ION

September 21-25, 2020
Live Streaming and On-Demand Technical Program
Virtual Exhibit Hall

GNSS+ 2020

VIRTUAL

PREVIOUSLY SCHEDULED IN ST. LOUIS, MISSOURI

The 33rd International Technical Meeting of the Satellite Division of the Institute of Navigation

VIRTUAL PROGRAM

FREE Access for First Time Attendees*

*Restrictions apply. See ION GNSS+ website for details.

ion.org

SCHEDULE OF EVENTS

All times listed in program are Central Daylight Time (CDT)

MONDAY, SEPTEMBER 21

Civil GPS Service Interface Committee (CGSIC Meeting) - for agenda and information, visit gps.gov/cgsic L S

TUESDAY, SEPTEMBER 22 • PRE-CONFERENCE TUTORIALS *(additional registration required)*

Civil GPS Service Interface Committee (CGSIC Meeting) - for agenda and information, visit gps.gov/cgsic L S

9:00 a.m. - 12:30 p.m.	**Multi-constellation GNSS Signals and Systems** Dr. Chris G. Bartone L S	**Introduction to Multiband and Multi-Constellation SatNav Receivers using Python** Dr. Sanjeev Gunawardena L S	
12:30 p.m. - 1:30 p.m. Break			
1:30 p.m. - 5:00 p.m.	**Indoor Navigation and Positioning** Dr. Li-Ta Hsu L S	**Autonomous System Navigation and Machine Learning** Dr. Mike Veth and Dr. Don Venable L S	

ION GNSS+ PLENARY SESSION • 6:30 p.m. – 8:30 p.m. L S

WEDNESDAY, SEPTEMBER 23

TRACK A High Performance and Safety Critical Applications	TRACK B Status and Future Trends in GNSS	TRACK C Mass Market and Commercial Applications	TRACK D Multisensor and Autonomous Navigation	TRACK E Algorithms and Methods	TRACK F Advanced GNSS Technologies
A1: Augmentation Services, Integrity and Authentication	8:30 a.m. - 12:15 p.m. B1: PANEL: Status of GPS, Galileo, BDS, QZSS, GLONASS, and NavIC L S	C1: Navigation in Urban Environments 1	D1: Alternative Technologies for GNSS-Denied Environments 1	E1: Advanced Technologies in High Precision GNSS Positioning 1	F1: GNSS Authentication and Anti-Spoofing 1
12:15 p.m. - 1:45 p.m. Break					
A2: Aviation and Aeronautics	B2: GNSS Augmentation Systems and Integrity 1	C2a: Navigation in Urban Environments 2 C2b: GNSS Receiver Manufacturer Showcase	D2: Urban and Indoor Positioning, Navigation and Mapping	E2: GNSS Receiver Technologies and Processing for Challenging Environments 1	1:45 p.m. - 5:30 p.m. F2: PANEL: PNT for AI-Enabled Autonomous Systems – The Good, the Bad, and the Ugly L S

THURSDAY, SEPTEMBER 24

A3: Land-Based Applications	B3: Trends in Future Satellite Navigation Technology, System Design and Development	C3: Novel Applications of GNSS Measurements from Smartphones	8:30 a.m. - 12:15 p.m. D3: PANEL: On the Road to Automated Vehicles L S	E3: Advanced Technologies in High Precision GNSS Positioning 2	F3: Atmospheric Effects on GNSS
12:15 p.m. - 1:45 p.m. Break					
1:45 p.m. - 5:30 p.m. A4: PANEL: Emerging Autonomous Applications – Challenges and Prospects L S	B4: GNSS Applications in Space	C4: Machine Learning in Location	D4: GNSS Augmentation and Robustness for Autonomous Navigation	E4a: GNSS Receiver Technologies and Processing for Challenging Environments 2 E4b: Next Generation GNSS Positioning	F4a: GNSS Vulnerabilities and Anti-jamming F4b: GNSS Receiver and Antenna Technologies

FRIDAY, SEPTEMBER 25

A5: Autonomous Applications	B5: GNSS Augmentation Systems and Integrity 2	8:30 a.m. - 12:15 p.m. C5: PANEL: UAV Package Delivery L S	D5: Alternative Technologies for GNSS-Denied Environments 2	E5: GNSS Receiver Signal Processing for Degraded Signal Conditions	F5: GNSS Authentication and Anti-Spoofing 2

12:30 p.m. - 1:30 p.m. Johannes Kepler and Bradford W. Parkinson Awards Ceremony L S

Please join us for a virtual presentation of this year's Satellite Division Awards during which the ION GNSS+ 2020 Program Committee will be recognized and the ION GNSS+ 2020 Student Awards, the Parkinson Award and the Kepler Award will be virtually presented. Additionally, Satellite Division election results will be announced, 2020 peer reviewers will be recognized, and the ION's 75th Anniversary will be shared.

A6: Marine Applications and Search and Rescue	B6: Spectrum: Protection and Optimization	C6: The Spectrum of Autonomy in Navigation	D6: Navigation Using Environmental Features	1:45 p.m. - 4:50 p.m. E6: PANEL: Redoing Global Satellite Navigation Systems from Scratch- The Perfect System L S	F6: Remote Sensing; Space Applications; Timing and Scientific Applications

Blue Titles = Commercial and Policy Sessions Green Titles = Research Sessions L S = Panels will be live streamed to registered virtual attendees

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The MITRE Corporation

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German Aerospace Center (DLR), Germany

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IS4S

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TRACK B
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TRACK C
Dr. Alexander Mitelman
AMM Technical Consulting

Research Tracks

TRACK D
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TRACK E
Dr. Christian Tiberius
Delft University of Technology, The Netherlands

TRACK F
Dr. Xiaochun Lu
NTSC, Chinese Academy of Sciences, China

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Pre-Conference Tutorial Information: This ION GNSS+ pre-conference tutorial has been organized to provide in-depth learning of a specific GNSS-related discipline and will be taught in a classroom setting. Electronic notes will be provided to registered attendees via the meeting website and a link provided for advance download. Power will not be made available for individual laptop computers; please come prepared with adequate battery power if required. It is also recommended that attendees dress in layers to accommodate varying temperatures in the facility.

Tutorial Costs and Registration: *$400 per half-day course if registered and paid by August 21; $450 per half-day course if payment is received after August 21. Please reference the ION GNSS+ registration page for process and policies. ION reserves the right to cancel a tutorial. If cancelled, the full cost of the course will be refunded via the original payment method.*

Multi-constellation GNSS Signals and Systems
Date: Tuesday, September 22, 2020
Time: 9:00 a.m. - 12:30 p.m.

Registration Fee:
$400 if paid on or before August 21
$450 if paid after August 21

Tutorials have been designed for an interactive classroom environment and will be live streamed. Courses will not be available for download or future viewing. The live course offers the benefits of an interactive classroom environment.

This course emphasizes the fundamentals of multi-constellation GNSS. The course begins with an overview of GNSS followed by presentation on each of the GNSS in operation and/or development today. The course will highlight common features of the various GNSSs and point out key differences between them. Topics to be covered include:

- GNSS Segments; space, ground, user segments
- GNSS Link Budget
- Fundamental concept of GNSS position and time determination
- GNSS Coordinate frames, datum's and time
- GNSS antenna & receiver technologies - overview
- GNSS signal structure formats: Carrier, Code, Data
    - Direct Sequence Spread Spectrum; auto and cross correlation
- GPS legacy and modernized signals:
    - GPS SV Blocks
    - Legacy GPS: C/A, P(Y) code and NAV formats
    - Modernized GPS: L2C, L5, L1C, CNAV and CNAV-2 formats
- GLONASS
    - GLONASS SV versions
    - Legacy C/A, P codes and FDMA signals
    - Modernized CDMA codes and frequencies
- Galileo, E1, E6/E6P, E5a, E5b, AltBOC, SAR Codes, frequencies and data formats
- BeiDou, BDS I, BDS II, BDS III, B1, B2, B3 signals and formats

- SBAS used throughout the Globe
- QZSS, L1, L2, L5, L6 signals, codes and services
- NAViC: L5, S band signals, message types
- GNSS corrections for clock, code, atmospheric, transit time, etc.
- GNSS User Solutions

Dr. Chris G. Bartone, P.E. is a professor at Ohio University with over 35 years of professional experience and is an ION Fellow. He received his PhD EE from Ohio University, a MSEE from the Naval Postgraduate School and BSEE from Penn State. Dr. Bartone has developed, and teaches, a number of GPS, radar, wave propagation and antenna classes. His research concentrates on all aspects of navigation.

