The IEEE/ION PLANS 2020 conference, originally scheduled to be held April 20-23 in Portland, Oregon, was cancelled due to the COVID-19 pandemic.

A revised IEEE/ION PLANSx 2020, will be hosted by ION GNSS+, September 23-25, at the St. Louis Union Station Hotel in St. Louis, Missouri.

The IEEE/ION PLANSx 2020 technical program will run Wednesday, September 23, through Friday, September 25, and will include a collection of the peer-reviewed papers originally scheduled to be presented in April. Attendees from both meetings will have the freedom to flow between ION GNSS+ and IEEE/ION PLANSx technical presentations and the ION GNSS+ commercial exhibit. Dr. Brad Parkinson, originally scheduled as a PLANS keynote speaker, will be giving his address as part of the ION GNSS+ plenary session on Tuesday, September 22.
## Plansx Session Schedule

| Tuesday, September 22 | 6:30 p.m. - 8:30 p.m. | ION GNSS+ Plenary Session  
4P’s to my Dream Job: Dr. Christine Darden  
Radio Navigation from Marconi to GNSS: Dr. Bradford W. Parkinson |
|-----------------------|-----------------------|-----------------------------------------------------------------|
| 8:30 a.m. - 10:05 a.m. | A1: Atmospheric Effects  
B1: Ground Vehicle Navigation |
| 10:35 a.m. - 12:15 p.m. | A2: Signals of Opportunity-based Navigation Systems  
B2: Advances in MEMS-based Inertial Sensors and Inertial Measurement Units |
| 12:15 p.m. - 1:15 p.m. | Buffet Lunch in ION GNSS+ Exhibit Hall  
1:15 p.m. - 1:45 p.m. | Free Time in Exhibit Hall |
| 1:45 p.m. - 3:25 p.m. | A3: Integrated Inertial Navigation Systems  
B3: Vision-based Navigation Systems |
| 3:55 p.m. - 5:30 p.m. | A4: Marine Vehicle Navigation  
B4: Precise GNSS Positioning |

| Wednesday, September 23 | 8:30 a.m. - 10:05 a.m. | A5: High Performance Inertial Sensor Technologies  
B5: Receiver Design, Signal Processing, and Antenna Technology 1 |
|-------------------------|-----------------------|-----------------------------------------------------------------|
| 10:35 a.m. - 12:15 p.m. | A6: Robotic and Indoor Navigation  
B6: Multisensor Integrated Systems and Sensor Fusion Technologies |
| 12:15 p.m. - 1:15 p.m. | Buffet Lunch in ION GNSS+ Exhibit Hall  
1:15 p.m. - 1:45 p.m. | Free Time in Exhibit Hall |
| 1:45 p.m. - 3:25 p.m. | A7: Navigation Using Environmental Features  
B7: Space Navigation and Observation |
| 3:55 p.m. - 5:30 p.m. | A8: GNSS Integrity and Augmentation Systems  
B8: Alternative Sensors for Aiding INSs and Precision Timing |

| Thursday, September 24 | 8:30 a.m. - 10:05 a.m. | A9: Collaborative and Networked Navigation  
|------------------------|-----------------------|-----------------------------------------------------------------|
| 10:35 a.m. - 12:15 p.m. | A10: Algorithms and Methods  
B10: Positioning with Non-GNSS Radio Signals (Invited Session) |
| 12:15 p.m. - 1:15 p.m. | Buffet Lunch in ION GNSS+ Exhibit Hall  
1:15 p.m. - 1:45 p.m. | Free Time in Exhibit Hall |
| 1:45 p.m. - 3:25 p.m. | A11: Frontiers of GNSS (Invited Session)  
B11: Aerial Vehicle Navigation |
| 3:55 p.m. - 5:30 p.m. | A12: Receiver Design, Signal Processing, and Antenna Technology 2  
B12: GNSS Resilience to Interference, Jamming, and Spoofing |

Exhibitor Hosted Reception in ION GNSS+ Exhibit Hall 5:30 p.m. - 7:30 p.m., Regency Ballroom
A1: Atmospheric Effects
Date: Wednesday, September 23, 2020
Time: 8:30 a.m. - 10:05 a.m.

