Conference Special Events
The following meals and events are all included in all full-conference registrations. Single day registrations include events taking place on the day the attendee is registered.

Informal Luncheon
Tuesday, April 21, 12:15 p.m. - 1:15 p.m., Exhibit Hall

Exhibitor Hosted Reception
Tuesday, April 21, 5:30 p.m. - 7:00 p.m., Exhibit Hall

Informal Luncheon
Wednesday, April 22, 1:00 p.m. – 2:20 p.m., Exhibit Hall

Awards Luncheon
Thursday, April 23, 12:15 p.m. - 1:45 p.m.
(late arrivals cannot be served after 12:45 p.m.)

The IEEE will present the Kershner Award and Walter Fried Award. This event is included in the price of a full-conference or Friday-only registration. Guest tickets may be purchased onsite for $70 each.

For Speakers and Session Chairs
A mandatory Speakers’ Breakfast will be held at 7:30 a.m. Tuesday through Thursday. This event is for session chairs and the presenting author (for both primary and alternate presentations), who are presenting that day only. Names will be checked at the door. Please attend the Speakers’ Breakfast the morning of your presentation only.

Registration Desk Hours
- Monday: 8:30 a.m. - 5:00 p.m.
- Tuesday: 7:30 a.m. - 5:30 p.m.
- Wednesday: 7:30 a.m. - 5:30 p.m.
- Thursday: 7:30 a.m. - 2:00 p.m.

Online Access to Technical Papers and Presentations
Qualified attendees may download copies of conference papers online for FREE by logging in to the ION website at www.ion.org/plans. Only papers provided to the ION by the presenting author will be available. If a desired document is not available, we recommend you contact the author directly. Official conference proceedings will be distributed electronically in May to all eligible conference participants.

Mobile Conference Site
Access the technical program, exhibitor listing, and other conference information from your mobile device at m.ion.org.

Photography Policy
Your presence at PLANS constitutes your agreement to be photographed, filmed, videotaped or otherwise recorded by conference management, or its agents, and your agreement that your image or voice may be distributed in print or electronic communications media without any compensation being paid to you. Video recording by participants is not allowed without written permission of ION during any portion of the conference. Photographs of copyrighted presentations are for personal use only and are not to be reproduced or distributed. Do not photograph any images labeled as proprietary. Flash photography, or any form of photography that disturbs those around you, is prohibited.
### Tutorial Sessions

<table>
<thead>
<tr>
<th>Monday, April 20</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contemporary and Emerging Inertial Sensor Technologies</strong></td>
</tr>
<tr>
<td>9:00 a.m. - 12:30 p.m.</td>
</tr>
<tr>
<td><strong>Alternative Navigation Methods Exploiting Integration with Inertial Measurements</strong></td>
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<tr>
<td><strong>Introduction to Inertial Navigation Systems, Kalman Filtering and Integrated Navigation</strong></td>
</tr>
<tr>
<td>1:30 p.m. - 5:00 p.m.</td>
</tr>
<tr>
<td><strong>Fundamentals of Nonlinear Recursive Estimation</strong></td>
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<tr>
<td>1:30 p.m. - 5:00 p.m.</td>
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### Technical Sessions: Track A

<table>
<thead>
<tr>
<th>Tuesday, April 21</th>
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<tbody>
<tr>
<td>A1: Inertial Measurement Units (IMU)</td>
</tr>
<tr>
<td>8:30 a.m. - 12:15 p.m.</td>
</tr>
<tr>
<td>A2: Advances in MEMS-based Inertial Sensors and Inertial Measurement Units (Invited Session)</td>
</tr>
<tr>
<td>1:45 p.m. - 5:30 p.m.</td>
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</table>

### Technical Sessions: Track B

<table>
<thead>
<tr>
<th>Tuesday, April 21</th>
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<tbody>
<tr>
<td>B1: Precise GNSS Positioning</td>
</tr>
<tr>
<td>8:30 a.m. - 12:15 p.m.</td>
</tr>
<tr>
<td>B2: GNSS Resilience to Interference, Jamming, and Spoofing</td>
</tr>
<tr>
<td>1:45 p.m. - 5:30 p.m.</td>
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### Technical Sessions: Track C

<table>
<thead>
<tr>
<th>Tuesday, April 21</th>
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<tbody>
<tr>
<td>C1: Navigation Using Environmental Features</td>
</tr>
<tr>
<td>8:30 a.m. - 12:15 p.m.</td>
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<tr>
<td>1:45 p.m. - 5:30 p.m.</td>
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### Technical Sessions: Track D

<table>
<thead>
<tr>
<th>Tuesday, April 21</th>
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</thead>
<tbody>
<tr>
<td>D1: Space Navigation and Observation</td>
</tr>
<tr>
<td>8:30 a.m. - 12:15 p.m.</td>
</tr>
<tr>
<td>D2: Robotic and Indoor Navigation</td>
</tr>
<tr>
<td>1:45 p.m. - 5:30 p.m.</td>
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</tbody>
</table>

### Technical Sessions: Track A

<table>
<thead>
<tr>
<th>Wednesday, April 22</th>
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</thead>
<tbody>
<tr>
<td>A3: Alternative Sensors for Aiding INSs and Precision Timing</td>
</tr>
<tr>
<td>10:00 a.m. - 1:00 p.m.</td>
</tr>
<tr>
<td>A4: Integrated Inertial Navigation Systems</td>
</tr>
<tr>
<td>2:20 p.m. - 6:00 p.m.</td>
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</table>

### Technical Sessions: Track B

<table>
<thead>
<tr>
<th>Wednesday, April 22</th>
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<tbody>
<tr>
<td>B3: Atmospheric Effects</td>
</tr>
<tr>
<td>10:00 a.m. - 1:00 p.m.</td>
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<tr>
<td>B4: GNSS Integrity and Augmentation Systems</td>
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<tr>
<td>2:20 p.m. - 6:00 p.m.</td>
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### Technical Sessions: Track C

<table>
<thead>
<tr>
<th>Wednesday, April 22</th>
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<tbody>
<tr>
<td>C3: Positioning with Non-GNSS Radio Signals (Invited Session)</td>
</tr>
<tr>
<td>10:00 a.m. - 1:00 p.m.</td>
</tr>
<tr>
<td>C4: Vision-based Navigation Systems</td>
</tr>
<tr>
<td>2:20 p.m. - 6:00 p.m.</td>
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### Technical Sessions: Track D

<table>
<thead>
<tr>
<th>Wednesday, April 22</th>
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<tbody>
<tr>
<td>D3: Marine Vehicle Navigation</td>
</tr>
<tr>
<td>10:00 a.m. - 1:00 p.m.</td>
</tr>
<tr>
<td>D4: Autonomous Vehicle Navigation in Challenging Environments (Invited Session)</td>
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<tr>
<td>2:20 p.m. - 6:00 p.m.</td>
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### Thursday, April 23

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>A5a: High Performance Inertial Sensor Technologies</td>
</tr>
<tr>
<td>8:30 a.m. - 10:05 a.m.</td>
</tr>
<tr>
<td>A5b: Small Size or Low Cost Inertial Sensor Technologies</td>
</tr>
<tr>
<td>10:35 a.m. - 12:15 p.m.</td>
</tr>
<tr>
<td>A6a: Frontiers of GNSS (Invited Session)</td>
</tr>
<tr>
<td>1:45 p.m. - 5:00 p.m.</td>
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<tr>
<td>A6b: Receiver Design, Signal Processing, and Antenna Technology 1</td>
</tr>
<tr>
<td>1:45 p.m. - 3:25 p.m.</td>
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</table>

### Awards Luncheon

<table>
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<tbody>
<tr>
<td>B6a: Frontiers of GNSS (Invited Session)</td>
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<tr>
<td>1:45 p.m. - 5:00 p.m.</td>
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<tr>
<td>B6b: Receiver Design, Signal Processing, and Antenna Technology 2</td>
</tr>
<tr>
<td>1:45 p.m. - 3:25 p.m.</td>
</tr>
<tr>
<td>C6: Collaborative and Networked Navigation</td>
</tr>
<tr>
<td>1:45 p.m. - 5:00 p.m.</td>
</tr>
<tr>
<td>D6a: Ground Vehicle Navigation</td>
</tr>
<tr>
<td>1:45 p.m. - 5:00 p.m.</td>
</tr>
<tr>
<td>D6b: Aerial Vehicle Navigation 2</td>
</tr>
<tr>
<td>3:30 p.m. - 5:00 p.m.</td>
</tr>
</tbody>
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**HOTEL FLOOR PLANS**

[Ballroom Level Diagram]

[Plaza Level Diagram]
Pre-conference tutorials have been organized to provide in-depth learning prior to the start of the technical program. All courses will be taught in a classroom setting. Electronic notes will be made available to registered tutorial attendees from the conference website one week prior to the course; tutorial registrants are encouraged to download notes in advance of courses. ION reserves the right to cancel a portion of the tutorial program based on availability of the instructor.

**Alternative Navigation Methods Exploiting Integration with Inertial Measurements**

**Date:** Monday, April 20, 2020  
**Time:** 9:00 a.m. - 12:30 p.m.

**Registration Fee:**  
$400 if paid on or before August 25  
$450 if paid after August 25

This tutorial provides an introduction to the latest technology trends for navigating in difficult urban and indoor environments where the performance of typical Global Navigation Satellite System (GNSS) receivers is deteriorated or absent. This introduction will shortly discuss three broad categories of alternative navigation (Alt-Nav) techniques including image/Ladar/Doppler/dead-reckoning aiding of inertial sensors, beacon-based navigation (including pseudolites), and navigation using signals-of-opportunity such as WiFi signals. Then the course will focus on the latest alternative navigation technologies based on electro-optical techniques specifically. The Alt-Nav technologies presented include laser- and image-aided INS and Simultaneous Localization and Mapping (SLAM) methods using laser and imaging sensors. In the former methods, tight integration with an INS should lead to navigation performance similar to that achieved in today’s GPS/INS integrations. The discussion includes the basic principles of integration with an IMU; EO/IMU integration mechanizations; the use of correlation techniques, feature-based techniques or optical-flow-based techniques; the use of a priori information such as terrain and feature databases; and SLAM approaches.

**Course Outline:**

- Introduction to alternative navigation  
- Alternative navigation categories  
- Basic principles of integration with an IMU  
- EO/IMU integration mechanizations  
- Correlation techniques, feature-based techniques or optical-flow-based techniques  
- Use of passive and active electro-optical sensors to aid the inertial  
- Passive EO sensors: image-based navigation using features  
- Active EO sensors: ladar-based navigation using correlation and feature based techniques  
- Simultaneous Localization and Mapping approaches  
- Integration of image-based and Ladar-based sensors

**Dr. Maarten Uijt de Haag** is a Professor in the Institute of Aeronautics and Astronautics at the Technical University of Berlin (TU Berlin) where he leads the Chair for Flight Guidance and Air Traffic. Before this, Dr. Uijt de Haag was Professor at Ohio University and a Principal Investigator (PI) with its Avionics Engineering. He obtained his M.S.E.E. from Delft University and a Ph.D. in Electrical Engineering from Ohio University. He has authored or co-authored over 180 navigation-related publications and eight book chapters, is a senior member of the IEEE, a member of the ION, an Associate Fellow of the AIAA, and an Associate Fellow of the Royal Institute of Navigation. Dr. Uijt de Haag received the ION's 2008 Thomas L. Thurlow Award for contributions to laser-based navigation and integrity monitors for synthetic vision systems.
Pre-conference tutorials have been organized to provide in-depth learning prior to the start of the technical program. All courses will be taught in a classroom setting. Electronic notes will be made available to registered tutorial attendees from the conference website one week prior to the course; tutorial registrants are encouraged to download notes in advance of courses. ION reserves the right to cancel a portion of the tutorial program based on availability of the instructor.

