

PROCEEDINGS OF SPIE

# ***Open Architecture/Open Business Model Net-Centric Systems and Defense Transformation 2023***

**Raja Suresh**  
*Editor*

**2–4 May 2023**  
**Orlando, Florida, United States**

*Sponsored and Published by*  
SPIE

**Volume 12544**

Proceedings of SPIE 0277-786X, V. 12544

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

Open Architecture/Open Business Model Net-Centric Systems and Defense Transformation 2023,  
edited by Raja Suresh, Proc. of SPIE Vol. 12544, 1254401 · © 2023 SPIE  
0277-786X · doi: 10.1117/12.2690352

Proc. of SPIE Vol. 12544 1254401-1

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 *Open Architecture/Open Business Model Net-Centric Systems and Defense Transformation 2023*, edited by Raja Suresh, Proc. of SPIE 12544, Seven-digit Article CID Number (DD/MM/YYYY); (DOI URL).

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

ISBN: 9781510662049  
ISBN: 9781510662056 (electronic)

Published by

**SPIE**

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time)

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

Copyright © 2023 Society of Photo-Optical Instrumentation Engineers (SPIE).

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 fees. To obtain permission to use and share articles in this volume, visit Copyright Clearance Center 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.

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:** A unique citation identifier (CID) number is assigned to each article in the Proceedings of SPIE 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 *Conference Committee*

---

**SESSION 1**     **SELF-ORGANIZING, COLLABORATIVE, UNMANNED ROBOTIC TEAMS I: JOINT SESSION WITH CONFERENCES 12544 AND 12549**

---

- 12544 02     **Drone-hosted autonomous radio mesh activity (DHARMA)** [12544-1]
- 12544 03     **What, how, and when? A hybrid system approach to multi-region search and rescue** [12544-2]
- 12544 04     **The implementation of modular, extensible, interoperable autonomy (MEIA) for an ArduCopter-equipped drone executing various missions** [12544-3]
- 12544 05     **Underwater swarm formation control with distributed beamforming** [12544-4]
- 12544 06     **Graph-based autonomy behavior classification** [12544-5]

---

**SESSION 2**     **SELF-ORGANIZING, COLLABORATIVE, UNMANNED ROBOTIC TEAMS II: JOINT SESSION WITH CONFERENCES 12544 AND 12549**

---

- 12544 07     **Control algorithms for guidance of autonomous flying agents using reinforcement learning** [12544-6]
- 12544 08     **mTITAN: multi-domain tactical intelligent teaming and autonomous navigation** [12544-7]
- 12544 09     **Target defense against a sequentially arriving cooperative intruder team** [12544-8]
- 12544 0B     **Terrain-aware autonomous robot navigation in outdoor environments** [12544-27]

---

**SESSION 3**     **MULTI-AGENT AUTONOMY**

---

- 12544 0D     **Tactical behaviors for autonomous maneuver: collaborative research program (TBAM-CRP)** [12544-12]
- 12544 0G     **Scaling up multi-agent patrolling in urban environments** [12544-17]
- 12544 0H     **Multi-agent reinforcement learning for UAV sensor management** [12544-18]

---

**SESSION 4 IMAGE PROCESSING AND PNT TECHNOLOGIES**

---

- 12544 0I **StegAI: detecting steganography with deep learning** [12544-19]
- 12544 0J **Frequency-based aerial video recognition** [12544-21]
- 12544 0K **Revitalizing reference architectures through modularity** [12544-22]
- 12544 0L **The PNT operating system (pntOS): a plug-in approach for rapid development and prototyping** [12544-23]
- 12544 0M **ASPN 2023: your community-developed PNT standard** [12544-24]
- 12544 0N **A video surveillance-based face image security system using post-quantum cryptography** [12544-20]

---

**SESSION 5 ARTIFICIAL INTELLIGENCE/MACHINE LEARNING METHODS**

---

- 12544 0O **Artificial intelligence to assist ground troop formation identification through tactical tracks** [12544-25]
- 12544 0P **Artificial intelligence to assist weapon package selection for airborne weapon delivery** [12544-28]
- 12544 0Q **Behavior analysis of search and rescue operations employing human-machine teaming** [12544-29]
- 12544 0R **Creating an interface between behavior-modeling software and a robotic simulation environment** [12544-30]

---

**SESSION 6 OPEN ARCHITECTURE SYSTEMS AND AUTONOMY**

---

- 12544 0S **Modular, extensible, interoperable autonomy: an autonomy architecture for the Internet of Military Things and the future of warfare** [12544-31]
- 12544 0T **A prototype architecture of smart sensor network** [12544-33]
- 12544 0U **Interoperability of armed forces unmanned systems: the INTERACT project** [12544-35]
- 12544 0V **Using metareasoning to improve autonomous robot planning** [12544-36]
- 12544 0W **State machine execution traces for verifying and validating robot behaviors** [12544-37]

**POSTER SESSION**

---

12544 0X **Doctrine informed maneuver in a large Starcraft2 environment [12544-15]**



# Conference Committee

## *Symposium Chairs*

**Tien Pham**, The MITRE Corporation (United States)  
**Douglas R. Droege**, L3Harris Technologies, Inc. (United States)

## *Symposium Co-chairs*

**Augustus W. Fountain III**, University of South Carolina (United States)  
**Teresa L. Pace**, L3Harris Technologies, Inc. (United States)

## *Program Track Chairs*

**Latasha Solomon**, DEVCOM Army Research Laboratory  
(United States)

## *Conference Chair*

**Raja Suresh**, General Dynamics Mission Systems (United States)

## *Conference Program Committee*

**Emily A. Doucette**, Air Force Research Laboratory (United States)  
**Patrick Jungwirth**, U.S. Army Research Laboratory (United States)  
**Wilmuth Muller**, Fraunhofer-Institut für Optronik, Systemtechnik und  
Bildauswertung IOSB (Germany)  
**Hoa G. Nguyen**, Office of Naval Research Global (Japan)  
**Brett H. Piekarski**, DEVCOM Army Research Laboratory (United States)  
**John Polson**, General Dynamics Mission Systems (United States)  
**Jonathan D. Shaver**, Air Force Research Laboratory (United States)  
**Jason R. Stack**, Office of Naval Research (United States)