Session Chairs:

Dr. Zhe (Jenny) Yang  
University of Colorado Boulder

Dr. Jiyun Lee  
KAIST, South Korea

8:35. 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

8:57. 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

9:20. Improve GNSS Orbit Determination by using Estimated Tropospheric and Ionospheric Models, Cazabonne Bryan, Maisonobe Luc, CS Group, France

9:43. Triple-Frequency GNSS Cycle Slip Detection Performance in the Presence of Diffractive Ionosphere Scintillation, Brian Breitsch and Jade Morton, University of Colorado, Boulder

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

10:05-10:35, Break. Refreshments in Exhibit Hall
B1: Ground Vehicle Navigation

Date: Wednesday, September 23, 2020
Time: 8:30 a.m. - 10:05 a.m.

Session Chairs:

Dr. David Bevly
Auburn University

Dr. Victoria Kropp
BMW, Germany

8:35. Evaluating the Urban Trench Model for Improved GNSS Positioning in Urban Areas, Lucy Icking, Tobias Kersten, and Steffen Schön, Institut für Erdfmessung, Germany


9:20. 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

9:43. Optimal Integrity-Constrained Path Planning for Ground Vehicles, Mahdi Maaref and Zaher (Zak) Kassas, University of California, Irvine

Alternate Presentations:


2. 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

3. 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

10:05-10:35, Break. Refreshments in Exhibit Hall
A2: Signals of Opportunity-based Navigation Systems

Date: Wednesday, September 23, 2020
Time: 10:35 a.m. - 12:15 p.m.

Session Chairs:

Dr. Ramsey Faragher  
Focal Point Positioning, UK

Dr. Jiwon Seo  
Yonsei University, South Korea

10:40. Navigation with Differential Carrier Phase Measurements from Megaconstellation LEO Satellites, Joe Khalife, Mohamad Neinavaie, and Zaher (Zak) Kassas; University of California, Irvine

11:03. 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

11:26. Implementation and Performance Evaluation of Cellular NB-IoT OTDOA Positioning, Mauro Salomon, Stefan Lippuner, Matthias Korb, Qiuting Huang, ETH Zurich, Switzerland


Alternate Presentations:

1. Improved Time-of-Arrival Estimation Algorithm for Cellular Signals in Multipath Fading Channels, Pai Wang and Yu Jade Morton, University of Colorado Boulder

2. 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

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall  
1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall
B2: Advances in MEMS-based Inertial Sensors and Inertial Measurement Units

Date: Wednesday, September 23, 2020
Time: 10:35 a.m. - 12:15 p.m.

Session Chair:

Ryan Knight
Army Research Lab


11:03. High-G Capacitive Accelerometer Arrays with Low bias Instability, Gary K. Fedder, Vincent P. J. Chung, Metin G. Guney, Xiaoliang Li, Yi-Chung Lin, Suresh Santhanam, Jeyanandh Paramesh, Tamal Mukherjee, Carnegie Mellon University

11:26. 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 Best Paper in Track


Alternate Presentations:

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

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall
A3: Integrated Inertial Navigation Systems

Date: Wednesday, September 23, 2020
Time: 1:45 p.m. - 3:25 p.m.

Session Chairs:

Dr. Yuanxin Wu  
Shanghai Jiao Tong University, China

Dr. Terry Moore  
University of Nottingham, UK

1:50. 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


2:35. 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

2:58. 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

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

3:25 - 3:55, Break. Refreshments in Exhibit Hall
B3: Vision-based Navigation Systems

Date: Wednesday, September 23, 2020
Time: 1:45 p.m. - 3:25 p.m.

Session Chairs:

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

Dr. Michael Veth
Veth Research Associates

1:50. 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


2:35. 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

2:58. 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

Alternate Presentations:

1. Three Flavors of RGBD Visual Odometry: Analysis of Cost Function Compromises and Covariance Estimation Accuracy, Prashant Ganesh, University of Florida; Kyle Volle National Research Council, University of Florida; Andrew R. Willis, University of North Carolina at Charlotte; Kevin M. Brink, Air Force Research Laboratory

3:25 - 3:55, Break. Refreshments in Exhibit Hall
A4: Marine Vehicle Navigation  
**Date:** Wednesday, September 23, 2020  
**Time:** 3:55 p.m. - 5:30 p.m.