**Contemporary and Emerging Inertial Sensor Technologies**

**Date:** Monday, April 20, 2020  
**Time:** 9:00 a.m. - 12:30 p.m.

**Registration Fee:**  
$400 if paid on or before August 25  
$450 if paid after August 25

This course will present an overview of current state-of-the art inertial instrument technology and how emerging developments in nano and micro-scale fabrication, solid-state optics and cold atom technologies are influencing gyroscope and accelerometer design. The course will initially focus on the recent developments in MEMS-based inertial instruments and how MEMS technology is revolutionizing the inertial guidance navigation and control (GN&C) industry. Current industry trends will be discussed along with examples of MEMS inertial technology in the commercial, military and space sectors, including advanced systems, which integrate inertial MEMS with GPS.

New developments in inertial instrument design will follow with discussion of how advanced nano and microfabrication methods, new solid state optical component developments and cold atom interferometry are being exploited in the next generation of precision gyro and accelerometer designs.

Suitable for experienced inertial instrument practitioners, it will also be of interest to novice developers as it will cover an overview of basic inertial sensing principles, and detailed discussion of gyroscope and accelerometer designs. This course will appeal to R&D, systems and manufacturing engineers, managers and executives, and will conclude with a discussion on the future direction of advanced inertial technologies.

**Course Outline**

- Overview of Inertial Sensing  
- MEMS Accelerometers and Gyroscopes  
- Emerging Inertial Sensors  
- Emerging INS Applications and Integration  
- Future Direction of Inertial Technology

**Ralph Hopkins** is a Distinguished Member of the technical staff and group leader in the Positioning Navigation and Timing (PNT) Division at Draper where he is responsible for the design and development of inertial instruments and sensors. Ralph has served as technical director of advanced inertial instrument development programs including strategic, navigation and tactical grade gyroscopes and accelerometers. He is an invited speaker for short course tutorials on inertial instruments and inertial technology and has presented internationally for the NATO Science Technology Organization sponsored lecture series and symposia on navigation technology.
Pre-conference tutorials have been organized to provide in-depth learning prior to the start of the technical program. All courses will be taught in a classroom setting. Electronic notes will be made available to registered tutorial attendees from the conference website one week prior to the course; tutorial registrants are encouraged to download notes in advance of courses. ION reserves the right to cancel a portion of the tutorial program based on availability of the instructor.

Fundamentals of Nonlinear Recursive Estimation

Date: Monday, April 20, 2020
Time: 1:30 p.m. - 5:00 p.m.

Registration Fee:
$400 if paid on or before August 25
$450 if paid after August 25

This course presents an overview of estimation techniques suitable for systems with nonlinearities that are not well suited to traditional linear or extended Kalman filter algorithms. The course begins with an overview of the generalized recursive estimation problem and associated notation and conventions. Next, the limitations of applying linear theory to nonlinear problems are addressed, along with techniques for compensating for these adverse effects, including a brief overview of the traditional extended Kalman filter and Gaussian sum techniques. In addition, the mathematical effects of system nonlinearities on random processes are presented and discussed along with computational techniques for efficiently capturing this information, which serves as the foundation for the development of many nonlinear estimators. Next, the unscented Kalman filter (UKF) and particle filters (PF) are presented and analyzed using multiple examples. Common limitations of nonlinear estimators are addressed and hybrid solutions are discussed including Rao-Blackwell marginalization approaches.

The course concludes with a discussion and qualitative comparison of the strengths and weaknesses of various recursive estimation techniques from linear Kalman filtering to particle filtering, and their applicability to various problem spaces. Numerous Matlab examples are presented to illustrate sample nonlinear estimation algorithms and performance.

This course will be presented at an engineering level with the goal of understanding the fundamental concepts behind current nonlinear estimation algorithms and how they compare to traditional approaches. The course is appropriate for engineers and scientists with linear and extended Kalman filter experience with an interest in the potential benefits of nonlinear estimation algorithms for difficult problems. The “Fundamentals of Kalman Filtering” sequence by Dr. Gewal is a recommended prerequisite for students wishing to enhance their background prior to this course.

Dr. Michael J. Veth, Ph.D., is the president and CEO of Veth Research Associates. He leads a team of engineers dedicated to pursuing novel solutions in autonomous navigation, control, and tracking applications for GNSS-denied and degraded environments. He received his BSEE from Purdue University and a Ph.D. in Electrical Engineering from the Air Force Institute of Technology. He is a member of the ION, a Senior Member of the IEEE, and a graduate of the US Air Force Test Pilot School.
Pre-conference tutorials have been organized to provide in-depth learning prior to the start of the technical program. All courses will be taught in a classroom setting. Electronic notes will be made available to registered tutorial attendees from the conference website one week prior to the course; tutorial registrants are encouraged to download notes in advance of courses. ION reserves the right to cancel a portion of the tutorial program based on availability of the instructor.

**Introduction to Inertial Navigation Systems, Kalman Filtering and Integrated Navigation**

**Date:** Monday, April 20, 2020  
**Time:** 1:30 p.m. - 5:00 p.m.

**Registration Fee:**  
$400 if paid on or before August 25  
$450 if paid after August 25

This course introduces the main principles of integrated navigation, without overloading the participant with underlying mathematical complexity. A detailed explanation of integrated navigation system design can be quite overwhelming at first. Yet, it is possible to introduce simpler implementation examples in order to explain key concepts. The course begins with the simplest one-dimensional (1D) inertial mechanization (integration of acceleration into velocity and position) and will gradually progress through 2D and 3D INS cases and review of Kalman filtering to an integrated filter for range-domain sensor-fusion. Key concepts will be illustrated with Matlab-based simulation examples. While the course will not consider advanced topics, simplified mechanizations offered in this course are generally still applicable for cases of low-cost inertial sensors (such as consumer-grade MEMS) where higher-order effects (such as, for example, Coriolis effect) stay below the level of sensor errors.

Main topics will include:

- Strap-down inertial navigation: from the simplest 1D case to a 3D system mechanization.
- Introduction to Kalman filtering:
  - Kalman filter as a recursive formulation of one-dimensional averaging;
  - Extension to multi-dimensional cases;
  - Modeling system dynamics and trade-offs between system noise and measurement noise; and
  - Range-domain complementary Kalman filter for the INS-based sensor fusion.

**Dr. Andrey Soloviev** is a principal at QuNav where he works on a variety of navigation mechanizations for GNSS-degraded and GNSS-denied environments. His research focuses on all aspects of multi-sensor fusion and GNSS signal processing for navigation applications. He is a recipient of the ION Early Achievement Award.
A1: Inertial Measurement Units (IMU)

Date: Tuesday, April 21, 2020
Time: 8:30 a.m. - 12:15 p.m.
Room: Pavilion Ballroom East

Session Chairs:

Burgess Johnson
Honeywell
Sam Dimashkiie
EMCORE

8:35. Determination of Allan Variance Coefficients Using Genetic Algorithm, Anil Sami Önen and Bagis Altinoz, Roketsan Missile Industries Inc., Turkey

8:57. Compact In-run Navigation Grade IMU, Based on Quartz MEMS, Sergey Zotov, Arvind Srivastava, Ken Kwon, Jeremy Frank, Erwin Parco, Semen Shtigluz, Kenneth Lyons, Michael Frazee, David Hoyh, Albert Lu, Emcore/Systron Donner Inertial


9:43. Research on the Calibrated Method for MEMS Magnetometer Arrays, Zetao Guo, Xiang Xu, School of Electronic and Information Engineering, Soochow University, China; Tao Zhang, School of Instrument Science and Engineering, Southeast University, China

10:05-10:35, Break. Refreshments in Exhibit Hall

10:40. Novel approach to improve performance of inertial navigation system via neural network, Evgeniy Pukhov and Haim Israel Cohen, Israeli Ministry of Defense, Tel Aviv, Israel

11:03. Dedicated calculation strategy for atom interferometry sensors in inertial navigation, Benjamin Tennstedt, Steffen Schön; Leibniz University Hannover, Institut für Erdmessung (IFE), Germany

11:26. Gyro Bias Estimation with Quasi-static Magnetic Field in Foot-mounted Pedestrian Dead Reckoning, Jae Hong Lee, Soyoung Park, Department of Mechanical & Aerospace Engineering / Automation and Systems Research Institute, Seoul National University, Republic of Korea; Seoung Yun Cho, Department of Robotics Engineering, Kyungil University, Republic of Korea; Chan Gook Park, Department of Mechanical & Aerospace Engineering / Automation and Systems Research Institute, Seoul National University, Republic of Korea

11:48. Analysis of Vibration Error of Resonant Fiber Optic Gyroscope, Weiqi Miao, Fei Yu, Guochen Wang, Wei Gao, Harbin Institute of Technology, China

Lunch in the Exhibit Hall, 12:15 p.m. - 1:15 p.m.
B1: Precise GNSS Positioning
Date: Tuesday, April 21, 2020
Time: 8:30 a.m. - 12:15 p.m.
Room: Pavilion Ballroom West

Session Chairs:

Dr. Miguel Angel Ribot
Albora Technologies, UK

Dr. Kyle O’Keefe
The University of Calgary, Canada

8:35. Solution Separation-based FDE to Mitigate the Effects of Multipath on PPP Integrity, Juan Blanch, Kazuma Gunning, Todd Walter, Stanford University Lance de Groot, Laura Norman, Hexagon Autonomy&Positioning

8:57. Benefits of Zero Position Updates for Robust, Low-cost, Dual-frequency, PPP GNSS / MEMS-IMU Navigation, Sudha Vana, Sunil Bisnath and Nacer Naciri, York University, Canada

9:20. From Single Point to Precise Point Positioning: The Impact on Time Retrieval, C. Gioia, European Commission, Joint Research Centre, Italy; E. Realini, Geomatics Research & Development srl, Italy; D. Borio, European Commission, Joint Research Centre, Italy; A. Gatti, G. Tagliaferro, Geomatics Research & Development srl, Italy

9:43. Assessment of Real-time Multipath Detection with Android Raw GNSS Measurements by Using a Xiaomi Mi 8 Smartphone, Lotfi Massarweh, Deimos Engenharia S.A., Instituto Superior Técnico, Portugal; Marco Fortunato, Sapienza University of Rome, Italy; Ciro Gioia, Joint Research Centre of the European Commission, Italy