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Introduction to Multiband and Multi-Constellation SatNav Receivers using Python
Date: Tuesday, September 22, 2020
Time: 9:00 a.m. - 12:30 p.m.

Registration Fee:
$400 if paid on or before August 21
$450 if paid after August 21

Tutorials have been designed for an interactive classroom environment and will be live streamed. Courses will not be available for download or future viewing. The live course offers the benefits of an interactive classroom environment.

This hands-on course aims to provide attendees with a solid understanding of the fundamentals of satellite timing and navigation (satnav) software receivers and associated signal processing. The course is divided into multiple modules, each comprised of a short lecture followed by the completion of a Python project that reinforces the concepts and techniques covered. By the end of the course, attendees will have an easy-to-use satnav software receiver running on their laptop that takes multiband live-sky sampled data files, acquires and tracks visible open satnav signals and outputs signal observables. This open-source code may be further extended to support numerous SDR based research applications.

Topics covered:

- Overview of satnav bands, signal structures, link budget, and receiver architecture
- FFT-based signal acquisition engines
- Correlation across satellite-referenced time epochs on data referenced to receiver epochs: the split-sum correlator
- Carrier tracking loops: FLL, PLL and FLL-aided-PLL
- Code tracking loops: DLL, non-coherent vs. coherent tracking, correlator spacing and carrier aiding
- Tracking of open satnav signals, including the new GPS L1C signal
- Inter-frequency aiding
- Tracking channel state machines
- Measurement computation
- Effects of fixed-point processing on tracking performance and measurement accuracy
- Performance acceleration using multi-threading and vectorization

Pre-requisites and equipment: Basic understanding of digital signal processing, object-oriented programming concepts and the Python programming language are required to work on the partially complete software projects provided. Attendees must supply their own laptop computers with adequate battery power. The instructor will provide relevant information and software to registered attendees in advance of the course.

Dr. Sanjeev Gunawardena is a research assistant professor with the Autonomy & Navigation Technology (ANT) Center at the Air Force Institute of Technology (AFIT). He has over 20 years of experience in RF, digital and FPGA-based system design. His expertise includes satnav receiver design, advanced satnav signal processing and implementation. Dr. Gunawardena received a BS in engineering physics, and a BSEE, MSEE and PhD EE from Ohio University.

Pre-Conference Tutorial Information: This ION GNSS+ pre-conference tutorial has been organized to provide in-depth learning of a specific GNSS-related discipline and will be taught in a classroom setting. Electronic notes will be provided to registered attendees via the meeting website and a link provided for advance download. Power will not be made available for individual laptop computers; please come prepared with adequate battery power if required. It is also recommended that attendees dress in layers to accommodate varying temperatures in the facility.

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Indoor Navigation and Positioning
Date: Tuesday, September 22, 2020
Time: 1:30 p.m. - 5:00 p.m.

Registration Fee:
$400 if paid on or before August 21
$450 if paid after August 21

Tutorials have been designed for an interactive classroom environment and will be live streamed. Courses will not be available for download or future viewing. The live course offers the benefits of an interactive classroom environment.

This course will provide an overview of Indoor Positioning and Indoor Navigation (IPIN) methods including, geometry-based positioning, scenario analysis (such as fingerprinting), proximity detection and dead reckoning.

Starting from the markets and applications using IPIN, we will introduce the popular technologies and related sensors including: radio signals, inertial measurements and mechanical waves etc., used in indoor positioning methods. Then, an IPIN framework will be introduced that consists of the source space, algorithm space, and integration. After introducing the single point positioning (SPP), we will discuss dead reckoning (DR).

Regarding the data sources of SPP, the course will separate the sources into homogeneous sources (geometry based) and heterogeneous sources (scene matching/analysis based). The former ones contain the measurements model of RSS-ranging, AOA, TOA and TDOA; while the latter ones contain the fingerprint and other transformed data sources that are used to match with pre-surveyed databases. Afterwards, the algorithms for SPP including, LS, NLS, ML, MAP and MMSE are introduced. The error and limitation of the SPP will be discussed. The popular DR using inertial and visual sensors, namely PDR and VO, will also be discussed before the sensor integration. Integration based on HMM, EKF and PF will be briefly introduced.

The course will conclude with a discussion on the future direction of indoor positioning system with the coming IoT and 5G era.

This course is suitable for entry-level R&D students, researchers and engineers; and managers and executives desirous to start a new project/application based on IPIN.

Dr. Li-Ta Hsu, born in Taiwan, is an assistant professor in Hong Kong Polytechnic University where he directs the Intelligent Positioning and Navigation Lab focused on the navigation for pedestrian and autonomous driving in urban canyons. He is currently a Technical Representative serving on ION Council and an Associate Fellow in the RIN.

Pre-Conference Tutorial Information: This ION GNSS+ pre-conference tutorial has been organized to provide in-depth learning of a specific GNSS-related discipline and will be taught in a classroom setting. Electronic notes will be provided to registered attendees via the meeting website and a link provided for advance download. Power will not be made available for individual laptop computers; please come prepared with adequate battery power if required. It is also recommended that attendees dress in layers to accommodate varying temperatures in the facility.

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Autonomous System Navigation and Machine Learning
Date: Tuesday, September 22, 2020
Time: 1:30 p.m. - 5:00 p.m.

Registration Fee:
$400 if paid on or before August 21
$450 if paid after August 21

Tutorials have been designed for an interactive classroom environment and will be live streamed. Courses will not be available for download or future viewing. The live course offers the benefits of an interactive classroom environment.

The revolution in autonomous vehicle development is providing novel solutions in an ever-growing range of applications. A critical component of autonomous vehicle design is the navigation system, which is required to provide a robust, accurate, navigation solution in a wide-range of operating environments. In this short course, we explore the concepts and technology associated with developing and testing navigation systems for autonomous vehicles by combining nonlinear multi-sensor fusion techniques and artificial neural networks (i.e., deep learning).

The course begins with an overview of sensors commonly used for autonomous systems including inertial sensors, GNSS, laser scanners, and image-based sensors. The associated error models are developed for each sensor and examples are presented regarding performance using experimental data. Next, core nonlinear filtering techniques are developed which support integration with the output of deep learning algorithms.

Finally, an overview of deep learning approaches for autonomous system navigation and associated performance capabilities is presented. The tutorial will begin with an overview of artificial neural network frameworks including, convolutional neural networks (CNN) and recurrent neural networks (RNN). The development will include both a theoretical and algorithmic perspective along with a review of hardware requirements for real-time implementation. Emphasis will be placed on designing a deep learning-based approach for ground vehicle navigation using a monocular camera sensor and open-source data.

Dr. Mike Veth is the co-founder of Veth Research Associates. His research focus is applying nonlinear estimation theory to optimally combine a wide range of sensors and non-traditional navigation sources to enable robust autonomous applications. He received his BS in Electrical Engineering from Purdue University and a PhD in Electrical Engineering from the Air Force Institute of Technology. He has served the ION as Eastern Region Vice President, Dayton Section chair, session chair, track chair and program chair. Dr. Veth has authored over 40 technical articles and book chapters in areas relating to computer vision, navigation and control theory. He is a member of the ION, a Senior Member of the IEEE and a graduate of the US Air Force Test Pilot School.

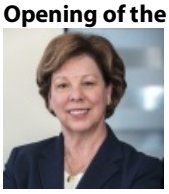
Dr. Don Venable is currently a principal researcher at Veth Research Associates. Previously, he was a senior electronics engineer at the Navigation and Communications Branch of the Air Force Research Laboratory (AFRL), Sensors Directorate. His research focus is combining probabilistic deep learning with traditional Bayesian estimation theory for non-GPS navigation and object tracking applications. He received his PhD from the Air Force Institute of Technology and both his MS and BS in Electrical Engineering from Ohio University. For his dissertation research, he designed and built a novel optical navigation system for airborne applications. Dr. Venable is active in the Institute of Navigation.

PLENARY SESSION
Date: Tuesday, September 22, 2020
Time: 6:30 p.m. - 8:30 p.m.
LIVE STREAM This session will be live streamed for registered virtual attendees.
ON DEMAND A video of this session will be available for on-demand viewing by all registered attendees.