**Session Chairs:**  
Bryan Hoffman  
*SPAWAR*  
Dr. Lonnie Parker  
*Georgia Tech Research Institute*

**4:00. 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

**4:23. Designing a Ranging Signal for use with VDE R-Mode,** Markus Wirsing, Armin Dammann, and Ronald Raulefs, German Aerospace Center (DLR), Germany

**4:46. Machine Learning-Assisted Anomaly Detection in Maritime Navigation Using AIS Data,** Sandeep Kumar Singh and Frank Heymann, German Aerospace Center (DLR), Germany

**5:08. Test and Evaluation of Autonomous Marine Vehicles: A Case Study,** Brian C. Reitz and Joshua L. Wilkerson, Naval Air Warfare Center - Weapons Division

**Alternate Presentations:**

1. **INS/Log Integrated Navigation System with Ocean Current Velocity Model Based on Multiple Model Adaptive Estimation,** Xinle Zang, Yueyang Ben, and Qian Li, College of Automation, Harbin Engineering University, China

2. **A Review of Polar Marine Navigation Schemes,** Wenting Cui, Yueyang Ben, and Hanxuan Zhang, College of Automation, Harbin Engineering University, China

Reception in Exhibit Hall • 5:30 p.m. - 7:30 p.m.
B4: Precise GNSS Positioning

**Date:** Wednesday, September 23, 2020  
**Time:** 3:55 p.m. - 5:30 p.m.

**Session Chairs:**

![Dr. Miguel Angel Ribot](image.jpg)  
*Albora Technologies, UK*  

![Dr. Kyle O'Keefe](image.jpg)  
*The University of Calgary, Canada*

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**4:00. 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

**4:23. Benefits of Zero Position Updates for Robust, Low-cost, Dual-frequency, PPP GNSS / MEMS-IMU Navigation**, Sudha Vana, Sunil Bsnath and Nacer Naciri, York University, Canada

**4:46. 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


**Alternate Presentations:**

1. **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

Reception in Exhibit Hall • 5:30 p.m. - 7:30 p.m.
A5: High Performance Inertial Sensor Technologies

Date: Thursday, September 24, 2020
Time: 8:30 a.m. - 10:05 a.m.

Session Chairs:
Burgess Johnson
Honeywell
Sam Dimashkie
EMCORE

8:35. Compact In-run Navigation Grade IMU, Based on Quartz MEMS, Sergey Zotov, Arvind Srivastava, Ken Kwon, Jeremy Frank, Erwin Parco, Semen Shitluz, Kenneth Lyons, Michael Frazee, David Hoyh, Albert Lu, Emcore/Systron Donner Inertial


9:20. 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

9:43. 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

Alternate Presentations:

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

10:05-10:35, Break. Refreshments in Exhibit Hall
**B5: Receiver Design, Signal Processing, and Antenna Technology 1**

**Date:** Thursday, September 24, 2020  
**Time:** 8:30 a.m. - 10:05 a.m.

**Session Chairs:**

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

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### 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. 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

### 9:20. Deep Neural Network Approach to GNSS Signal Acquisition

Parisa Borhani-Darian and Pau Closas, Electrical and Computer Engineering Dept., Northeastern University

### 9:43. A Machine Learning Approach for GPS Code Phase Error Estimation in Multipath Environments

Mohamad Orabi and Samer Saab, Lebanese American University, Lebanon; Joe Khalife, Ali Abdallah, and Zaher (Zak) Kassas, University of California, Irvine

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**Alternate Presentations:**

1. **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

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10:05-10:35, Break. Refreshments in Exhibit Hall
A6: Robotic and Indoor Navigation

Date: Thursday, September 24, 2020
Time: 10:35 a.m. - 12:15 p.m.