10:05-10:35, Break. Refreshments in Exhibit Hall

10:40. Cycle-slip Detection and Repair Using an Array of Receivers with Known Geometry for RTK Positioning, Xiao Hu, Paul Thevenon, Christophe Macabiau, ENAC, Université de Toulouse, France

11:03. GNSS Attitude Determination Using a Constrained Wrapped Least Squares Approach, Xing Liu, Tarig Ballal, Tareq Y. Al-Naffouri, King Abdullah University of Science and Technology (KAUST), Saudi Arabia

11:26. Demonstration of Fused RTK (Fixed) + Inertial Positioning Using Android Smartphone Sensors Only, Mohamed Bochkati, Himanshu Sharma, Thomas Pany, Universität der Bundeswehr München, Germany

11:48. Deployment and Evaluation of a Real-time Kinematic System Using tinc-VPN Software, Xing Liu, Tarig Ballal, Martins Bruvelis, Tareq Y. Al-Naffouri, King Abdullah University of Science and Technology (KAUST), Saudi Arabia

Lunch in the Exhibit Hall, 12:15 p.m. - 1:15 p.m.
C1: Navigation Using Environmental Features

**Date:** Tuesday, April 21, 2020  
**Time:** 8:30 a.m. - 12:15 p.m.  
**Room:** Atrium Ballroom

**Session Chairs:**  
Dr. Dorota Grejner-Brzezinska  
The Ohio State University  
Dr. Li-Ta Hsu  
Hong Kong Polytechnic University, Hong Kong

8:35. Navigation and Estimation Improvement by Environmental-Driven Noise Mode Detection, Jindrich Dunik, Honeywell International, Advanced Technology Europe, Czech Republic and University of West Bohemia, Czech Republic; Oliver Kost, Ondrej Straka, University of West Bohemia, Czech Republic; Erik Blasch, Air Force Research Laboratory, USA

8:57. Recursive Gaussian Processes and Fingerprinting for Indoor Navigation, Tales Imbiriba, Peng Wu, Gerald LaMontain, Deniz Erdogmus, Pau Closas, Electrical and Computer Engineering Dept., Northeastern University

9:20. Joint Train Localization and Track Identification based on Earth Magnetic Field Distortions, Benjamin Siebler, Oliver Heirich, Stephan Sand, German Aerospace Center (DLR), Germany; Uwe D. Hanebeck, Karlsruhe Institute of Technology, Germany

9:43. Celestial Navigation – Correcting the Folklore, Peter F Swaszek, University of Rhode Island; Richard J Hartnett and Kelly C Seals, US Coast Guard Academy

10:05-10:35, Break. Refreshments in Exhibit Hall

10:40. The Utilization of DNN-based Semantic Segmentation for Improving Low-Cost Integrated Stereo Visual Odometry in Challenging Urban Environments, Hany Ragab, Queen’s University, Canada; Mohamed Elhabiby, Ain Shams University, Egypt; Sidney Givigi, Queen’s University, Canada; Aboelmagd Noureldin, Royal Military College, Canada

11:03. Quantifying Feature Association Error in Camera-based Positioning, Chen Zhu, Institute of Communications and Navigation, German Aerospace Center (DLR), Germany; Mathieu Joerger, Virginia Tech; Michael Meurer, Institute of Communications and Navigation, DLR, Germany


11:48. A Hybrid Position Estimation Framework Based on GNSS and Visual Sensor Fusion, Sara Baldoni, Federica Battisti, Michele Brizzi, Roma Tre University, Italy; Alessandro Neri, Roma Tre University and RadioLabs, Italy

**Alternate Presentations:**

1. Rotating GNSS Antenna: Simultaneous LOS and NLOS Multipath Mitigation, Taro Suzuki, Chiba Institute of Technology, Kazuki Matsuo, Yoshiharu Amano, Waseda University, Japan
2. Landmark Aided GPS-denied Navigation for Orchards and Vineyards, Austin Costley and Randall Christensen, Utah State University
3. Towards Real-Time Channel-SLAM Multipath Assisted Positioning, Rostislav Karásek and Christian Gentner, German Aerospace Center (DLR), Germany
4. IoT Localization Systems Based on a Single AoA Estimation Unit: An Application for Smart Pedestrian Crossing, Noori BniLam, Dennis Joosens, Rafael Berkvens, University of Antwerp - imec, IDLab - Faculty of Applied Engineering, Belgium; Jan Steckel, University of Antwerp, Cosys-lab Research Group, Antwerp, Belgium and Flanders Make Strategic Research Center, Belgium; Maarten Weyn, University of Antwerp - imec, IDLab - Faculty of Applied Engineering, Belgium
5. Compressed Smoothing of Pseudo-SLAM for UAV Navigation Applications, Jonghyuk Kim, Centre for Autonomous Systems, University of Technology, Australia; Jose Guivant, University of New South Wales, Australia
6. Effect of Coherent Integration Options on Target Detectability with Bistatic GNSS-based Airborne Receiver, Prahalad Kuthethoor and Andrew Dempster, University of New South Wales, Australia
Lunch in the Exhibit Hall, 12:15 p.m. - 1:15 p.m.
D1: Space Navigation and Observation

Date: Tuesday, April 21, 2020
Time: 8:30 a.m. - 12:15 p.m.
Room: Galleria I/II

Session Chairs:

Dr. Randy Christensen  
Utah State University

Dr. Costantinos Zagaris  
Air Force Institute of Technology

8:35. Development of GNC for Optimal Relative Spacecraft Trajectories, Wyatt Harris, Dax Linville, Joshuah Hess, Richard Cobb, Air Force Institute of Technology


9:20. Effect of Sensor Quality on Relative State Estimation of Formation Flying of Satellites, Russell Babb, Trevor Pratt, Brian Merrell, and Randall Christensen, Utah State University

9:43. Precision Onboard Navigation for LEO Satellite based on Precise Point Positioning, Masaya Murata, Isao Kawano, Koichi Inoue, Japan Aerospace Exploration Agency, Japan

10:05-10:35, Break. Refreshments in Exhibit Hall

10:40. Improve GNSS Orbit Determination by using Estimated Tropospheric and Ionospheric Models, Cazabonne Bryan, Maisonobe Luc, CS Group, France

11:03. Linear Covariance Navigation Analysis of Autonomous Lunar Lander Missions, Dr. Randall Christensen Assistant Professor Utah State University, Dr. David Geller Professor Utah State University, Dr. Michael Hansen Graduate Research Assistant Utah State University

11:26. CubeSat-Based Lunar Map Refinement Utilizing Surface Beacons and a Monocular Camera, Tyler Gardner, Michael Hansen, Natalie Wisniewski, Dr. Randall Christensen, Utah State University

11:48. An End-to-end Process for Local Space Situational Awareness from Optical Observers, David Zuehlke and Troy Henderson, Embry-Riddle Aeronautical University

Alternate Presentations:

1. Demonstration of LEO object detection using GNSS passive radar: A proof of concept, Md Sohrab Mahmud, Sana Ullah Qaisar, Andrew Lambert and Craig Benson, School of Engineering and Information Technology University of New South Wales, Australia

2. Autonomous Navigation of Satellite via Intelligent Factor Graphs Theory, Bing Xiao, Xiwei Wu, Chihang Wu, lingwei Li, Northwestern Polytechnical University, China

3. Systematic Error Analysis of Calculation Error of Starlight Refraction Angle, Zhang Shaoxiong, Beihang University, China

Lunch in the Exhibit Hall, 12:15 p.m. - 1:15 p.m.
A2: Advances in MEMS-based Inertial Sensors and Inertial Measurement Units (Invited Session)

Date: Tuesday, April 21, 2020
Time: 1:45 p.m. - 5:30 p.m.
Room: Pavilion Ballroom East

Session Chairs:

Dr. Andrei Shkel
University of California, Irvine

Dr. Ronald Polcawich
DARPA


3:25 - 3:55, Break. Refreshments in Exhibit Hall

4:00. Vibration Immune, Long-Term Stable and Low Noise Synchronized Mass MEMS Gyroscope for Autonomous Vehicles, Igor Prikhodko, Jeffrey Gregory, John Geen, Carey Merritt, Sam Zhang, Analog Devices, Inc.

4:23. Environmentally-Robust High-Performance Silicon TIMU Chip, Farrokh Ayazi, Georgia Institute of Technology, Haoran Wen, Georgia Institute of Technology, Anosh Daruwalla, Georgia Institute of Technology, Pranav Gupta, Georgia Institute of Technology

4:46. Manufacturing Transition of High-Performance MEMS Gyroscopes, Jeffrey DeNatale, Teledyne Scientific & Imaging; Stephane Martel, Francois Dion and Jonathan Lachance, Teledyne DALSA Semiconductor, Inc.

Exhibitor Hosted Reception, 5:30 p.m. - 7:00 p.m.
B2: GNSS Resilience to Interference, Jamming, and Spoofing

Date: Tuesday, April 21, 2020
Time: 1:45 p.m. - 5:30 p.m.
Room: Pavilion Ballroom West

Session Chairs:

Dr. Daniele Borio
Joint Research Centre, European Union, Italy

Dr. Andrew Dempster
University New South Wales, Australia

1:50. Demonstration of a Multi-Layer Spoofing Detection Implemented in a High Precision GNSS Receiver, Ali Broumandan, Sandy Kennedy, John Schleppe NovAtel Inc., Canada

2:12. Detecting GNSS spoofing using INS for an en route ADS-B equipped aircraft, Birendra Kujur, Samer Khanafseh, and Boris Pervan, Illinois Institute of Technology

2:35. GNSS Spoofing Mitigation Using Multiple Receivers, Niklas Stenberg, Erik Axell, Jouni Rantakokko, Swedish Defence Research Agency, Sweden; Gustaf Hendeby, Linköping University, Sweden

2:58. Spoofing Detection by Distortion of the Correlation Function, Michael Turner, Steve Wimbush, Airbus Defence and Space, UK; Christoph Enneking, Andriy Konovaltsev, German Aerospace Center (DLR), Germany

3:25 - 3:55, Break. Refreshments in Exhibit Hall

4:00. Protecting GNSS-based Services using Time Offset Validation, Kewei Zhang, Marco Spanghero, Panagiotis Papadimitratos, KTH Royal Institute of Technology, Sweden

4:23. Model and Observation of the Impact of JTIDS/MIDS on GNSS C/N0 Degradation, Axel Garcia-Pena, Christophe Macabiau, ENAC, France; Mikael Mabileau, Pierre Durel, GSA, France

4:46. High-rate DFT-based Data Manipulator (HDDM) Algorithm for Effective Interference Mitigation, J. Rossouw van der Merwe, Fabio Garzia, Alexander Rügamer, and Wolfgang Felber, Fraunhofer IIS, Germany

5:08. ITAR Free Smart Antenna Array for Resilient GNSS in Aviation, E. Pérez-Marcos, German Aerospace Center (DLR) & Chair of Navigation, RWTH Aachen University, Germany; L. Kurz, German Aerospace Center (DLR), Germany; M. Cuntz, German Aerospace Center (DLR) & Chair of Navigation, RWTH Aachen University, Germany; S. Caizzone, A. Konovaltsev, German Aerospace Center (DLR), Germany; M. Meurer, German Aerospace Center (DLR) & Chair of Navigation, RWTH Aachen University, Germany

Alternate Presentations:

1. Improved Spatial Processing through High-Fidelity Antenna Modeling, John N. Spitzmiller, Parsons Government Services, Inc.