Welcome, Meeting Highlights and Introduction of Technical Committee

Satellite Division Chair
Dr. Chris Hegarty
The MITRE Corporation

Opening of the Plenary Session



Satellite Division Vice Chair
Patricia Doherty
Boston College

KEYNOTE ADDRESSES:

4P's to my Dream Job!

Dr. Christine Darden
Retired NASA Program Manager, Mathematician and Aerospace Engineer

Dr. Christine Darden's 40-year career at NASA led her to become one of the world's leading experts on sonic boom prediction, sonic boom minimization and supersonic wing design. During this keynote, Darden will highlight the process she used to develop and test new designs, including those for the supersonic wing design.

During her 40-year career at NASA, she led an advisory team composed of representatives from industrial manufacturers and academic institutions; became the deputy program manager of The TU-144 Experiments Program, an element of NASA's High Speed Research Program; and in 1999, she was appointed as the director in the Program Management Office of the Aerospace Performing Center where she was responsible for Langley's research in air traffic management and other aeronautics programs managed at other NASA Centers. Darden also served as technical consultant on numerous government and private projects, and she is the author of more than 50 publications in the field of high lift wing design in supersonic flow, flap design, sonic boom prediction, and sonic boom minimization.

Dr. Darden will also share her personal "4P Formula" that helped her when she encountered roadblocks and detours in her career and in life. She shared some of these with Margot Lee Shetterly in Shetterly's New York Times best-selling book, *Hidden Figures*.

Radio Navigation from Marconi to GNSS

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

- 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?

A1: Augmentation Services, Integrity and Authentication
Date: Wednesday, September 23, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Chris Wullems
Qascom, Australia

Javier Simon
European GNSS Agency (GSA), Czech Republic

1. **Broadcast Data Authentication Concepts for Future SBAS Services,** Luciano Tosato, Andrea Dalla Chiara, Chris Wullems, Qascom, Italy; Guillermo Fernandez Serrano, Alessandra Calabrese, GMV, Spain; Adrian Perrig, Mikael Mabilleau, GSA; Giovanni Vecchione, RHEA, Belgium
2. **Experimentation Results on Autonomous and Semi-autonomous Signal Authentication Techniques,** S. Cancela, J. Navarro, D. Calle, GMV, Spain; A. Dalla Chiara, I. Fernández-Hernández, G. Seco-Granados, UAB, Spain
3. **Bounding Temporally Correlated Measurement Noise: Review of Techniques and an Application to GNSS Integrity,** Juan Blanch, Eric Phelts, Kaz Gunning, Todd Walter, Stanford University; Lance de Groot, Laura Norman, Hexagon Autonomy & Positioning, Canada
4. **SAPA: Bringing Centimeter Accuracy to the Masses with Safe GNSS Correction Services,** Rodrigo Leandro, Botho Eulenburg, Cornelia Waldecker, Sapcorda
5. **GNSS SSR Real-Time Corrections: The Geo++® SSRZ Format and Applications,** Gerhard Wübbena, Christopher Perschke, Jannes Wübbena, Temmo Wübbena, Martin Schmitz, Geo++ GmbH, Germany

B1: PANEL: Status of GPS, GLONASS, Galileo, BeiDou, QZSS, NavIC, and UK GNSS
Date: Wednesday, September 23, 2020
Time: 8:30 a.m. - 12:15 p.m.
LIVE STREAM This session will be live streamed for registered virtual attendees.
ON DEMAND A video of this session will be available for on-demand viewing by all registered attendees.

Session Chairs:

Deborah Lawrence
Federal Aviation Administration

Dr. John Betz
The MITRE Corporation

An update on satellite-based navigation systems in operation or under development. A representative for each system will provide a system overview, summarize current or planned characteristics and performance, report recent programmatic events, update schedule and plans, and summarize ongoing interactions with other service providers. Questions from the audience are encouraged.

This session provides an update on the world's satellite-based navigation system. A representative for each system will provide a system overview, summarize current or planned characteristics and performance, report recent programmatic events, update schedule and plans, and summarize ongoing interactions with other service providers. Questions from the audience are encouraged.

Panel Members:

1. **GPS,** Col Ryan Colburn, Chief, PNT Mission Integration (invited)
2. **GLONASS,** Dr. Sergey Karutin, GLONASS General Designer, Central Institute of Machine Building, Russia
3. **Galileo,** Eric Chatre, Head of EU-GNSS Services and Evolution, European Commission, Belgium; Javier Benedicto, Galileo Project Manager, European Space Agency, The Netherlands
4. **BeiDou,** Dr. Jun Shen, Deputy Director, International Cooperation Center, China Satellite Navigation Office, China (invited)
5. **QZSS,** Mr. Satoshi Kogure, Executive Director for QZSS Development, QZSS Strategy Office, National Space Policy Secretariat, Cabinet Office, Japan
6. **NavIC,** Representative from Indian Space Research Organization (invited)

C1: Navigation in Urban Environments 1
Date: Wednesday, September 23, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. David Herlihy
Waymo

James Tidd
Swift Navigation

1. **A Sub-meter Real-time Positioning Service for Smartphones,** Joshua Critchley-Marrows, William Roberts, Malgorzata Siutkowska, Maria Ivanovici, NSL, UK; Valentin Barreau, Soufian Ayachi, Laurent Arzel, Telespazio, France
2. **Particle Filter Based RTK-GNSS: NLOS Detection Using Double Differenced Pseudorange Residuals for Robust Vehicle Localization,** Taro Suzuki, Chiba Institute of Technology, Japan
3. **Trajectory Planning Under Stochastic and Bounded Sensing Uncertainties Using Stochastic Reachability,** Akshay Shetty, University of Illinois Urbana-Champaign and Grace Xingxin Gao, Stanford University
4. **3D LiDAR Aided GNSS and its Tightly Coupled Integration with INS Via Factor Graph Optimization,** Weisong Wen and Li-Ta Hsu, Hong Kong Polytechnic University , Hong Kong
5. **Precise Positioning for 2-Wheel Urban Mobility Applications,** Mike Horton, HYFIX.AI and Jens Windau, Lyft, Hardware Data Scientist
6. **Seamless Accurate Positioning in Deep Urban Area using Mode Switching between DGNSS and CMC-based Multipath Mitigation,** Yongjun Lee, Byungwoon Park, Sejong University, South Korea
7. **Tightly-coupled Integration of a GNSS/INS System Aided by the RAIM Satellite Selection Algorithm,** Shih-Chien Hung and Shau-Shiun Jan, National Cheng Kung University, Taiwan
8. **A Satellite Selection Method Based on the Consistency Analysis of the Doppler Frequency and the Carrier Phase Difference,** Tomoaki Takewa ,Takafumi Nagano and Wataru Tsujita, Mitsubishi Electric Corporation, Japan

D1: Alternative Technologies for GNSS-Denied Environments 1
Date: Wednesday, September 23, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Christian Gentner
German Aerospace Center (DLR), Germany

Dr. Allison Kealy
RMIT University, Australia

1. **Hybrid Navigation Filters Performances Between GPS, Galileo and 5G TOA Measurements in Multipath Environment,** Anne-Marie Tobie, TéSA, France; Axel Garcia-Pena, Paul Thevenon, Jérémy Vezinet, ENAC, France; Marion Aubault, François-Xavier Marmet, CNES, France
2. **Tight Integration of Digital Map and Tethered Positioning and Navigation Solution for IoT Applications and Land Vehicles,** Yashar Balazadegan Sarvrood, Haiyu Lan, Aboelmagd Noureldin, and Naser El-Sheimy, Profound Positioning Inc., Canada
3. **Accuracy and Performance of the Network Location Provider in Android Devices,** Filip Nedelkov, Dong-Kyeong Lee, Damian Miralles, Dennis M. Akos, University of Colorado Boulder, Stanford University
4. **Effect of Antenna Ports on TOA Estimation with 4G LTE Signals in Urban Mobile Environments,** Chun Yang, QuNav, Thomas Pany, Petra Weitkemper, Universität der Bundeswehr München, Germany
5. **Vehicle Motion Estimation by Low Cost GNSS / IMU Accuracy Improvement by IMU Correction Using GNSS,** Aoki Takanose, Yoshiki Atsumi, Kanamu Takikawa, Junichi Meguro, Department of Mechatronics Engineering, Faculty of Science and Technology, Meijo University, Japan
6. **Resilient Peer-to-Peer Ranging using Narrowband High-Performance Software-Defined Radios,** Vincent C. Beech and Paul D. Groves, University College London, UK; Paul Wright, Terrafix Limited , UK
7. **Enhanced Land Vehicles Navigation by Fusing Automotive Radar and Speedometer Data,** Ashraf Abosekeen, Military Technical College, Egypt; Umar Iqbal, Mississippi State University; Aboelmagd Noureldin, Royal Military College of Canada, Canada;
8. **Demonstration of a Decimeter-level Accurate Hybrid Optical-wireless Terrestrial Positioning System,** Cherif Diouf, Han Dun, Tarik Kazaz, Gerard Janssen, Christian Tiberius, Delft University of Technology, Netherlands