Session Chairs:

Dr. Mohammed Khider
Google

Dr. Vibhor Bageshwar
Honeywell


Best Student Paper

11:03. Approach for Autonomous Robot Navigation in Greenhouse Environment for Integrated Pest Monitoring, Smita Tiwari, Yuheng Zheng, Michael Pattinson, NSL, UK; María Campo-Cossío, Raúl 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; Vojtech Adam, Mendelova Univerzita v Brno, Czech Republic; Joaquín Reyes Gonzalez, European GNSS Agency GSA

11:26. 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


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. 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

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall
B6: Multisensor Integrated Systems and Sensor Fusion Technologies

Date: Thursday, September 24, 2020
Time: 10:35 a.m. - 12:15 p.m.

Session Chairs:

Dr. Dorota Grejner-Brzezinska  
The Ohio State University

Dr. Jason Gross  
West Virginia University

10:40. Automotive-Radar-Based 50-cm Urban Positioning, Lakshay Narula, Peter A. Iannucci, Todd E. Humphreys, The University of Texas at Austin

IEEE Walter R. Fried Memorial Award

11:03. A New Approach for Modeling Correlated Gaussian Errors Using PSD Overbounding, Steven Langel, The MITRE Corporation; Omar Garcia Crespillo, Institute of Communications and Navigation, German Aerospace Center (DLR), Germany; Mathieu Joerger, Virginia Tech

11:26. 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

11:48. 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, Technology Technique University of Chemnitz, Germany; Xiwei Bai, Li-Ta Hsu, Interdisciplinary Division of Aeronautical and Aviation Engineering, the Hong Kong Polytechnic University, China

Alternate Presentations:

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

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall
A7: Navigation Using Environmental Features
Date: Thursday, September 24, 2020
Time: 1:45 p.m. - 3:25 p.m.

Session Chairs:

Dr. Allison Kealy  
RMIT University, Australia

Dr. Li-Ta Hsu  
Hong Kong Polytechnic University, Hong Kong

1:50. 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

2:12. 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

2:35. 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

2:58. 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. Celestial Navigation – Correcting the Folklore, Peter F Swaszek, University of Rhode Island; Richard J Hartnett and Kelly C Seals, US Coast Guard Academy

2. Landmark Aided GPS-denied Navigation for Orchards and Vineyards, Austin Costley and Randall Christensen, Utah State University

3:25 - 3:55, Break. Refreshments in Exhibit Hall
B7: Space Navigation and Observation

Date: Thursday, September 24, 2020
Time: 1:45 p.m. - 3:25 p.m.

Session Chairs:

Dr. Randy Christensen  
Utah State University

Dr. Costantinos Zagaris  
Air Force Institute of Technology


2:12. **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

2:35. **CubeSat-Based Lunar Map Refinement Utilizing Surface Beacons and a Monocular Camera**, Tyler Gardner, Michael Hansen, Natalie Wisniewski, Dr. Randall Christensen, Utah State University

2:58. **An End-to-end Process for Local Space Situational Awareness from Optical Observers**, David Zuehlke*, Troy Henderson*, T. Alan Lovell**, and Alex Sizemore**; *Embry-Riddle Aeronautical University, Daytona Beach, FL; **Space Vehicles Directorate, Air Force Research Laboratory, Kirtland AFB, NM, USA

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

3:25 - 3:55, Break. Refreshments in Exhibit Hall
A8: GNSS Integrity and Augmentation Systems

Date: Thursday, September 24, 2020
Time: 3:55 p.m. - 5:30 p.m.

Session Chairs:

Dr. Juan Blanch
Stanford University

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

4:00. A Rigid Message Scheduler for SBAS, Todd Walter and Andrew Neish, Stanford University


4:46. Analyzing the Time-correlation of Satellite orbit and Clock Errors for ARAIM Offline Monitoring, Jaymin Patel and Boris Pervan, Illinois Institute of Technology

5:08. Air-Traffic-Based Synchronization of Ground Infrastructure, Okuary Osechas and Gabriele Giorgi, German Aerospace Center (DLR), Germany

Alternate Presentations:

1. Potential Candidates for SBAS E5b and SBAS L5/E5a-Q Signals, Axel Garcia-Pena, Rémi Chauvat, Christophe Macabiau, ENAC, France; Jaron Samson, Cyrille Boulanger, Ivan LAPIN, ESA, France

5:45 p.m. - 7:30 p.m., Scavenger Hunt, Meet at “Base Camp” in Midway East
B8: Alternative Sensors for Aiding INSs and Precision Timing

Date: Thursday, September 24, 2020
Time: 3:55 p.m. - 5:30 p.m.