2. Mitigation of Frequency-Hopped Tick Jamming Signals, Daniele Borio and Ciro Gioia, European Commission, Joint Research Centre, Italy

Exhibitor Hosted Reception, 5:30 p.m. - 7:00 p.m.

Date: Tuesday, April 21, 2020
Time: 1:45 p.m. - 5:30 p.m.
Room: Atrium Ballroom

Session Chairs:

Dr. Ramsey Faragher
Focal Point Positioning, UK

Dr. Jiwon Seo
Yonsei University, South Korea

1:50. Advanced TOA Estimation for Multipath Channels, Rabih Chrabieh, Peter Bagnall, Serdar Sezginer, Nestwave, France


2:35. Implementation and Performance Evaluation of Cellular NB-IoT OTDOA Positioning, Mauro Salomon, Stefan Lippuner, Matthias Korb, Qiuting Huang, ETH Zurich, Switzerland


3:25 - 3:55, Break. Refreshments in Exhibit Hall

4:00. Algorithm for Three-Dimensional Geodetic Positioning Based on Measurements of Automatic Dependent Surveillance-Broadcast Signals, Nicholas A. Baine and Richard A. Gross, Grand Valley State University

4:23. Navigation with Differential Carrier Phase Measurements from Megaconstellation LEO Satellites, Joe Khalife, Mohamad Neinavaie, and Zaher (Zak) Kassas; University of California, Irvine

4:46. Using UWB aided GNSS/INS Integrated Navigation to Bridge GNSS Outages Based on Optimal Anchor Distribution Strategy, Rongge Zhang, Feng Shen, Qinghua Li, Harbin Institute of Technology, China

5:08. Urban Wi-Fi RSSI Analysis along a Public Transport Route for Kinematic Localization, Guenther Retscher and Aizhan Bekenova, Department of Geodesy and Geoinformation, TU Wien, Austria

Alternate Presentations:

1. Compass Aided TDoA Tracking in LoRaWAN Networks, Nico Podevijn, Jens Trogh, David Plets, Michiel Aernouts, Noori BniLam, Rafael Berkvens, Luc Martens, Maarten Weyn, Wout Joseph, University of Ghent - imec,WAVES, Belgium

2. A Dynamic RSSI Fingerprint Matching Method for Low-Cost Indoor Positioning and Tracking Based on Smartphone, Xiaodong Gong, Jingbin Liu, Sheng Yang, Zhenbing Zhang, Zheng Li, Gege Huang, Yu Bai, Xinyi Lei and Ruizhi Chen, State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, China

3. Algorithm Analysis of WKNN and Bayes Estimation in WiFi Fingerprint Localization Method, Wei Gao, Kedong Wang, School of Astronautics, Beihang University, China

Exhibitor Hosted Reception, 5:30 p.m. - 7:00 p.m.
D2: Robotic and Indoor Navigation

**Date:** Tuesday, April 21, 2020  
**Time:** 1:45 p.m. - 5:30 p.m.  
**Room:** Galleria I/II

**Session Chairs:**
- Dr. Mohammed Khider  
- Dr. Vibhor Bageshwar

**1:50. Acoustic Positioning and Navigation System for GNSS Denied/Challenged Environments,** Rohan Kapoor, Alessandro Gardi, and Roberto Sabatini, RMIT University – School of Engineering, Australia

**2:12. Approach for Autonomous Robot Navigation in Greenhouse Environment for Integrated Pest Monitoring,** Smita Tiwari, Yuheng Zheng, Michael Pattinson, NSL, UK; María Campo-Cossio, Raül Arnau, David Obregón, Centro Tecnológico CTC, Spain; Ander Ansuategui, Carlos Tubio, Iker Lluvia, Fundación Tekniker, Spain; Oscar Rey, Inkoa Sistemas, Spain; Jeroen Verschoore, Aerovision BV, Spain; Vojtch Adam, Mendelova Univerzita v Brno, Czech Republic; Joaquin Reyes Gonzalez, European GNSS Agency GSA

**2:35. A Motion Induced Passive Infrared (PIR) Sensor for Stationary Human Occupancy Detection,** Jack Andrews, Oakland University; Meghana Kowsika, University of Michigan - Ann Arbor; Asad Vakil and Jia Li, Oakland University

**2:58. A Power-Efficient BLE augmented GNSS Approach to Site-Specific Navigation,** Zhuangzhuang Dai, Department of Computer Science, University of Oxford, UK; Frank JW Podd, Department of Electrical and Electronic Engineering, University of Manchester, UK

3:25 - 3:55, Break. Refreshments in Exhibit Hall

**4:00. Evaluation of Virtual Reality Tracking Performance For Indoor Navigation,** Rui Wu, Jeevitha Pandurangaiah, Grayson Morgan Blankenship, Christopher Xavier Castro, Shanyue Guan, Andrew Ju, Zhen Zhu, East Carolina University

**4:23. Indoor Localization from Channel State Information with Recurrent Neural Networks,** Jianyuan Yu, R. Michael Buehrer, Bradley Department of Electrical and Computer Engineering, Virginia Tech

**4:46. Deep Learning-Aided Spatial Discrimination for Multipath Mitigation,** Ali Abdallah and Zaher (Zak) Kassas, University of California, Irvine

**5:08. SLAM based Topological Mapping and Navigation,** Wuyang Xue, Rendong Ying, Zheng Gong, Ruihang Miao, Fei Wen, Peilin Liu, Shanghai Jiao Tong University, Shanghai, China

**Alternate Presentations:**

1. **An Enhanced Indoor Ranging Method using CSI Measurements with Extended Kalman Filter,** Jing Jing Wang, Jun Gyu Hwang, Joon Goo Park, Kyungpook National University Graduate school of Electronics Engineering, South Korea

2. **Indoor Localization for Pedestrians with High Accuracy and Usability Based on Smartphones,** Sheng Yang, Jingbin Liu, Zhenbing Zhang, Xiaodong Gong, Gege Huang and Yu Bai, State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, China

3. **Development of a Flexible Hardware and Software Platform for UAV Research,** Sam Christensen, Utah State University

Exhibitor Hosted Reception, 5:30 p.m. - 7:00 p.m.
PLENARY SESSION

Date: Wednesday, April 22, 2020
Time: 8:30 a.m. - 9:30 a.m.
Room: Atrium Ballroom

Session Chairs:

Dr. Mathieu Joerger
Virginia Tech

Dr. Zak Kassas
University of California, Irvine

KEYNOTE SPEAKER

Dr. Bradford W. Parkinson
Edward Wells Professor, Emeritus, Aeronautics and Astronautics (Recalled)
Co-Director Stanford Center for Position, Navigation and Time, Stanford University

Radio Navigation from Marconi to GNSS

- The early pioneers and enablers
- Jimmy Doolittle - the first Aeronautical PhD
- Early systems - Direction and timing
- The first three world-wide system
- Observations - where are we today?

Break in the Exhibit Hall, 9:30 a.m. - 10:00 a.m.
A3: Alternative Sensors for Aiding INSs and Precision Timing

**Date:** Wednesday, April 22, 2020  
**Time:** 10:00 a.m. - 1:00 p.m.  
**Room:** Pavilion Ballroom East

**Session Chairs:**

Dr. Adam Schofield  
CCDC/C5ISR, U.S. Army  
Dr. Charles Toth  
The Ohio State University

**10:05. A Modular Sensor Fusion Approach for Complementary Navigation Sensors,** Kyle Kauffman, John Raquet, Daniel Marietta, IS4S; Adam Schofield, Michael Caporellie, CCDC/C5ISR; Aaron Canciani, Rob Leishman, AFIT

**10:27. An Investigation of GPS-Denied Navigation Utilizing Airborne Synthetic Aperture Radar Images Based on the Range Doppler Algorithm,** Colton Lindstrom, Randall Christensen, Jacob Gunther, Utah State University

**10:49. Application of Neural Network and Improved Untraceable Kalman Filter for GPS/SINS Integration Navigation System,** Di Zhao, Huawei Qian, College of Automation, Harbin Engineering University, China; Feng Shen, School of Instrumentation Science and Engineering, Harbin Institute of Technology, China

**11:11. Global Localization of Ground Vehicles Using Self-Describing Fiducials Coupled with IMU Data,** Justin Whitaker and Randall Christensen, Utah State University


**11:55. Influence of Receiver Clock Modeling in GNSS-based Flight Navigation: Concepts and Experimental Results,** Ankit Jain and Steffen Schön, Institut für Erdmessung, Leibniz University Hannover, Germany

**12:17. Precise Positioning Through a Loosely-coupled Sensor Fusion of GNSS-RTK, INS and LiDAR for Autonomous Driving,** Andreas Schütz, Daniela Sánchez-Morales, Thomas Pany, Institute of Space Technology and Space Applications, Bundeswehr University Munich, Germany

**12:39. Stand-Alone Navigation System Based on Visual SLAM,** Sergey Zotov, Zotov Dynamics, LLC

**Alternate Presentations:**

1. **Monocular Direct Visual Odometry Aid for Low-Cost IMU in Unknown GNSS-denied Environment,** Jun Shi, Institute of Flight System Dynamics, Technical University of Munich, Germany; Yajie Chen, Institute of Photogrammetry and Geoinformation, Leibniz University Hannover, Germany; Johann Dambeck, Florian Holzapfel, Institute of Flight System Dynamics, Technical University of Munich, Germany

2. **Experimental Assessment of Indoors UWB Range Error Mitigation Techniques,** Harris Perakis, School of Rural and Surveying Engineering, National Technical University of Athens (NTUA), Greece; Andrea Masiero, interdepartmental Research Center of Geomatics, University of Padova, Italy; Jelena Gabela, Department of Electrical and Electronic Engineering, The University of Melbourne, Australia; Vassilis Gikas, School of Rural and Surveying Engineering, NTUA, Greece; Guenther Retscher, Department of Geodesy and Geoinformation, TU Vienna University of Technology, Austria; Charles Toth, Department of Civil, Environmental and Geodetic Engineering, The Ohio State University, USA; Salil Goel, Department of Civil Engineering, Indian Institute of Technology, India; Allison Kealy, Department of Geospatial Science, RMIT University, Australia; Zoltán Koppányi, Leica Geosystems, Switzerland; Wioleta Blaszczyk-Bak, Institute of Geodesy of the University of Warmia and Mazury, Poland; Yan Li, Department of Electrical and Electronic Engineering, The University of Melbourne, Australia; Dorota Grejner-Brzezinska, College of Engineering, The Ohio State University, USA

Lunch in Exhibit Hall, 1:00 p.m. - 2:20 p.m.
B3: Atmospheric Effects

Date: Wednesday, April 22, 2020
Time: 10:00 a.m. - 1:00 p.m.
Room: Pavilion Ballroom West

Session Chairs:

Dr. Zhe (Jenny) Yang
University of Colorado Boulder

Dr. Jiyun Lee
KAIST, South Korea

10:05. Geomagnetic Storm Induced Mid-latitude Ionospheric Plasma Irregularities and Their Implications for GPS Positioning over North America: A Case Study, Zhe Yang, University of Colorado, Boulder; Sebastijan Mrak, Boston University; Y. Jade Morton, University of Colorado, Boulder


11:11. Robust Modeling of Tropospheric Delay Dynamics for Sequential Positioning, Elisa Gallon, Illinois Institute of Technology; Mathieu Joerger, Virginia Tech; Boris Pervan, Illinois Institute of Technology

11:33. Alternative Strategy for Estimating Zenith Tropospheric Delay from Precise Point Positioning, Jareer Mohammed, University of Nottingham UK and Civil Engineering Department, College of Engineering, University of Wasit, Iraq; Terry Moore, Chris Hill, Nottingham Geospatial Institute, University of Nottingham, UK; Richard M. Bingley, NERC British Isles continuous GNSS Facility (BIGF), University of Nottingham, UK

11:55. Conjugate Transfer Function Compensation of Ionospheric Refractive Effects, William Krier and Jade Morton, University of Colorado Boulder


12:39. Precision-Aided Partial Ambiguity Resolution Technique for Short to Medium Baseline Positioning, Daniel Medina, Juan Manuel Castro-Arvizu, German Aerospace Center (DLR), Germany; Jordi Vilà-Valls, ISAE-SUPAERO, France; Pau Closas, Northeastern University; Ralf Ziebold, DLR, Germany

Alternate Presentations:

1. Mitigation of High Latitude Ionospheric Scintillation Effects on Precise Point Positioning (PPP) During the September 2019 Geomagnetic Storm, Kai Guo, Marcio Aquino, Sreeja Vadakke Veettil, Chris Hill, Brian Weaver, Nottingham Geospatial Institute, University of Nottingham, UK

2. Evaluation of Scintillation Mitigation Using PLL and DLL Tracking Jitter Models in a Multi-GNSS Kinematic Precise Point Positioning Model, Brian Weaver, Marcio Aquino, Sreeja Vadakke Veettil, Lei Yang, Kai Guo, University of Nottingham, UK

3. Application of Machine Learning to Ionospheric Scintillation Forecast, Yunxiang Liu, Zhe Yang, Y. Jade Morton, University of Colorado Boulder


Lunch in Exhibit Hall, 1:00 p.m. - 2:20 p.m.
C3: Positioning with Non-GNSS Radio Signals (Invited Session)

**Date:** Wednesday, April 22, 2020  
**Time:** 10:00 a.m. - 1:00 p.m.  
**Room:** Atrium Ballroom

**Session Chairs:**

Dr. Gonzalo Seco Granados  
*Universitat Autonoma de Barcelona, Spain*

Dr. Howard Huang  
*Nokia Bell Labs*

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**10:05. Performance Analysis for Autonomous Vehicle 5G-Assisted Positioning in GNSS-Challenged Environments**  
Zohair Abu-Shaban, School of Engineering and IT, University of New South Wales, Australia; Gonzalo Seco-Granados, Department of Telecom and Systems Engineering, Universitat Autònoma de Barcelona, Spain; Craig R. Benson, School of Engineering and IT, University of New South Wales, Australia; Henk Wymeersch, Department of Electrical Engineering, Chalmers University of Technology, Sweden

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**10:27. Reinforcement Learning for UAV Autonomous Navigation, Mapping and Target Detection**  
Anna Guerra, University of Bologna, Italy & Stony Brook University, USA; Francesco Guidi, University of Bologna, Italy; Davide Dardari, University of Bologna, Italy; Petar M. Djuric, Stony Brook University, USA

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**10:49. Location Inference Based on Channel Impulse Response**  
Zehao Yu, Wireless Information and Network Sciences Laboratory, MIT; Zhenyu Liu, Wireless Information and Network Sciences Laboratory, MIT; Florian Meyer, Scripps Institution of Oceanography, UCSD; Andrea Conti, Department of Engineering, University of Ferrara; Moe Z. Win, Laboratory for Information and Decision Systems, MIT

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**11:11. Multipoint Channel Charting with Multiple-Input Multiple-Output Convolutional Autoencoder**  
Chunhua Geng, Howard Huang, and Jack Langerman, Nokia Bell Labs

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**11:33. WiFi-RTT Indoor Positioning**  
Christian Gentner, Markus Ulmschneider, Isabel Kuehner, and Armin Dammann, German Aerospace Center (DLR), Germany

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**11:55. Metric Learning for Fingerprint RSSI-Localization**  
Kevin Elgui, Pascal Bianchi, Télécom Paris, France; Olivier Isson, Renaud Marty, Sigfox, France

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Chun Yang and Andrey Soloviev, QuNav

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**12:39. Combining TDOA and AOA with a Particle Filter in an Outdoor LoRaWAN Network**  
Aernouts Michiel, BniLam Noori, University of Antwerp - imec, IDLab - Faculty of Applied Engineering, Belgium; Podevijn Nico, Plets David, Joseph Wout, University of Ghent - imec, Waves, Belgium; Berkvens Rafael, Weyn Maarten, University of Antwerp - imec, IDLab - Faculty of Applied Engineering, Belgium

**Alternate Presentations:**

1. **Enhanced Multilateration Methods with a Global Approach**, Rabih Chrabieh, Mazen Neifer, Ganda Ouedraogo, Ines Ben Hamida, Peter Bagnall, Nestwave, France

2. **Seamless Navigation using UWB-based Multisensor System**, Vincenzo Di Pietra, Paolo Dabove, Marco Piras, Dept. of Environment, Land and Infrastructure Engineering, Politecnico di Torino, Italy

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Lunch in Exhibit Hall, 1:00 p.m. - 2:20 p.m.
D3: Marine Vehicle Navigation

Date: Wednesday, April 22, 2020
Time: 10:00 a.m. - 1:00 p.m.
Room: Galleria I/II

Session Chairs:

Bryan Hoffman
SPAWAR

Dr. Lonnie Parker
Georgia Tech Research Institute

10:05. Monocular Visual Odometry with Unmanned Underwater Vehicle Using low Cost Sensors, Paolo Dabove, Vincenzo Di Pietra, Marco Piras, Politecnico di Torino, Department of Environment, Land, and Infrastructure Engineering, Italy

10:27. A SINS/DVL Integrated Navigation Algorithm Considering the Impact of Ocean Currents, Jianxiong Wei, Ya Zhang, Pan Jiang, Shiwei Fan, Fei Yu, Harbin Institute of Technology, China

10:49. Underwater Model Aided Navigation Using Constrained Low Dynamic Motion, Scott Koziol and Daniel Drake, Baylor University

11:11. Designing a Ranging Signal for use with VDE R-Mode, Markus Wirsing, Armin Dammann, and Ronald Raulefs, German Aerospace Center (DLR), Germany

11:33. Redesigned Waveforms in the Maritime Medium Frequency Bands, Lars Grundhoefer German Aerospace Center Neustrelitz Germany, Stefan Gewies German Aerospace Center Neustrelitz Germany, Niklas Hehenkamp German Aerospace Center (DLR) Neustrelitz Germany, Giovanni Del Galdo Institute for Information Technology Technische Universität Ilmenau Fraunhofer Institute for Integrated Circuits IIS, Ilmenau Germany

11:55. Machine Learning-Assisted Anomaly Detection in Maritime Navigation Using AIS Data, Sandeep Kumar Singh and Frank Heymann, German Aerospace Center (DLR), Germany

12:17. An Error Compensation Method of DVL Assisted by IMU and Differential GPS, Jianxiong Wei, Ya Zhang, Pan Jiang, Shiwei Fan, Fei Yu, Harbin Institute of Technology, China


Alternate Presentations:

1. A Combinational Underwater Aided Navigation Algorithm Based on ICCP and Shannon Entropy Based Adaptive Fusion Particle Filter, Chao Liu, Wei Gao, Jiaochong Chang, Ya Zhang, Harbin Institute of Technology, China

Lunch in Exhibit Hall, 1:00 p.m. - 2:20 p.m.
A4: Integrated Inertial Navigation Systems

Date: Wednesday, April 22, 2020
Time: 2:20 p.m. - 6:00 p.m.
Room: Pavilion Ballroom East

Session Chairs:

Dr. Yuanxin Wu  
Shanghai Jiao Tong University, China  
Dr. Terry Moore  
University of Nottingham, UK


2:47. UWB Ranging Aided Pedestrian Geolocation with GPB-based Filtering for LoS and NLoS Measurement Processing, Jianan Zhu, and Solmaz S. Kia, University of California, Irvine

3:09. Performance Validation and Comparison of Range/INS Integrated System in Urban Navigation Environment using Unity3D and PILS, Eunhak Koh, Gwangsoo Park, Byoungjin Lee, Donggyun Kim and Sangkyung Sung, Konkuk University, South Korea


3:55 p.m. - 4:25 p.m., Break. Refreshments in Exhibit Hall

4:30. High-speed Railway Track Integrated Inspecting by GNSS-INS Multisensor, Richie Li, Zhengdong Bai, Bobo Chen, Haohao Xin, Yuhang Cheng, Qiong Li, Fei Wu, Tsinghua University, China


5:14. Tightly Coupled GNSS/INS Using Fisher Information Matrix Based Observability Analyzing for Urban Scenarios, Zihuan Hao, Jian Li, Yiran Luo, School of Information and Electronics, Beijing Institute of Technology, Key Laboratory of Electronic and Information Technology in Satellite Navigation, Ministry of Education, China

5:36. GNSS/INS Integration of Next-generation MEMS IMU Technology for UAV Applications, Marnix Volckaert, Bora Barin, Kristof Smolders, Danilo Sabbatini and Frank Boon, Septentrio, Belgium

Alternate Presentations:

1. Accuracy Analysis of Attitude Non-commutativity Error Compensation Algorithm, Pan Jiang, Yanyan Wang, Jiachong Chang, Dingjie Xu, Harbin Institute of Technology, China
B4: GNSS Integrity and Augmentation Systems

Date: Wednesday, April 22, 2020
Time: 2:20 p.m. - 6:00 p.m.
Room: Pavilion Ballroom West

Session Chairs:

Dr. Juan Blanch  
Stanford University

Dr. Okuary Osechas  
German Aerospace Center (DLR), Germany

2:25. A Rigid Message Scheduler for SBAS, Todd Walter and Andrew Neish, Stanford University

2:47. An Integrity Monitoring Method for Multi-sensor Collaborative Navigation, Jun Xiong, Zhi Xiong, Navigation Research Center, Nanjing University of Aeronautics & Astronautics, China; Joon Wayn Cheong, Andrew G Dempster, School of Electrical, Electronic and Telecommunications Engineering, University of New South Wales, Australia

3:09. Potential Candidates for SBAS E5b and SBAS L5/ESa-Q Signals, Axel Garcia-Pena, Rémi Chauvat, Christophe Macabiau, ENAC, France; Jaron Samson, Cyrille Boulanger, Ivan LAPIN, ESA, France