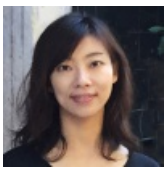
Alternate Presentations:

1. **Evaluation of 5G New Radio Positioning Performance,** Olivier Renaudin, Universitat Autònoma de Barcelona (UAB), Spain; José A. Del Peral-Rosado, Universitat Autònoma de Barcelona (UAB) and Airbus Defense and Space; Francesca Zanier, European Space Agency (ESA), The Netherlands; José A. López-Salcedo, Gonzalo Seco-Granados, UAB, Spain
2. **A Proof-of-concept of Cooperative DGNSS for UAV/UGV Navigation,** Neil Gogoi, Alex Minetto, and Fabio Dovis, Politecnico di Torino, Italy

E1: Advanced Technologies in High Precision GNSS Positioning 1
Date: Wednesday, September 23, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Safoora Zaminpardaz
RMIT University, Australia



Dr. Jihye Park
Oregon State University

1. **DGNSS-based Cooperative Positioning using Statistics-Adaptive Particle Filter,** Alex Minetto, Fabio Dovis, Alessandro Gurrieri, Politecnico di Torino, Italy
2. **Privacy-preserving Cooperative Positioning,** Guillermo Hernandez, Gerald LaMountain, and Pau Closas, Electrical, and Computer Engineering Dept., Northeastern University
3. **Analysis of the Network Dimension Impact on the Performance of Ionosphere-weighted Single-receiver Integer Ambiguity Resolution-enabled PPP,** Dimitrios Psychas, Department of Geoscience and Remote Sensing, Delft University of Technology, and Fugro Innovation & Technology B.V., The Netherlands; Sandra Verhagen, Department of Geoscience and Remote Sensing, Delft University of Technology, The Netherlands
4. **State-space Positioning Corrections via Single-receiver GNSS Data,** A. Khodabandeh and N. Nadarajah, The University of Melbourne, Australia
5. **Uncertainty Model Estimation in an Augmented Data Space for Robust State Estimation,** Ryan M. Watson, Jet Propulsion Laboratory; Jason N. Gross, West Virginia University; Clark N. Taylor, Robert C. Leishman, Air Force Institute of Technology
6. **Vector Tracking in GNSS Receivers: Implementation and Results,** Nikolay Mikhaylov, David Oertel, Robert Bosch GmbH, Germany; Valery Chistyakov, Bora Ltd., Russia
7. **A Riemannian Algorithm for Precise GNSS Attitude Determination,** Xing Liu, Tarig Ballal, King Abdullah University of Science and Technology (KAUST), Soudi Arabia; Ahmed Douik, California Institute of Technology (Caltech); Tareq Y. Al-Naffouri, KAUST, Saudi Arabia; Babak Hassibi, Caltech
8. **On the Evaluation of Confidence Levels with Applications to GNSS,** Safoora Zaminpardaz, School of Science, College of Science, Engineering & Health, RMIT University, Australia; Peter JG Teunissen, GNSS Research Centre, Curtin University, Australia & Department of Geoscience and Remote Sensing, Delft University of Technology, The Netherlands; Christiaan C.J.M. Tiberius, Department of Geoscience and Remote Sensing, Delft University of Technology, The Netherlands

Alternate Presentations:

1. **Multivariate Constrained Wrapped Least Squares for 3-D GNSS Attitude Determination,** Xing Liu, Tarig Ballal, Tareq Y. Al-Naffouri, King Abdullah University of Science and Technology (KAUST), Saudi Arabia
2. **Focus on Height Fluctuation Kinematic Positioning Reliability Judgment,** Aoki Takanose, Yoshiki Atsumi, Kanamu Takikawa, Junichi Meguro, Department of Mechatronics Engineering, Faculty of Science and Technology, Meijo University, Japan
3. **Virtual Base Station Algorithm and Performance Assessment,** Mourad Saidani, Alexis Guinamard, Patrick Sarri, Daniel Gallego Maya, SBG Systems, France

F1: GNSS Authentication and Anti-Spoofing 1
Date: Wednesday, September 23, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Ranwa Haddad
The Aerospace Corporation

Dr. Sanjeev Gunawardena
Air Force Institute of Technology

1. **A Solution Separation Monitor using INS for Detecting GNSS Spoofing,** Birendra Kujur, Samer Khanafseh, and Boris Pervan, Illinois Institute of Technology
2. **A GNSS Spoofing Exclusion Method based on Density Clustering with the Rough User Position,** Jianfeng Li, Hong Li, Mingquan Lu, Department of Electronic Engineering, Tsinghua University, China
3. **GPS Spoofing Resilience via NMA/Watermarks Authentication and INS Prediction,** Michael C. Esswein & Mark L. Psiaki, Kevin T. Crofton Department of Aerospace and Ocean Engineering, Virginia Tech
4. **Optimal Sequential Spoof Detection Based on Direction of Arrival Measurements,** Fabian Rothmaier, Stanford University
5. **Barometer Based GNSS Spoofing Detection,** Dong-Kyeong Lee, Filip Nedelkov, University of Colorado Boulder; Dennis Akos, University of Colorado Boulder & Stanford University; Byungwoon Park, Sejong University, South Korea
6. **Spoofing Detection on Ships Using Multipath Monitoring and Moving-baseline Analysis,** Kaito Kobayashi and Nobuaki Kubo, Tokyo University of Marine Science and Technology, Japan
7. **Blind Spoofing Detection for Multi-Antenna Snapshot Receivers using Machine-Learning Techniques,** Johannes Rossouw van der Merwe, Fraunhofer IIS, Germany; Ana Nikolikj, Ss. Cyril and Methodius University Skopje, Macedonia; Sebastian Kram, Ivana Lukcin, Fraunhofer IIS, Germany; Gorjan Nadzinski, Ss. Cyril and Methodius University Skopje, Macedonia; Alexander Rügamer, and Wolfgang Felber, Fraunhofer IIS, Germany
8. **A Proposal for Securing Terrestrial Radio-Navigation Systems,** Ronnie X.T. Kor, Peter A. Iannucci, Lakshay Narula, Todd E. Humphreys, Department of Aerospace Engineering and Engineering Mechanics, The University of Texas at Austin

Alternate Presentations:

1. **Deep Neural Network Approach to Detect GNSS Spoofing Attacks,** Parisa Borhani-Darian, Haoqing Li, Peng Wu, Pau Closas, Electrical, and Computer Engineering Dept., Northeastern University
2. **GNSS Anti-Spoofing Defense Based on Cooperative Positioning,** Akmal Rustamov, Neil Gogoi, Alex Minetto, Fabio Dovis, Politecnico di Torino, Italy
3. **All Signal Acquisition Processing for Spoofing Detection, Estimation, Mitigation, and Intent Analysis,** Chun Yang and Andrey Soloviev, QuNav
4. **Identifiability Analysis and Sparse Detection of GPS Spoofing Attacks on Phasor Measurement Units,** Ali Khalajmehrabadi, Samsung Semiconductor Inc.; Nikolaos Gatsis, Ahmad Taha, and David Akopian, Department of Electrical and Computer Engineering, University of Texas at San Antonio

A2: Aviation and Aeronautics
Date: Wednesday, September 23, 2020
Time: 1:45 p.m. - 5:30 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Juan Blanch
Stanford University