Session Chairs:

Dr. Adam Schofield  
CCDC/CSISR, U.S. Army

Dr. Charles Toth  
The Ohio State University

4:00. Global Localization of Ground Vehicles Using Self-Describing Fiducials Coupled with IMU Data, Justin Whitaker and Randall Christensen, Utah State University


4:46. 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

5:08. Stand-Alone Navigation System Based on Visual SLAM, Sergey Zotov, Zotov Dynamics, LLC

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

5:45 p.m. - 7:30 p.m., Scavenger Hunt, Meet at "Base Camp" in Midway East
A9: Collaborative and Networked Navigation

Date: Friday, September 25, 2020
Time: 8:30 a.m. - 10:05 a.m.

Session Chairs:

Dr. Solmaz Kia
University of California, Irvine

Dr. Michael Angermann
Google


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

9:43. Multi-Objective Motion Planning Strategy in Opportunistic Navigation Environments, Yanhao Yang, Joshua Morales, Joe Khalife, and Zaher (Zak) Kassas; University of California, Irvine

Alternate Presentations:

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

2. 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

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

Date: Friday, September 25, 2020
Time: 8:30 a.m. - 10:05 a.m.

Session Chairs:

Dr. Todd Humphreys  
University of Texas at Austin

Dr. Boris Pervan  
Illinois Institute of Technology


8:57. 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


9:43. 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

Alternate Presentations:

1. 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.

2. Intelligent Navigation in Urban Environments Based on an H-infinity Filter and Reinforcement Learning Algorithms, Ivan Smolyakov and Richard B. Langley, Department of Geodesy and Geomatics Engineering, University of New Brunswick, Canada


10:05-10:35, Break. Refreshments in Exhibit Hall
A10: Algorithms and Methods

**Date:** Friday, September 25, 2020

**Time:** 10:35 a.m. - 12:15 p.m.

**Session Chairs:**

Dr. Demoz Gebre-Egziabher  
*University of Minnesota*

Dr. Clark Taylor  
*Air Force Institute of Technology*

### 10:40. 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

### 11:03. 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

### 11:26. 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

### 11:48. 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

**Alternate Presentations:**

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

Awards Luncheon, 12:15 p.m. - 1:30 p.m.
B10: Positioning with Non-GNSS Radio Signals (Invited Session)

**Date:** Friday, September 25, 2020  
**Time:** 10:35 a.m. - 12:15 p.m.

**Session Chairs:**

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

Dr. Howard Huang  
*Nokia Bell Labs*

10:40. WiFi-RTT Indoor Positioning, Christian Gentner, Markus Ulmschneider, Isabel Kuehner, and Armin Dammann, German Aerospace Center (DLR), Germany

11:03. Field Testing of Mobile Positioning with Signals of Opportunity in Urban and Urban Canyon Environments, Chun Yang and Andrey Soloviev, QuNav

11:26. 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

11:48. Multipoint Channel Charting with Multiple-Input Multiple-Output Convolutional Autoencoder, Chunhua Geng, Howard Huang, and Jack Langerman, Nokia Bell Labs

**Alternate Presentations:**

1. 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

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

**Awards Luncheon:** 12:15 p.m. - 1:30 p.m.
A11: Frontiers of GNSS (Invited Session)

Date: Friday, September 25, 2020
Time: 1:45 p.m. - 3:25 p.m.