3:31. Overbounding GNSS/INS Integration with Unknown Gauss-Markov Error Parameters, Omar Garcia Crespillo, German Aerospace Center (DLR), Germany; Mathieu Joerger, Virginia Tech; Steve Langel, The MITRE Corporation

3:55 p.m. - 4:25 p.m., Break. Refreshments in Exhibit Hall

4:30. Analyzing the Time-correlation of Satellite orbit and Clock Errors for ARAIM Offline Monitoring, Jaymin Patel and Boris Pervan, Illinois Institute of Technology

4:52. Evaluating Integrity and Continuity Over Time in Advanced RAIM, Carl Milner, SINA ENAC, France; Boris Pervan, Illinois Institute of Technology; Juan Blanch, Stanford University; Mathieu Joerger, Virginia Tech


5:36. Air-Traffic-Based Synchronization of Ground Infrastructure, Okuary Osechas and Gabriele Giorgi, German Aerospace Center (DLR), Germany

Alternate Presentations:

1. GNSS System Interoperability Evaluation using Geodetic Active Networks, Isai Robles-Bravo, INAOE, Mexico; Rogerio Enriquez-Calder, INAOE/CRICTEALC, Mexico; Jose Guichard Romero, CRICTEALC/INAOE, Mexico; Sergio Camacho Lara, CRICTEALC, Mexico

2. Analysis and Verification of RAIM Techniques Implemented in GNSS Receivers, Cemil Kesik, Gazi University & Turkish Aerospace Industries, Inc., Turkey
C4: Vision-based Navigation Systems

Date: Wednesday, April 22, 2020
Time: 2:20 p.m. - 6:00 p.m.
Room: Atrium Ballroom

Session Chairs:

Dr. Chen Zhu
German Aerospace Center (DLR), Germany

Dr. Michael Veth
Veth Research Associates

2:25. Perception-aided Visual/Inertial Integrated Positioning in Dynamic Urban Areas, Xiwei Bai, Department of Mechanical Engineering, the Hong Kong Polytechnic University, China; Bo Zhang, Interdisciplinary Division of Aeronautical and Aviation, the Hong Kong Polytechnic University, China; Weisong Wen, Department of Mechanical Engineering, the Hong Kong Polytechnic University, China; Li-Ta Hsu, Interdisciplinary Division of Aeronautical and Aviation, the Hong Kong Polytechnic University, China; Huiyun Li, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, China

2:47. Feature Assisted Direct Visual Odometry with Virtual Wide Field-of-View Tracking, Ruihang Miao, Peilin Liu, Zheng Gong, Wuyang Xue, Fei Wen, Rendong Ying, Shanghai Jiao Tong University, China


3:55 p.m. - 4:25 p.m., Break. Refreshments in Exhibit Hall

4:30. Towards Collaborative Obstacle Avoidance using small UAS in Indoor Environments, Daniel Reyes Duran, Richard S. Stansbury, Embry Riddle Aeronautical University & Institute for Human and Machine Cognition; Matthew Johnson, Institute for Human and Machine Cognition

4:52. Visual Servoing for Final Approach Phase of Spacecraft Rendezvous, Wyatt Harris, Richard Cobb, Clark Taylor, Air Force Institute of Technology

5:14. Robust Navigation under Incomplete Localization Using Reinforcement Learning, Wuyang Xue, Rendong Ying, Xiao Chu, Ruihang Miao, Jiuchao Qian, Pei Lin Liu, Shanghai Jiao Tong University, China

5:36. Virtual Track: A Vision-based Integrity Enhancement, Sara Baldoni, Federica Battisti, Michele Brizzi, Roma Tre University, Italy; Alessandro Neri, Roma Tre University and RadioLabs, Italy

Alternate Presentations:


2. Landmark Selection and Recognition with Hopfield Attractor Networks, Kyle Volle, NRC & University of Florida; Prashant Ganesh, University of Florida; Kevin Brink, Air Force Research Lab

3. Addressing UAS Effects on ORB SLAM2 Localization Quality, Gordon Keller, University of California, Santa Cruz; Nicholas Cramer, NASA Ames Research Center; Mircea Teodorescu, University of California, Santa Cruz

4. A GNSS-based Monocular Visual-Inertial Odometry Method for Large-scale Scene Positioning, Zhijun He, Hongbo Zhao, Wenquan Feng, Beihang University, China
D4: Autonomous Vehicle Navigation in Challenging Environments (Invited Session)

Date: Wednesday, April 22, 2020
Time: 2:20 p.m. - 6:00 p.m.
Room: Galleria I/II

Session Chairs:

Dr. Todd Humphreys
University of Texas at Austin

Dr. Boris Pervan
Illinois Institute of Technology


2:47. Longhorn Urban Positioning Challenge: A GNSS-Focused Public Benchmark Dataset, Lakshay Narula, Daniel M. LaChapelle, Matthew J. Murrian, J. Michael Wooten, Todd E. Humphreys, The University of Texas at Austin; Jean-Baptiste Lacambre, Elliot de Toldi, iXblue S.A.S.

3:09. Cross-Modal Localization: Using an automotive radar for absolute geolocation within a map produced with visible-light imagery, Peter A. Iannucci, Lakshay Narula, and Todd E. Humphreys, UT Austin

3:31. A New Integrated Navigation Scheme for the Level 4 Autonomous Vehicles in Dense Urban Areas, Li-Ta Hsu, Weisong Wen, The Hong Kong Polytechnic University, Hong Kong

3:55 p.m. - 4:25 p.m., Break. Refreshments in Exhibit Hall


Alternate Presentations:

A5a: High Performance Inertial Sensor Technologies

**Date:** Thursday, April 23, 2020  
**Time:** 8:30 a.m. - 10:05 a.m.  
**Room:** Pavilion Ballroom East

**Session Chairs:**

Brian Fly  
Kearfott  
Dr. Fang-Cheng Chan  
Polynesian Exploration, Inc.

### Technical Sessions

**8:35. Continuous Time Rate Gyro Calibration and Monocular Camera Misalignment Estimation using a Nonlinear Observer**, Joseph Conroy, U.S. Army Research Laboratory; Sangjin Han, Booz Allen Hamilton; William Nothwang, Gregory Gremillion, U.S. Army Research Laboratory

**8:57. A Fast In-motion Alignment Based on Inertial Frame and Reverse Navigation**, Bo Xu, Lianzhao Wang, Shengxin Li, Tenghui Duan, Kunming Jing, Jiao Zhang, Harbin Engineering University, China


**9:43. Research on Multi-model Adaptive Hull Deformation Measurement Algorithm**, Yanyan Wang, Ya zhang, Dingjie Xu, Jiachong Chang, Chao Liu, Harbin Institute of Technology, China

10:05-10:35, Break. Refreshments in Exhibit Hall

### Alternate Presentations:

1. **In-Flight Estimation of Satellite Mass Properties and Calibration Parameters for Actuators**, Michael Rososhansky and Philip Ferguson, Department of Mechanical Engineering, University of Manitoba, MB, Canada.

2. **Performance of a High Q-factor QMG in Open-loop and Closed-loop Instrumentations**, Sina Askari, Mohammad H. Asadian, and Andrei M. Shkel, University of California Irvine


4. **Strapdown Attitude Computation: Functional Iterative Integration versus Taylor Series Expansion**, Yuanxin Wu, Shanghai Jiao Tong University, China; Yury A. Litmanovich, Central Scientific and Research Institute “Elektropribor”, Russia
A5b: Small Size or Low Cost Inertial Sensor Technologies

**Date:** Thursday, April 23, 2020  
**Time:** 10:35 a.m. - 12:15 p.m.  
**Room:** Pavilion Ballroom East  

**Session Chairs:**  
Ryan Knight  
Army Research Lab  
Dr. Alissa Fitzgerald  
AMFitzgerald

10:40. **Sub-Degree-Per-Hour MEMS Gyroscope for Measurement While Drilling at 300°C,** David Lin, Robert MacDonald, Dorin Calbaza, Brian Scherer, Tammy Johnson, Tim Toepfer, David Shaddock, Emad Andarawis, General Electric, Global Research

11:03. **Universal ASIC for Low C-SWaP INS,** Jeremy D. Popp, A. Dorian Challoner, Peter W. Bond, InertialWave, Inc.

11:26. **Low Cost MEMS Based Systems Augmenting Location and Navigation Performance in Consumer and Industrial Electronics Applications,** Marcellino Gemelli, Thomas Block, Ryotaro Sakauchi, Sergej Scheiermann, Bosch Sensortec, Germany

11:48. **Low-Cost Validation of Complementary Filter-based AHRS,** Pavlo Vlastos, Renwick Curry, and Gabriel Elkaim, University of California Santa Cruz

**Alternate Presentations:**

1. **Compensation of Systematic Error in ZUPT-Aided Pedestrian Inertial Navigation,** Yusheng Wang, Yu-Wei Lin, Sina Askari, Chi-Shih Jao, Andrei M. Shkel, University of California, Irvine

2. **On the Calibration Aspects of MEMS-IMUs used in Micro UAVs for Sensor Orientation,** Philipp Clausen and Jan Skaloud, Geodetic Engineering Laboratory - TOPO, Swiss Federal Institute of Technology - EPFL, Switzerland

3. **High-Q 3D Dual-Shell Resonators for High Shock Environments,** Mohammad H. Asadian, Yusheng Wang, Danmeng Wang, Andrei M. Shkel, MicroSystems Lab, University of California, Irvine

4. **Efficient GPS Scheduling in Wildlife Tags using an Extended Kalman Filter-based Uncertainty Suppression Strategy,** Maxwell Lichtenstein and Gabriel H Elkaim, University of California Santa Cruz

Awards Luncheon, 12:15 p.m. - 1:45 p.m.
**TECHNICAL SESSIONS**

**B5: Receiver Design, Signal Processing, and Antenna Technology 1**

**Date:** Thursday, April 23, 2020  
**Time:** 8:30 a.m. - 12:15 p.m.  
**Room:** Pavilion Ballroom West

**Session Chairs:**  
Dr. Thomas Pany  
University of Munich, Germany  
Dr. Sanjeev Gunawardena  
Air Force Institute of Technology

**8:35. Theoretical and Practical Evaluation of an Overlay Multi-band Front-end,** Alexander Rügamer, J. Rossouw van der Merwe, Inigo Cortes Vidal, and Wolfgang Felber (Fraunhofer IIS), Germany

**8:57. Optimizing Signal Processing Kernels for GNSS Software Receivers,** Cillian O'Driscoll, Independent Consultant, Cork, Ireland

9:20. **Adaptive Loop-Bandwidth Control Algorithm for Scalar Tracking Loops,** Inigo Cortes, Johannes Rossouw van der Merwe, Alexander Rügamer, and Wolfgang Felber, Fraunhofer IIS, Germany

9:43. **Robust GNSS Phase Tracking in Case of Slow Dynamics using Variational Bayes Inference,** Fabio Fabozzi, Stéphanie Bidon, ISAE-SUPAERO, France; Sébastien Roche, Airbus Defence and Space, France; Benoît Priot, ISAE-SUPAERO, France.