Dr. Yawei Zhai
Shanghai Jiao Tong University, China

1. **A New Model for Terrestrial Multipath in Aviation,** Okuary Osechas, Gianluca Zampieri, German Aerospace Center (DLR), Germany; Nicolas Schneckenburger, Hensoldt GmbH, Germany
2. **GPS and GALILEO Airframe Multipath Error Bounding Method and Test Results,** Matt Harris, Paul Schlais, Tim Murphy, Boeing Commercial Airplanes; Angelo Joseph, Jeremy Kazmierczak, Collins Aerospace
3. **Global Flight Test Results for a DFMC Primary Navigator on a Civil Air Transport Aircraft,** Angelo Joseph, Jeremy Kazmierczak, Collins Aerospace; Matt Harris, Paul Schlais, Boeing
4. **GPS Ephemeris Analysis for SoL Applications: URE Evaluation and Antenna Offsets,** José Gabriel Pericacho, Julián Barrios, David Rodríguez Muñoz, Susana Domenech Rodriguez-Rey, GMV, Spain
5. **Evaluation of the Impact of Ionospheric Scintillation on Airborne GNSS Receivers,** Sai Kalyanaraman, Collins Aerospace; Todd Walter, Stanford University; Angelo Joseph, Jeremy Kazmierczak, Collins Aerospace
6. **IGNSS Computation Models and Values for GPS and GALILEO Civil Aviation Receivers,** Axel Javier Garcia Pena, Christophe Macabiau, ENAC, France; Olivier Julien, u-blox, Switzerland; Mikael Mabilleau, Pierre Durel, GSA, Czech Republic
7. **Positioning Performance Analysis for Different UAV's use Cases and Testing Campaigns Using EGNSS,** G. Moreno, C. Sanz, M. Cueto, A. Cezón, GMV, Spain; A. Viguria, A. Jiménez, CATEC, Spain; T. Tavares, K. Callewaert, VVA, Spain; M. Aguilera, I. Alcantarilla, European Commission, Belgium
8. **Navigation Performance Derivation for Safe Separation of UAVs for Local-area UAS Traffic Management Based on Ground Risk Map,** Younsil Kim, Am Cho, Joongwon Bae, Korea Aerospace Research Institute, South Korea

Alternate Presentations:

1. **In-band RFI GNSS L5/E5a Mask Definition,** Axel Javier Garcia Pena, Christophe Macabiau, ENAC, France; Olivier Julien, u-blox, Switzerland; Mikael Mabilleau, Pierre Durel, GSA, Czech Republic
2. **GPAHRS – New Building Block to Enhance Safety and Availability of Future Aircraft Navigation,** Pavol Malinak, Zdenek Kana, Milos Sotak, Tomas Vaispacher, Radek Baranek, Libor Slabak, Honeywell International, Advanced Technology Europe, Czech Republic
3. **Multi-sensor Fusion for Autonomous Deep Space Navigation,** Chengjun Guo, Shiyan Deng, Yalan Xu, Jing He, University of Electronic Science and Technology of China
4. **Identification, Attitude Estimation and Capture of Tumbling Spacecraft Based on SLAM,** Chengjun Guo, Shiyan Deng, Jing He, Yalan Xu, University of Electronic Science and Technology of China

B2: GNSS Augmentation Systems and Integrity 1
Date: Wednesday, September 23, 2020
Time: 1:45 p.m. - 5:30 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Jim Waid
Honeywell

Dr. Santiago Perea Diaz
Airbus Defense and Space GmbH, Germany

1. **Frequency-Domain Modeling of Orbit and Clock Errors for Sequential Positioning,** Elisa Gallon, Illinois Institute of Technology; Mathieu Joerger, Virginia Tech; Boris Pervan, Illinois Institute of Technology
2. **Overbounding Sequential Estimation Errors Due to Non-Gaussian Correlated Noise,** Steven Langel, The MITRE Corporation; Omar Garcia-Crespillo, Institute of Communications and Navigation, German Aerospace Center (DLR), Germany; Mathieu Joerger, Virginia Tech
3. **Error Bounding for ARAIM Integrity Support Message Generation,** Ilaria Martini, European Commission Advisor, Rhea, Belgium; Matteo Sgammini, European Commission, Joint Research Centre, Italy; Juan Pablo Boyero, European Commission (DG-DEFIS), Belgium
4. **DARP Project. A Proposal of ARAIM Receiver Algorithm for Aviation Applications,** Mariano Wis, Paolo D'Angelo, Antonio Fernández, Deimos Space, Spain; Markus Rippl, German Aerospace Center (DLR), Germany; Javier de Andrés, ENAIRE, France; Gianluca Franzoni, Thales Alenia Space Italia, Italy; Denis Bouvet, Thales AVS France; Michel Monnerat, Thales Alenia Space France; Katerina Strelcova, European GNSS Agency, GSA, Czech Republic
5. **Benefit of SFMC SBAS and its Performance Assessment for WAAS, EGNOS, and MSAS,** Cheolsoon Lim, Byungwoon Park, Changdon Kee, Youngsun Yun, Sejong University, South Korea
6. **Analysis on the Impact of Different Time Constants of Smoothing Filter on Compliance of Ranging Source Monitors in Dual-Frequency GBAS,** Junesol Song and Carl Milner, ENAC, Université de Toulouse, France
7. **Flight Test Validation of Ground Based Augmentation System Prototype in Taiwan,** Yueh-Wen Lin, Yi-Ting Sung, Shuo-Ju Yeh, and Shau-Shiun Jan, National Cheng Kung University, Taiwan
8. **Development of DFMC SBAS Receiver Supporting QZSS L5S Signals,** Motoki Higuchi, Masahito Mogamiya, Takahiro Yamamoto, CORE Corporation, Japan; Takeyasu Sakai, National Institute of Maritime, Port and Aviation Technology, Japan

C2a: Navigation in Urban Environments 2
Date: Wednesday, September 23, 2020
Time: 1:45 p.m. - 3:25 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. David Herlihy
Waymo

James Tidd
Swift Navigation

1. **Tight Coupling between Radar and INS/GNSS with AUTO software for Accurate and Reliable Positioning for Autonomous Vehicles,** Abdelrahman Ali, Billy Chan, Trusted Positioning Inc., TDK Group Company, Canada; Amr Ahmed, University of Calgary, Canada; Medhat Omr, Dylan Krupity, Qingli Wang, Amr Al-Hamad, Jacques Georgy, and Christopher Goodall, Trusted Positioning Inc., TDK Group Company, Canada
2. **The Path to Robust Municipal PNT,** Steven Polunsky, Alabama Transportation Policy Research Center, University of Alabama
3. **Evaluation of a "Black-Box" State-of-the-Art Vision-Based Navigation Algorithm for GPS-Denied Navigation,** Simone Bortolami, Helen Webb, Mike Richman, and Peter Norton, BAE Systems – Electronic Systems
4. **Precise Positioning into Urban Environments: A Low-cost Single-Frequency PPP System,** Hongzhou Yang, Fei Liu and Yang Gao, Profound Positioning Inc., Canada

C2b: GNSS Receiver Manufacturer Showcase
Date: Wednesday, September 23, 2020
Time: 3:55 p.m. - 5:30 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Stewart Cobb
Satelles

Dr. Michael Koenig
L3 Technologies

1. **Low-cost and Cloud-based and PPP-RTK/INS module/platform-Aceinna OpenRTK 330,** Yihe Li, Yudan Yi, Da Wang, Zhengpeng Xu, Xuanxuan Hu, Xuehai Dong, Chen Zhang, Zhihua Dong, Yundong Zou, Chenghe Dai, Mingjin Yu, Aceinna Inc., China
2. **MediaTek's First Dual-Frequency GNSS Solution on the First MediaTek 5G-NR Mobile Platform,** Pei-Hung Jau, Chin-Tang Weng, WenChun Shih, CW Chen, Sam Chen and ShengYu Huang, MediaTek Inc., Taiwan
3. **BeiDou B2b and QZSS L6 Message Decoding Accuracy in a Low-power Low-cost Platform,** Marco Mendonca, Ali Pirsiavash, Altti Jokinen, Allystar Technology Ltd., Canada; Ryan Yang, Hongtao Yu, Gary Hau, Mingo Tsai, Allystar Technology Co., Ltd., Hong Kong, China; Yi-Fen Tseng, Allystar Technology Co., Ltd., China

D2: Urban and Indoor Positioning, Navigation and Mapping
Date: Wednesday, September 23, 2020
Time: 1:45 p.m. - 5:30 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. David Bevly
Auburn University