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. Exploring the Design Space of Lunar GNSS in Frozen Orbit Conditions, Filipe Pereira, Cornell University; Daniel Selva, Texas A&M

2:35. Economical Broadband LEO Navigation Systems, Peter A. Iannucci, and Todd E. Humphreys, UT Austin

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

Alternate Presentations:

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

2. A European Perspective for the Evolution of GNSS at Different Time-scales, Roberto Prieto Cerdeira, ESA/ESTEC, The Netherlands
B11: Aerial Vehicle Navigation

Date: Friday, September 25, 2020
Time: 1:45 p.m. - 3:25 p.m.

Session Chairs:

Dr. Demoz Gebre-Egziabher  
University of Minnesota

Dr. Clark Taylor  
Air Force Institute of Technology

1:50. Intercepting Unmanned Aerial Vehicle Swarms with Neural-Network-Aided Game-Theoretic Target Marking, Nick Montalbano and Todd Humphreys, University of Texas - Austin


2:35. 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


Alternate Presentations:

1. 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

2. 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
A12: Receiver Design, Signal Processing, and Antenna Technology 2
Date: Friday, September 25, 2020
Time: 3:55 p.m. - 5:30 p.m.

Session Chairs:

Dr. Thomas Pany
University of Munich, Germany

Dr. Sanjeev Gunawardena
Air Force Institute of Technology

3:20. 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

3:42. Optimizing Signal Processing Kernels for GNSS Software Receivers, Cillian O’Driscoll, Independent Consultant, Cork, Ireland

4:04. 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; Benoit Priot, ISAE-SUPAERO, France.

4:26. On Efficient and Low-Complexity Decoding of Binary LDPC-coded CSK signals for GNSS Links with Increased Data Rates, Rémi Chauvat, Axel García-Pena, École Nationale de l’Aviation Civile, France; Matteo Paonni, Joint Research Centre, European Commission, Italy

Alternate Presentations:

1. 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
B12: GNSS Resilience to Interference, Jamming, and Spoofing

Date: Friday, September 25, 2020
Time: 3:55 p.m. - 5:30 p.m.

Session Chairs:

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

Dr. Andrew Dempster
University New South Wales, Australia


3:42. Demonstration of a Multi-Layer Spoofing Detection Implemented in a High Precision GNSS Receiver, Ali Broumandan, Sandy Kennedy, John Schleppe NovAtel Inc., Canada

Best Paper in Track

4:04. 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

4:26. 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. Model and Observation of the Impact of JTIDS/MIDS on GNSS C/N0 Degradation, Axel Garcia-Pena, Christophe Macabiau, ENAC, France; Mikael Mabilleau, Pierre Durel, GSA, France
Climate
St. Louis sees an average daytime September temperature of 80 degrees Fahrenheit/27 degrees Celsius.

Conference Location and Parking
The conference will be held at the St. Louis Union Station Hotel, 1820 Market Street, St. Louis, MO 63103. The building has plentiful onsite parking. Overnight parking is included in the room rate for attendees booking rooms in ION room block.

St. Louis Union Station
There’s so much to do at St. Louis Union Station; you could stay on-campus all week and never run out of things to do!

- **The Wheel:** The St. Louis Wheel is a 200-foot high observation wheel with 42 fully enclosed gondolas that take three to four rotations over the St. Louis skyline during the 15-minute ride.
- **Carousel:** Located beneath the historic Union Station trainshed, this is an experience you will not want to miss!
- **Mini Golf:** This beautifully-landscaped 18-hole course features a variety of interactive elements, and a fun yet challenging design.
- **St. Louis Aquarium:** This aquarium boasts 13,000 animals from 257 species, including a 250,000 gallon shark tank!
- **Mirror Maze:** Navigate through the labyrinth of mirrors, test your World’s Fair knowledge, and explore the curiosities in this reimagined attraction from the 1904 World’s Fair.
- **Rope Course:** Do you have what it takes to soar 3-stories up? Test your agility and nerves on this indoor ropes course.
- **Dine** at the Station Grille, Grand Hall, Landry’s, the train Shed, 1894 Cafe and the Union Station Soda Fountain.
- **Fire and Lights Show**
- **Grand Hall Light Show**

Local Transportation
St. Louis’s light-rail network, **MetroLink**, is a modern, efficient public amenity that has been called one of the best mass transit systems in the country. The rail system offers multiple lines and stops throughout St. Louis. Metro generally operates from 4 a.m. to 1 a.m. Certain MetroLink tickets come pre-validated with a time stamp, but some do not. Double check your ticket to make sure it has a time stamp, and if it doesn’t, insert it in one of the red validation machines located at all station platforms. Tickets start at $2.50.