10:05-10:35, Break. Refreshments in Exhibit Hall

10:40. **High-resolution Correlator Based Detection of GPS Spoofing Attacks Using the LASSO,** Erick Schmidt, Nikolaos Gatsis, David Akopian, The University of Texas at San Antonio

11:03. **On Efficient and Low-Complexity Decoding of Binary LDPC-coded CSK signals for GNSS Links with Increased Data Rates,** Rémi Chauvat, Axel García-Pena, Ecole Nationale de l’Aviation Civile, France; Matteo Paonni, Joint Research Centre, European Commission, Italy

11:26. **Deep Neural Network Approach to GNSS Signal Acquisition,** Parisa Borhani-Darian and Pau Closas, Electrical and Computer Engineering Dept., Northeastern University


**Alternate Presentations:**

1. **Real Time Results of Vector Delay Lock Loop in a Light Urban Scenario,** Katrin Dietmayer, Florian Kunzi, Fabio Garzia, Matthias Overbeck, Wolfgang Felber, Fraunhofer IIS, Germany
2. **Design and Implementation of a Software Defined Radio GNSS Receiver based on OpenCL,** Janos Buttgereit and Götz C. Kappen, University of Applied Science Münster, Germany
3. **DOA Estimation Method of Short Snapshots Based on Cultural Pigeon-inspired Optimization Algorithm,** Hongyuan Gao, Yuwei Ma, Wanting Xie, Harbin Engineering University, China
4. **Wideband DOA Estimation Based on Quantum Charged System Search Algorithm,** Hongyuan Gao, Guojian Zang, Yuwei Ma, Harbin Engineering University, China

Awards Luncheon, 12:15 p.m. - 1:45 p.m.
C5: Multisensor Integrated Systems and Sensor Fusion Technologies

Date: Thursday, April 23, 2020
Time: 8:30 a.m. - 12:15 p.m.
Room: Atrium Ballroom

Session Chairs:

Dr. Allison Kealy  
RMIT University, Australia

Dr. Jason Gross  
West Virginia University

8:35. Automotive-Radar-Based 50-cm Urban Positioning, Lakshay Narula, Peter A. Iannucci, Todd E. Humphreys, The University of Texas at Austin

8:57. A New Approach for Modeling Correlated Gaussian Errors Using PSD Overbounding, Steven Langel, The MITRE Corporation; Omar Garcia Crespilio, Institute of Communications and Navigation, German Aerospace Center (DLR), Germany; Mathieu Joerger, Virginia Tech

9:20. GNSS Interference Source Tracking using Kalman Filters, Sanat K. Biswas, Department of Electronics and Communication Engineering, IIIT Delhi, India and Ediz Cetin School of Engineering, Macquarie University, Australia

9:43. A Graph Approach to Dynamic Fusion of Sensors, Xin Zhang, Shanghai Jiao Tong University, School of Aeronautics and Astronautics, China; Haipeng Sun, Shanghai Qianxun Spatial Intelligence Inc., Sensor Fusion Team, China

10:05-10:35, Break. Refreshments in Exhibit Hall

10:40. Relational Database for PNT Data, Sean Mochocki, Kyle Kauffman, Robert Leishman, Air Force Institute of Technology; John Raquet, IS4S

11:03. Pedestrian Inertial Navigation System Augmented by Vision-Based Foot-to-foot Relative Position Measurements, Chi-Shih Jao, Yusheng Wang, and Andrei M. Shkel, University of California, Irvine

11:26. Localization Based on Lidar and GNSS for Connected Vehicles, Jae-hoon Ahn, Jong-hoon Won, Inha University / Auto Nav Lab., South Korea

11:48. Integration of Electronic Scanning Radars with Inertial Technology for Seamless Positioning in challenging GNSS Environments, Marwan A. Rashed, Queen’s University, Canada; Aboelmagd Noureldin, Royal Military College (RMC), Canada; Mohamed Elhabiby, Public Works Department, Ain Shams University, Egypt; Umar Iqbal, Mississippi State University, USA; Michael J. Korenberg, Queen’s University, Canada

Alternate Presentations:

1. GPS Positioning in Reduced Coverage Environments Using Batched Doppler and Pseudorange Measurements, Joshua M. Wood, Sterling H. Thompson, Scott M. Martin, and David M. Bevly, Auburn University

2. Sensor Scheduling by Greedily Maximizing Shannons-per-Joule, Maxwell Lichtenetein and Gabriel Elkaim, University of California Santa Cruz

3. PEGASUS - Development of a Prototype, Self-trained, Iorrr Driver Coaching System Based on Geolocation, IoT and BI Techniques: Design Considerations and System Setup, Vassilis Gikas, Harris Perakis, Ioannis Stratakos, Panagiotis Sotiriou, School of Rural and Surveying Engineering, National Technical University of Athens, Greece; Dimitrios Pelekoudas, Fortion S.A., Greece


5. A Vision-assisted GNSS-RTK Ambiguity Fixing Method Considering Visual Lane Line Ambiguity, Chuang Qian, Hongjuan Zhang, Wenzhuo Li, Hui Liu, Bijun Li, Wuhan University, China

Awards Luncheon, 12:15 p.m. - 1:45 p.m.
D5: Aerial Vehicle Navigation 1

Date: Thursday, April 23, 2020
Time: 8:30 a.m. - 12:15 p.m.
Room: Galleria I/II

Session Chairs:

Dr. Demoz Gebre-Egziabher
University of Minnesota

Dr. Clark Taylor
Air Force Institute of Technology

8:35. A UAV-based Algorithm to Assist Ground SAR Teams in Finding Lost Persons Living with Dementia, Dalia Hanna and Alexander Ferworn, Department of Computer Science, Ryerson University, Canada

8:57. Intercepting Unmanned Aerial Vehicle Swarms with Neural-Network-Aided Game-Theoretic Target Marking, Nick Montalbano and Todd Humphreys, University of Texas - Austin

9:20. Maneuver Optimization for Synthetic Aperture based DOA estimation of GNSS Jammers, Gerald LaMountain and Pau Closas, Northeastern University

9:43. Model Predictive Control for Vision-Based Quadrotor Guidance, Karsten Mueller, Michael Fennel, Institute of Systems Optimization (ITE), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany; Gert F. Trommer, ITE, KIT, Germany and ITMO University, Russia

10:05-10:35, Break. Refreshments in Exhibit Hall

10:40. A Fault Detection and Isolation Design for a Dual Pitot Tube Air Data System, Kerry Sun and Demoz Gebre-Egziabher, University of Minnesota Twin Cities

11:03. Low SWaP-C Radar for Urban Air Mobility, William A. Lies, Lakshay Narula, Peter A. Iannucci, Todd E. Humphreys, Radionavigation Laboratory, University of Texas at Austin


Alternate Presentations:

1. Adaptive Cooperative Navigation Strategies for Complex Environments, Flavia Causa, Giancarmine Fasano, University of Naples Federico II, Italy

2. Autonomous UAV-based Forest Mapping Below the Canopy, Joakim Rydell, Michael Tulldahl, Linnéa Axelsson, Pontus Köhler, Erika Billock, Swedish Defence Research Agency (FOI), Sweden

3. Doppler Based Relative Positioning for Aircraft-to-aircraft and Drone-to-drone Communication Systems, Michael Walter, Martin Schmidhammer, and Dmitriy Shutin, German Aerospace Center (DLR), Germany

Awards Luncheon, 12:15 p.m. - 1:45 p.m.
B6a: Frontiers of GNSS (Invited Session)

Date: Thursday, April 23, 2020
Time: 1:45 p.m. - 5:00 p.m.
Room: Pavilion Ballroom West

Session Chairs:

Dr. Chris Hegarty
The MITRE Corporation

Roberto Prieto Cerdeira
European Space Agency, The Netherlands

1:50. Update on BeiDou Navigation Satellite System and PNT System, Xiaochun Lu, National Time Service Center, Chinese Academy of Sciences, China Xia Guo, National Time Service Center, Chinese Academy of Sciences, China Shuren Guo, Beijing Institute of Tracking and Telecommunications Technology, Beijing, China Xing Li, Beijing Institute of Tracking and Telecommunications Technology, Beijing, China Kun Jiang Beijing Institute of Tracking and Telecommunications Technology, Beijing, China Jade Morton, University of Colorado, Colorado, US

2:12. GPS Modernization and Beyond, Ranwa Haddad and Karl Kovach, The Aerospace Corporation

2:35. A European Perspective for the Evolution of GNSS at Different Time-scales, Roberto Prieto Cerdeira, ESA/ESTEC, The Netherlands

2:58. Comparing the 'Big 4' – A User's View on GNSS Performance, Oliver Montenbruck, Peter Steigenberger, André Hauschild, German Aerospace Center (DLR/GSOC), Germany

3:20. Securing GNSS: A Trip Down Cryptography Lane, Andrew Neish, Todd Walter, Stanford University

3:42. PPP: Perhaps the Natural Processing Mode for Precise GNSS PNT, Sunil Bisnath, York University, Canada

4:04. Economical Broadband LEO Navigation Systems, Peter A. Iannucci, and Todd E. Humphreys, UT Austin

4:26. Exploring the Design Space of Lunar GNSS in Frozen Orbit Conditions, Filipe Pereira, Cornell University; Daniel Selva, Texas A&M
B6b: Receiver Design, Signal Processing, and Antenna Technology 2

Date: Thursday, April 23, 2020
Time: 1:45 p.m. - 3:25 p.m.
Room: Pavilion Ballroom East

Session Chairs:

Dr. Thomas Pany
University of Munich, Germany

Dr. Sanjeev Gunawardena
Air Force Institute of Technology

1:50. Accurate Position and Attitude Determination in a Severe Multipath Environment Using an Uncalibrated Multi-Antenna-System, Soeren Zorn, Christian Siebert, Michael Niestroj, Marius Brachvogel, RWTH Aachen University, Germany; Michael Meurer, RWTH Aachen University & German Aerospace Center (DLR), Germany

2:12. A Subspace-based Spatial and Temporal Multipath Mitigation for Multi-antenna GPS Receiver, Xi Hong, Tian Gan, Menghan Lin, Ning Chang, Wenjie Wang, and Qinye Yin, Xi’an Jiaotong University, China

2:35. Sparse Spatial and Temporal Estimation for Multipath Mitigation in GNSS, Ning Chang, Wenjie Wang, Xi Hong, Ministry of Education Key Lab for Intelligent Networks and Network Security, Xi’an Jiaotong University, China; Jose A. Lopez-Salcedo, Gonzalo Seco-Granados, Department of Telecommunications and Systems Engineering, Universitat Autonoma de Barcelona (UAB), Spain.