Dr. Ryan Watson
Jet Propulsion Laboratory

1. **Wheel Odometry Aided Visual-Inertial Odometry for Land Vehicle Navigation in Winter Urban Environments,** Cheng Huang, Yang Jiang, and Kyle O'Keefe, Position Location And Navigation (PLAN) Group, Department of Geomatics Engineering Schulich School of Engineering University of Calgary, Canada
2. **Localization in High-Speed Motion using IMU-aided Event Flow Estimation,** Jae Hyung Jung, Department of Mechanical & Aerospace Engineering, Seoul National University, Republic of Korea; Chan Gook Park, Department of Mechanical & Aerospace Engineering / Automation and Systems Research Institute, Seoul National University, Republic of Korea
3. **Robust and Accurate Deterministic Visual Odometry,** Pierre Bénet and Alexis Guinamard, SBG Systems, France
4. **An Evaluation of Vision-aided Navigation Uncertainty,** Erik Rodenburg and Clark Taylor ANT Center Air Force Institute of Technology
5. **Multi-Antenna Vision-and-Inertial-Aided CDGNSS for Micro Aerial Vehicle Pose Estimation,** James E. Yoder, Peter A. Iannucci, Lakshay Narula, Todd E. Humphreys, Aerospace Engineering and Engineering Mechanics, The University of Texas at Austin
6. **The Performance Analysis of Multi-Sensor Integration Using Smartphone's Sensor for Seamless Urban and Indoor Navigation,** Dinh Thuan Le, Kuan-Ying Lin, Syun Tsai, Dept. of Geodetics, College of Engineering, National Cheng Kung University, Taiwan
7. **Integrity-Driven Landmark Attention for GPS-Vision Navigation via Stochastic Reachability,** Sriramya Bhamidipati, University of Illinois at Urbana-Champaign and Grace Xingxin Gao, Stanford University
8. **Combining Inertially-aided Extended Coherent Integration (Supercorrelation) with 3D-Mapping-Aided GNSS,** Paul D. Groves, Qiming Zhong, University College London, United Kingdom; Ramsey Faragher, Paulo Esteves, Focal Point Positioning, United Kingdom

Alternate Presentations:

1. **Integrity-Based Path Planning Strategy for Urban Autonomous Vehicular Navigation Using GPS and Cellular Signals,** Halim Lee, Yonsei University, Korea; Mahdi Maaref, University of California, Irvine; Zak (Zaher) M. Kassas, University of California, Irvine; and Jiwon Seo, Yonsei University, Korea
2. **Indoor Positioning Algorithm Based on Channel State Information using Bootstrap Filter,** Jingjing Wang, Joon Goo Park Kyungpook National University Electronics Engineering, South Korea
3. **Automated Road Elements Generation to Produce HD Maps for Autonomous Driving Applications Using a Low-Cost Mapping Payload,** Guang-Je Tsai, Jhih-Cing Zeng, Kai-Wei Chiang, National Cheng Kung University, Taiwan
4. **Adaptive Strategy for Non-line-of-sight PNT Weighting in Urban Canyons,** Xurxo Otero Villamide, Floor Melman, Jose Antonio García Molina, European Space Agency, Netherlands; Gerarda de Pasquale, Intecs Solutions S.p.A., Italy

E2: GNSS Receiver Technologies and Processing for Challenging Environments 1
Date: Wednesday, September 23, 2020
Time: 1:45 p.m. - 5:30 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Thomas Pany
Bundeswehr University Munich, Germany

Dr. Rong Yang
Shanghai Jiaotong University, China

1. **GNSS Sequence Extraction and Reuse for Navigation,** Johannes Rossouw van der Merwe, Fraunhofer IIS, Germany; Sascha Bartl, Digital Solutions GmbH (OHB), Austria; Cillian O'Driscoll, Cillian O'Driscoll Consulting (CODC), Ireland; Alexander Rügamer, Frank Förster, Fraunhofer IIS, Germany; Philipp Berglez, OHB, Austria; Alexander Popugaev, and Wolfgang Felber, Fraunhofer IIS, Germany
2. **Blind Opportunistic Navigation: Cognitive Deciphering of Partially Known Signals of Opportunity,** Mohammad Neinavaie, Joe Khalife, and Zak (Zaher) M. Kassas; University of California, Irvine
3. **Long Coherent Combining and Integration for BOC-Signal Acquisition Under Strong Interference,** Chun Yang, Andrey Soloviev, Ananth Vadlamani, QuNav; Joung C. Ha, AFRL/RYWN
4. **Frequency Diversity-Combined Robust GNSS Signal Tracking Using a Bank of Correlators,** Peirong Fan, Department of Electronic Engineering, Tsinghua University and China Satellite Navigation Center, China; Yang Gao, China Satellite Navigation Center, China; Xiaowei Cui, Department of Electronic Engineering, Tsinghua University, China; Mingquan Lu, Department of Electronic Engineering, Beijing National Research Center for Information Science and Technology, Tsinghua University, Beijing, China; Weihua Xie, China Satellite Navigation Center, China
5. **GNSS Multi-frequency Carrier Tracking with Cycle Slip Detection and Mitigation Under Strong Ionosphere Scintillation,** Rong Yang, Xingqun Zhan, Jihong Huang, School of Aeronautics and Astronautics, Shanghai Jiao Tong University, China; Y. Morton, Department of Aerospace Engineering Sciences, University of Colorado, USA
6. **Cooperative Navigation with the Vector Delay/Frequency Lock Loop,** Tanner M. Watts and Scott M. Martin, Auburn University
7. **A Post Processing Based IRNSS/NavIC Software Receiver for Analysis and Development of New Algorithms and Signals,** Chittimalla Srinu and Laxminarayana Parayitam, Research and Training Unit for Navigational Electronics Osmania University, India
8. **Deep Learning of GNSS Signal Correlation,** Haoqing Li, Parisa Borhani-Darian, Peng Wu, Pau Closas, Electrical, and Computer Engineering Dept., Northeastern University

Alternate Presentations:

1. **An Improved Dual Binary Phase-shift Keying Tracking Method for Standard BOC Signals,** Chuhan Wang, Department of Electronic Engineering, Tsinghua University & Beijing Satellite Navigation Center & Beijing National Research Center for Information Science and Technology, China; Yang Gao, Beijing Satellite Navigation Center, China; Xiaowei Cui, Department of Electronic Engineering, Tsinghua University, China; Mingquan Lu, Department of Electronic Engineering, Tsinghua University & Beijing National Research Center for Information Science and Technology, China
2. **A Tool for Integrity Analysis in Harsh Propagation Conditions with Hybrid GNSS/INS Solutions – Initial Results,** T. Panicciari, J.A. García-Molina, G. Lopez Risueno, R. Ioannidis, European Space Agency (ESA/ESTEC), The Netherlands
3. **Vector Delay and Frequency Lock Loop in a Real-time Hardware Environment,** Katrin Dietmayer, Fabio Garzia, Matthias Overbeck, Wolfgang Felber, Fraunhofer IIS, Germany

F2: PANEL: GNSS for AI-Enabled Autonomous Systems – The Good, the Bad, and the Ugly
Date: Wednesday, September 23, 2020
Time: 1:45 p.m. - 5:30 p.m.
LIVE STREAM This session will be live streamed for registered virtual attendees.
ON DEMAND A video of this session will be available for on-demand viewing by all registered attendees.

Session Chair:

Dr. Zak Kassas
University of California, Irvine

The world is abuzz with artificial intelligence (AI), as it gets integrated into numerous application domains. In parallel, there are ambitious plans to fully integrate unmanned aerial vehicles (UAVs) into the national airspace and bring self-driving cars into our streets. Endowing these autonomous, safety-critical cyber-physical systems (CPS) with AI could bring numerous opportunities. But how about the new challenges that would arise and what about the unintended consequences? This panel will bring together aviation, transportation, and GNSS experts to discuss the opportunities and challenges of AI-enabled autonomous systems in safety-critical applications.