For more travel information, visit ion.org/gnss/travel.cfm

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Other Services
A Business Center will be provided at the hotel to provide access to basic business services including copying and printer capabilities. A coat/luggage check will be offered on Friday.

Conference Policies
Your presence at the conference constitutes your agreement to be photographed, filmed, videotaped or otherwise recorded by conference management, or its agents, and your agreement that your image/voice may be distributed in print/electronic communications media without any compensation being paid to you.

Video recording by participants is not allowed without permission of ION during any portion of the conference. Speakers may record their own presentation to provide to attendees at their discretion.

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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. Note that the Institute does not intervene in U.S. State Department’s issuance of Visas.

Conference attendees requesting a visa letter to attend a conference must:

1. Submit the visa letter request form found at ion.org/gnss
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.
HOTEL AND REGISTRATION

PLANSx session attendees should reserve their hotel room in the ION GNSS+ 2020 hotel block.

How to Reserve
• Online: Go to ion.org/gnss/hotel.cfm
• Phone: 1-847-996-5846 or toll-free 1-800-967-8717

Hotel Rate Deadline is August 21
August 21 is the last day that this rate will be available, but rooms at the discounted rates may fill up before then. Make your reservations now to avoid missing out on discounted room rates!

Hotels
St. Louis Union Station Hotel (Headquarters Hotel)
1820 Market Street, St. Louis, MO 63103
Phone: 314-231-1234 (not for reservations)
Rate: $169 single/double, limited government rate availability*
In-Room Internet: Free for guests in ION room block.
Parking: Included in room rate for guests in ION room block.

Courtyard St. Louis Downtown West
2340 Market Street, St. Louis, MO 63103
Distance from Conference Venue: 0.5 mi. (10 minute walk)
Phone: 314-241-9111 (not for reservations)
Rate: $169 single/double, limited government rate availability*
In-Room Internet: Free for ION GNSS+ attendees
Parking: $10 daily for self-parking

Drury Inn St. Louis at Union Station
201 South 20th Street, St. Louis, MO 63103
Distance from Conference Venue: Next door
Phone: 314-231-3900 (not for reservations)
Rate: $169 single/double, limited government rate availability*
In-Room Internet: Free for ION GNSS+ attendees
Parking: 7 daily for self-parking

*About Government Rates
Government rates are only for U.S. government personnel paying for a room with a U.S. government issued credit card. Failure to pay with a U.S. government issued credit card will result in your reservation being honored at the group rate. Government contractors not traveling with government travel orders are not eligible for this rate. MITRE/Aerospace personnel do qualify.

How to Register
Those individuals desiring to attend PLANSx technical sessions should register for ION GNSS+ 2020. You will have access to sessions from both meetings.

1. Make your hotel reservation at one of the three official ION GNSS+ conference hotels. Make your reservation at ion.org/gnss/hotel.cfm or by calling your preferred hotel directly.
2. Record your hotel confirmation number. All ION GNSS+ attendees staying at one of the two official conference hotels listed to the left are eligible to receive a $200 discount on their conference registration fees. Attendees must provide their valid hotel confirmation number at the start of the registration process to claim this discount. Hotel discounts will not be provided retroactively.
3. Register for ION GNSS+ at www.ion.org. Rates for attendees registering by August 21 and staying in an official conference hotel start at:
   • Full Technical Registration: $980.00
   • Single Day: $460.00
   • Student: $600.00
   • Tutorials (per course): $400
4. Complete the online registration process. Be sure to input your hotel confirmation number during the registration process to claim your discount.
5. Check in onsite at ION GNSS+ 2020

A PDF registration form is available online at: www.ion.org/gnss/registration.cfm

Book your hotel with ION and save $200 in registration fees!
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