2:58. A Cellular-Modem-Hosted Low-Cost Single-Shot Dual-Mode Assisted-GNSS Receiver for the Internet of Things, Matthias Korb, ETH Zurich, Integrated Systems Laboratory, Switzerland; Philipp Stockel, Goetz C. Kappen, FH Muenster University of Applied Science, Germany; Benjamin Weber, Miguel Garcia, ACP AG, Switzerland; Qiuting Huang, ETH Zurich, Integrated Systems Laboratory, Switzerland

Alternate Presentations:

1. A Comparative Signal Quality Analysis of the New GPS L1C and Beidou B1C MBOC Modulated Signals, Nikolaos Batzilis, Paolo Crosta, Luciano Musumeci, Xurxo Otero, Jose V. Perello, Rui Sarnadas, European Space Research and Technology Centre (ESA/ESTEC), Netherlands

2. Multi-Constellation Integrated Navigation Satellite Selection Algorithm Based on Integrity Protection Level, Ershen Wang, Caimiao Sun, Chuanyun Wang, Pingping Qu, Tao Pang, He He, Yufeng Huang, Shenyang Aerospace University, China
**C6: Collaborative and Networked Navigation**

**Date:** Thursday, April 23, 2020  
**Time:** 1:45 p.m. - 5:00 p.m.  
**Room:** Atrium Ballroom

**Session Chairs:**
- Dr. Solmaz Kia  
  University of California, Irvine  
- Dr. Michael Angermann  
  Google

1:50. **Multi-Objective Motion Planning Strategy in Opportunistic Navigation Environments**, Yanhao Yang, Joshua Morales, Joe Khalife, and Zaher (Zak) Kassas; University of California, Irvine

2:12. **Cooperative swarm localization and mapping with inter-agent ranging**, Young-Hee Lee, Institute for Communications and Navigation, Technical University of Munich (TUM), Germany; Chen Zhu, Institute of Communications and Navigation, German Aerospace Center (DLR), Germany; Gabriele Giorgi, DLR, Germany; Christoph Günther, TUM and DLR, Germany


2:58. **Maplets: An Efficient Approach for Cooperative SLAM Map Building Under Communication and Computation Constraints**, Kevin M. Brink, Air Force Research Laboratory; Jincheng Zhang, Andrew R. Willis, University of North Carolina at Charlotte; Ryan E. Sherrill, Jamie L. Godwin, Air Force Research Laboratory

3:20. **Matching Maps of Physical and Virtual Radio Transmitters Using Visibility Regions**, Markus Ulmschneider, Christian Gentner, Armin Dammann, German Aerospace Center (DLR), Germany

3:42. **Exploration Planning of a UAV/UGV Team with Localization Uncertainty in a Subterranean Environment**, Matteo De Petrillo, Jared Beard, Yu Gu, Jason N. Gross, West Virginia University

4:04. **Centralized UAV Swarm Formation Estimation with Relative Bearing Measurements and Unreliable GPS**, John Akagi, Randall S Christensen and Matthew W Harris, Utah State University

**Alternate Presentations:**

1. **Improved Maximum Correntropy Cubature Kalman Filter for Cooperative Localization**, Shengxin Li, Bo Xu, and Asghar A. Razzaqi, Harbin Engineering University, China

2. **Research on Indoor Cooperative Positioning Algorithm for Multi-Robot System**, Sheng Chen, Hongbo Zhao, Zhijun He, Beihang University, China
TECHNICAL SESSIONS

D6a: Ground Vehicle Navigation

Date: Thursday, April 23, 2020
Time: 1:45 p.m. - 5:00 p.m.
Room: Galleria I/II

Session Chairs:

Dr. David Bevly
Auburn University

Dr. Victoria Kropp
BMW, Germany

1:50. Evaluating the Urban Trench Model for Improved GNSS Positioning in Urban Areas, Lucy Icking, Tobias Kersten, and Steffen Schön, Institut für Erdmessung, Germany


2:35. GNSS/LiDAR Integration Aided by Self-adaptive Gaussian Mixture Model in Urban Scenarios: An Approach Robust to Non-Gaussian Noise, Weisong Wen, Department of Mechanical Engineering, the Hong Kong Polytechnic University, China; Tim Pfeifer, Department of Electrical Engineering and Information, Technologie Technique University of Chemnitz, Germany; Xiwei Bai, Interdisciplinary Division of Aeronautical and Aviation Engineering, the Hong Kong Polytechnic University, China

2:58. Optimal Integrity-Constrained Path Planning for Ground Vehicles, Mahdi Maaref and Zaher (Zak) Kassas, University of California, Irvine

3:20. Robust Vehicle Localization and Integrity Monitoring Based on Spatial Feature Constrained Particle Filter, Jelena Gabela, Ivan Majic, University of Melbourne, Australia; Allison Kealy, RMIT University, Australia; Mark Hedley, Shenghong Li, CSIRO, Data 61, Australia

3:42. Novel Snapshot Integrity Algorithm for Automotive Applications: Test Results based on Real Data, Rod Bryant, Olivier Julien, Chris Hide, Said Moridi, u-blox, Switzerland; Ian Sheret, Polymath Insight Limited, Switzerland

4:04. Effect of Wheel Odometer on Low-cost Visual-Inertial Navigation System for Ground Vehicles, Jae Hyung Jung, Jae Young Chung, Tae Ihn Kim, Chan Gook Park, Department of Mechanical & Aerospace Engineering / Automation and Systems Research Institute, Seoul National University, Republic of Korea; Myung Hwan Seo, Sang Yeon Park, Jong Yun Yeo, IVS, In-Vehicle Solution, Development Team, Hyundai MnSOFT, Republic of Korea


Alternate Presentations:

1. LiDAR Data Enrichment Using Deep Learning Based on High-Resolution Image: An Approach to Achieve High-Performance LiDAR SLAM Using Low-cost LiDAR, Jiang Yue, Hong Kong Polytechnic University & Nanjing University of Science and Technology, China; Weisong Wen, Hong Kong Polytechnic University, China; Jing Han, Nanjing University of Science and Technology, China Li-Ta Hsu, Hong Kong Polytechnic University, China
TECHNICAL SESSIONS

D6b: Aerial Vehicle Navigation 2
Date: Thursday, April 23, 2020
Time: 3:30 p.m. - 5:00 p.m.
Room: Pavilion Ballroom East

Session Chairs:

Dr. Demoz Gebre-Egziabher
University of Minnesota

Dr. Clark Taylor
Air Force Institute of Technology


4:04. Object Classification and Semantic Mapping, Jamal Atman, Institute of Systems Optimization (ITE), Karlsruhe Institute of Technology (KIT), Germany; Gert F. Trommer, ITE, KIT, Germany and ITMO University, Russia


Alternate Presentations:

1. Visual Servoing of Micro Aerial Vehicles with the Cooperation of Ground Vehicle, Jiayi Li, Wei Dong, Xinjun Sheng, and Sen Xu, Shanghai Jiao Tong University, SJTU, China
Show Hours:
Tuesday, April 21
10:00 a.m. – 7:00 p.m. Exhibit Hall Open
5:30 p.m. – 7:00 p.m. Exhibitor Hosted Reception

Wednesday, April 22
9:30 a.m. – 4:30 p.m. Exhibit Hall Open

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Airports
- Portland International Airport (PDX): 10 miles from hotel (30 minutes)
- Seattle-Tacoma International Airport: 175 miles from hotel (2.5 hours)

Airport Shuttle Service
The Hilton Portland Downtown does not provide airport shuttle service.

Rideshare
Rideshare service such as Uber, Lyft and Wingz average about $25 from PDX to the Hilton Portland Downtown. All rideshare services pick up at Island 2 outside of baggage claim. For more information, see www.flypdx.com/GroundTransportation/Rideshare

MAX Light Rail
The Metropolitan Area Express (MAX) Light Rail runs daily, every 15 minutes. To travel from Portland International Airport to the Hilton, board the MAX Red Line and travel to Pioneer Square Station. The hotel is a two-block walk from the station. Current MAX fare is $2.50 for 2 hours, or $5 for a one-day pass. Ticket machines are located at each MAX station. For routes, schedules, riding instructions, or information in other languages, visit www.trimet.org

Rental Car
Five rental car companies currently offer rental car services at PDX; car pickup is located on level 1 of the short-term garage. For a list of rental car companies and more information on rental cars, please visit the airport’s rental car information page at https://www.flypdx.com/RentalCars

Portland Streetcar
The Portland Streetcar offers convenient and affordable transport throughout greater Portland, including the Pearl District, Old Town, Chinatown, the Lloyd District, Downtown, and South Portland. For more information, see www.portlandstreetcar.org

Parking Fees
Valet parking at the Hilton Portland Downtown is $52 per day, with in-and-out privileges. Self-parking is not available.

There are several parking garages within walking distance of the hotel that offer hourly, daily and overnight self-parking.

Weather
The average high in April is 61°F (16°C) and the average low is 43°F (6°C).

More Information
For more travel information, please see www.ion.org/plans/travel.cfm

Visa Information

Visa Waiver Countries:
Visa waiver travelers from all 27 Visa Waiver Program countries must present either a machine-readable passport or a U.S. Visa. To learn more about the Visa Waiver Program & Machine Readable Passports see http://travel.state.gov/visa.

Non-Visa Waiver Countries:
We recommend that you apply for your Visa at least three months in advance. Currently there is a mandatory security check period of 30 days for people whose passports are issued from several countries. U.S. consular offices now interview most applicants as part of the application process. Please ensure you arrive at the embassy with all required documentation at the time of your interview.

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1. Submit the visa letter request form found at ion.org/plans or
2. Register and pay all conference registration fees BEFORE a letter of invitation will be sent.

Exemptions to this policy apply only to those authors whose papers have been accepted for presentation, company personnel working in the exhibit area or trade associated press.

If the attendee is unable to secure a Visa, he/she will need to apply for a refund according to the printed refund rules of the event.

Visa letter requests will only be reviewed AFTER you have submitted the Visa letter request form for your desired conference.
Conference Location
The conference will be held at the Hilton Portland Downtown, located at 921 Sixth Ave. SW, Portland, OR 97204. The hotel is located two blocks from the Pioneer Square Station on the MAX Light Rail system (Red Line).

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- In-room internet is available on a complimentary basis to PLANS guests at the Hilton.
- Valet parking at the Hilton is $52 per day. Self-parking is not available. There are several parking garages within walking distance of the hotel that offer hourly, daily and overnight self-parking.

Reservations
A block of rooms have been set aside for conference attendees until Friday, March 20, 2020 (or until the room block sells out), at the discounted group rate of $199 per night for single/double occupancy. Reservations made after this date will be on a space-available basis and may not be at the special ION rate. Please note that the room block does sell out quickly, so we strongly encourage you to make your hotel reservations early. Make your reservations by March 20, 2020 to qualify for discounted conference rates.

Government Rate: A limited number of government rate rooms are available at the prevailing government per diem rate night for single/double occupancy. U.S. Government rates will be honored only for U.S. government employees travelling with U.S. Government travel orders and paying with a U.S. Government-issued credit card. Failure to provide these validations at check-in will result in your reservation being honored at the group rate. Government contractors and/or retired or non-active military personnel do not qualify for government rate rooms.

How to Register—www.ion.org

1. Make your hotel reservation at the Hilton Portland Downtown. Write down your confirmation number; you’ll need it to claim the $200 registration fee discount you’ll earn for staying in the official conference hotel.

2. Access the online registration form at ion.org/plans by clicking “Registration” in the navigation bar on the left. A PDF registration form is also available on this web page.

3. Complete the online registration process. Be sure to input your hotel confirmation number during the registration process to claim your discount as hotel discounts will not be issued retroactively.

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