Panel Members:

1. **Mr. Andrew Hansen,** Principal, Aviation Modeling & System Design, US Department of Transportation Volpe Center
2. **Mr. Mitch Narins,** Principal Consultant and Owner, Strategic Synergies
3. **Dr. Yang Gao,** Professor, Department of Geomatics Engineering, University of Calgary, Canada
4. **Dr. Robert Leishman,** Air Force Institute of Technology

A3: Land-Based Applications
Date: Thursday, September 24, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Miguel Azaola
GMV, Spain

Lionel Ries
ESA, The Netherlands

1. **A Globally Referenced and High-precision Visual Positioning Device based on Multi-sensor Fusion Technology,** Stefan Schaufler, Michele Fischell, Geo Boffi, Xiaoguang Luo, Jose Aponte, Leica Geosystems, Switzerland
2. **An Analysis to Enhance the Reliability of an Integrated Navigation System at Multiple Stages by using FOS,** Umar Iqbal, Electrical and Computer Engineering, Mississippi State University; Ashraf Abosekeen, Military Technical College, Cairo, Egypt Aboelmagd Noureldin, Electrical and Computer Engineering, Queen's University, Royal Military College of Canada, Canada; Michael J. Korenberg, Electrical and Computer Engineering, Queen's University Canada
3. **Infrastructure Free Solution for Train Positioning Using Track Database,** Philippe Brocard, Raphael Pons, Gabriele Ligorio, Airbus, France; Jan Wendel, Airbus Defence and Space GmbH, Germany; Antoine Barré, Alexia Le Quilliec, SNCF, France
4. **A Multi-sensor Platform for High Integrity Multi-modal Positioning System,** Roberto Capua, Sogei, Italy; Ales Filip, University of Pardubice, Italy; Alessandro Neri, RadioLabs, Italy; Sam Pullen, University of Stanford; Francesco Rispoli, Pietro Salvatori, Cosimo Stallo, RadioLabs, Italy
5. **GINTO5G: GNSS Integration into 5G Wireless Networks,** F.J. Mata, GMV, Spain; F. Grec, ESA; M. Azaola, F. Blázquez, A. Fernández, E. Dominguez-Tijero, G. Cueto-Felgueroso, GMV, Spain; G. Seco-Granados, J.A. del Peral-Rosado, UAB, Spain; E. Staudinger, C. Gentner, German Aerospace Center (DLR), Germany; M. Kasparek, C. Backet, Fraunhofer IIS, Germany; D. Bartlett, u-blox, Switzerland; E. Serna, Telefónica I+D, Spain; L. Ries, R. Prieto-Cerdeira, ESA, The Netherlands
6. **Reliable Localization on Micro Mobility Platforms for Public Safety and By-law Compliance,** Zainab Syed, Juan Carlos Terrazas Borbon, Lucas Hossack, Curtis Pidgeon, Husain Syed, Kyle Chau, Amy Cai, TDK - Canada
7. **GNSS/INS Sensor Fusion with On-Board Vehicle Sensors,** Ryan Dixon, Brett Kruger, Michael Bobye, Jonathan Jacox Hexagon, NovAtel, Inc., Canada
8. **Project Road Runner: A Demonstration of Swift Navigation's Precise Positioning Solution Across the Continental US,** Jared Wilson, Anil Goparaju, Sebastien Carcanague, Ben Segal, Anthony Cole, and Fergus Noble, Swift Navigation

Alternate Presentations:

1. **Allystar Lowest Power and Size Single-chip Dual-frequency RTK,** Altti Jokinen, Ryan Yang, Yi-Fen Tseng, Hongtao Yu, Mingo Tsai, Gary Hau, Ali Pirsiavash, Marco Mendonca, Allystar Technology Co., Ltd., Canada
2. **Novel Vehicle Dynamic Heading and Pitch Angle Determination Using Only Single GNSS Antenna,** Rui Sun, Qi Cheng, Junhui Wang, College of Civil Aviation, Nanjing University of Aeronautics and Astronautics, China

B3: Trends in Future Satellite Navigation Technology, System Design and Development
Date: Thursday, September 24, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Takeyasu Sakai
Electronic Navigation Research Institute, Japan

Dr. Dinesh Manandhar
University of Tokyo, Japan

1. **ESA GNSS Science Support Centre, a World-wide Reference GNSS Environment for Scientific Communities,** Vicente Navarro, Javier Ventura-Traveset, Roberto Prieto, ESA, The Netherlands; Jesús Cegarra, María del Mar Millan, GMV, Spain; Sara del Rio, RHEA, Belgium
2. **Communication and Ranging System for the Kepler Laboratory Demonstration,** Raphael Wolf, Janis Surof, Juraj Poliak, Ludwig Blümel, Laura Agazzi, Ramon Mata Calvo, German Aerospace Center (DLR), Germany
3. **Combining Genetic Algorithms and Machine Learning for Exploring the Navigation Satellite Constellation Design Tradespace,** Jacob Chang, University of Notre Dame; Rachel Duquette, Boston College; Katherine Thai, Rutgers University; Tongyu Zhou, Williams College; Minh Pham, UCLA; Victor Lin, Karen Wood, Aerospace Corporation
4. **Simulation of the Future QZSS Equipped the Optical Clock,** Saya Matsushita, Hiroshi Takiguchi, Toshitaka Sasaki, Hideki Yamada, Isao Kawano, Koichi Inoue, Japan Aerospace Exploration Agency, Japan; Yuichi Takeuchi, Mitsuru Musha, The University of Electro-Communications, Japan
5. **GNSS Acquisition Performance of Short Spreading Codes,** Christoph Enneking, German Aerospace Center (DLR), Germany; Felix Antreich, Instituto Tecnológico de Aeronáutica (ITA), Brazil; André L.F. de Almeida, Federal University of Ceará (UFC), Brazil
6. **GNSS Performance Standards: How are They Holding Up?,** John W. Lavrakas, Advanced Research Corporation
7. **Open Format Specifications for PPP/PPP-RTK Services: Overview and Interoperability Assessment,** Rui Hirokawa, Mitsubishi Electric Corporation, Japan; Ignacio Fernández-Hernández, European Commission, Belgium

Alternate Presentations:

1. **Review of the GPS IIIF Acquisition Process,** Frank Czopek, Frank Czopek Consulting
2. **Non-stop Intersection using GNSS+ Positioning Information Exchange Standard: Max/Min Implementation for One-way Crossovers,** Koki Asari, SPAC, Japan; Masaaki Hayashi,Seiko Epson Corp., Japan; Naoyasu Suzuki, TECKS Inc., Japan; Masayuki Saito, SPAC, Japan; Izumi Mikami, SPAC, Japan

C3: Novel Applications of GNSS Measurements from Smartphones
Date: Thursday, September 24, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Ken Pesyna
Apple

Dr. Todd Humphreys
University of Texas at Austin

1. **Enhancing Smartphones' Location with EDAS (EGNOS Data Access Service) Internet Corrections,** J. Morán, J. Vázquez, M.A. Sánchez, ESSP SAS, Spain; H. Pampanas, Sogeti J. Reyes González, European GNSS Agency, GSA, Czech Republic
2. **Towards a Plug&Play Solution for Real-Time Precise Positioning on Mass-Market Devices,** Marco Fortunato, Augusto Mazzoni, Geodesy and Geomatics Division, DICEA, "Sapienza" University of Rome, Italy
3. **Detecting Ionospheric Irregularity Based on ROT Variation Using Android Devices Cloud System,** Jeonghyeon Yun, Cheolsoon Lim, Byungwoon Park, Sejong University, South Korea; Jade Morton, University of Colorado, Boulder
4. **3D City Model Validation using GNSS Signals.,** Celina Grabowska, Saara Kuismanen, Stefan Söderholm, HERE Technologies, Finland
5. **An Assessment Methodology of Smartphone Positioning Performance for Collaborative Scenarios in Urban Environment,** Thomas Verheyde, TéSA - Cooperative Research Laboratory, France; Antoine Blais, Christophe Macabiau, ENAC - École Nationale de l'Aviation Civile, France; François-Xavier Marmet, CNES - Centre National d'Études Spatiales, France
6. **Multipath Error Modelling and Position Error Over-bounding for Precise RTK Positioning using GNSS Raw Measurements from Smartphone for Automotive Navigation,** Himanshu Sharma, Christian Lichtenberger, Thomas Pany, Universität der Bundeswehr München (ISTA), Germany
7. **Android Raw GNSS Measurement Datasets for Precise Positioning,** Guoyu (Michael) Fu, Mohammed Khider, Frank van Diggelen, Google LLC
8. **GNSS in the Classroom: Taking the Paralysis out of Analysis,** Andrew Neish, Stanford University; Tyler Reid, Xona Space Systems; Frank van Diggelen, Google; Grace Gao, Stanford University

Alternate Presentations:

1. **Galileo Ionospheric Correction Algorithm: A Smart and Ready-to-go Implementation,** Angela Aragon-Angel, Joint Research Centre, European Commission, Italy

D3: PANEL: On the Road to Automated Vehicles
Date: Thursday, September 24, 2020
Time: 8:30 a.m. - 12:15 p.m.
LIVE STREAM This session will be live streamed for registered virtual attendees.
ON DEMAND A video of this session will be available for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Dorota Grejner-Brzezinska
The Ohio State University

Dr. Tyler Reid
Xona Space Systems

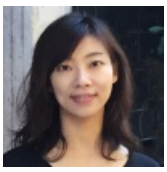
Why do we still have to drive ourselves? How will automated navigation enter our personal lives in the future? What are the remaining challenges that hold back self-driving vehicles from the mass market? How fast will this technology be accepted by different societies? What are the legal and ethical challenges? Can we really ever rely on artificial intelligence in critical situations? Seek answers to these questions and ask more in this panel on automated personal transportation.

