in an increase in the quality of the presented content. In addition, the conference was supported by the Honorary Patronage of the National Security Bureau, a patronage of the Polish Space Agency, and a medial patronage of Polska Zbrojna Magazine.

**Piotr Kaniewski**