Panel Members:

1. **Dr. Ashley Clark,** Argo AI
2. **Dr. Niels Joubert,** Uber ATG
3. **Mr. Yoav Zangvil,** Regulus Cyber

E3: Advanced Technologies in High Precision GNSS Positioning 2
Date: Thursday, September 24, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:



Dr. Jihye Park
Oregon State University

Dr. Safoora Zaminpardaz
RMIT University, Australia

1. **Rapid Multi-frequency PPP Ambiguity Resolution Using Galileo E6 and BeiDou-3 B2a Signals,** Jianghui Geng and Jiang Guo, Wuhan University, China
2. **Galileo High Accuracy Service Demonstration on Mosaic, Centimeter Accuracy on Chip,** Frank Boon, Jean-Marie Sleewaegen, Bruno Bougard, Jan Dumon, Septentrio Satellite Navigation, Belgium, Simón Cancela, David Calle, GMV, Spain
3. **NavIC Signals Multipath Analysis, Estimation, and Mitigation for Precise Point Positioning,** A. Althaf, and H.B. Hablani, Discipline of Astronomy, Astrophysics and Space Engineering, Indian Institute of Technology Indore, India
4. **Challenges and Opportunities in Mass Market RTK,** Altti Jokinen, Ryan Yang, Yi-Fen Tseng, Hongtao Yu, Mingo Tsai, Gary Hau, Ali Pirsiavash, Marco Mendonca, Allystar Technology Co., Ltd., Canada
5. **RTK Feasibility Analysis for GNSS Snapshot Positioning,** Xiao Liu, Miguel Ángel Ribot Sanfélix, Adrià Gusi-Amigo, Adrià Rovira Garcia, Jaume Sanz Subirana, Universitat Politècnica de Catalunya, Spain
6. **Impact of GPS Flex Power on Differential Code Bias Estimation for Block IIR-M and IIF Satellites,** Özge Gizem Esenbuga, André Hauschild, Peter Steigenberger, German Aerospace Center, (DLR), Germany
7. **Open-World Virtual Reality Headset Tracking,** Todd E. Humphreys, Ronnie Xian Thong Kor, Peter A. Iannucci, Department of Aerospace Engineering and Engineering Mechanics, The University of Texas at Austin
8. **Positioning for Train-infrastructure Asset Health Status Monitoring within the Sia-project,** Ramin Moradi, Yuheng Zheng, Michael Hutchinson, Nottingham Scientific Limited, UK; Michael Roth, Kanwal Jahan, German Aerospace Center, Institute of Transportation Systems, Germany; Goya, Jon, Unai Alvarado, Asociación Centro Tecnológico Ceit-IK4, UK

Alternate Presentations:

1. **Closed-Loop GNSS/INS Simulation Chain with RTK-accuracy for Sensor Fusion Algorithm Verification,** Andreas Schütz, Mohamed Bochkati, Daniel Maier, Thomas Pany, University of the Bundeswehr Munich, Germany
2. **Multi-GNSS Ambiguity Resolution as a Substitute to Obstructed Satellites in Precise Point Positioning processing,** Nacer Naciri and Sunil Bisnath, York University, Canada
3. **A Performance Improvement Method for Single Epoch, Single Frequency Attitude Determination Using Low-cost GNSS Receiver,** Yinbin Yao, Xinzhe Wang,Chaoqian Xu, Qizhi Li, Yinzhi Zhao, School of Geodesy and Geomatics, Wuhan University, China

F3: Atmospheric Effects on GNSS
Date: Thursday, September 24, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Manuel Hernández-Pajares
Universitat Politècnica de Catalunya (UPC), Spain

Dr. Attila Komjathy
Jet Propulsion Laboratory

1. **Modeling Scintillation Impacts on GNSS Tracking Loop Performance,** Charles S. Carrano, Keith M. Groves, William McNeil, Rezy Pradipta, Patricia H. Doherty, Institute for Scientific Research, Boston College
2. **Time lags in Ionospheric Scintillation Response to Geomagnetic Storms: Alaska Observations,** Zhe Yang and Y. Jade Morton Smead Aerospace Engineering Sciences Department, University of Colorado
3. **Atmospheric Characterization of Antarctic Polar Regions and Validation of Tropospheric and Ionospheric Models based on GNSS Experimental Campaign Data,** Carlos Moriana-Varo, Carlos Sanz-Garzón, GMV, Spain; Fernando Martín-Porqueras, ESA-ESAC/Telespazio Vega UK SL; Manuel Castillo-Fraile, Javier Ventura-Travesset, ESA-ESAC, The Netherlands
4. **Assessment of Ionospheric Corrections Algorithms using the GNSS Laboratory Tool Suite (gLAB): From STEC to Navigation Performance,** A. Aragon-Angel, Joint Research Centre, European Commission, Italy; A. Rovira-Garcia and D. Ibáñez-Segura, gAGE/UPC, gAGE/UPC, Spain
5. **Ionosphere Monitoring Using Dual Frequency Multi-Constellation Smartphones,** R. Warnant, M. Debelle, Geodesy and GNSS, University of Liege, Belgium; Q. Warnant, Augmenteo, France
6. **Simulating Realistic High Latitude Ionospheric Scintillation of GPS Signals for Robust PNT Testing,** T. Pinto Jayawardena, C. N. Mitchell, R. Boyles, J. Bruno, K. Bolmgren, A.M. Ali, G. Buesnel, B. Forte and R. Watson, Spirent Communications, UK
7. **Unbiased SSR Ionospheric Corrections for Real-time GNSS Positioning in Regions of Ionospheric Instabilities,** Paulo Sergio de Oliveira Jr., PPGCG/UFPR, Brazil; João Francisco Galera Monico, PPGCC/UNESP, Brazil; Claudinei Rodrigues Aguiar, UTFPR, Brazil; Lucas dos Santos Bezerra, PPGCG/UFPR, Brazil
8. **Study of Structures of the Sporadic E Layer by Using Dense GNSS Network Observations,** Susumu Saito, Electronic Navigation Research Institute, National Institute of Maritime, Port, and Aviation Technology, Japan; Keisuke Hosokawa, Jun Sakai, and Ichiro Tomizawa, University of Electro-Communications, Japan

Alternate Presentations:

1. **Ship-based GNSS Measurements for TIDs Detection: An Application for 2010 Maule Tsunami,** Michela Ravanelli, Geodesy and Geomatics Division, DICEA, Sapienza University of Rome, Italy; James Foster, School of Ocean and Earth Science and Technology, University of Hawai'i at Manoa; Mattia Crespi, Geodesy and Geomatics Division, DICEA, Sapienza University of Rome, Italy
2. **Analysis of Ionosphere Threats and the Impact on the Design and Operation of Sapcorda's Real-Time GNSS Correction Networks,** Landon Urquhart, Rodrigo Leandro, Dragos Catalin, Susan Heath, Jens Guenther, Sapcorda
3. **Improved Signal Delay Estimation for Arbitrary Raypaths Passing through the Ionosphere,** Lawrence Sparks, Jet Propulsion Laboratory, California Institute of Technology

A4: PANEL: Emerging Autonomous Applications – Challenges and Prospects
Date: Thursday, September 24, 2020
Time: 1:45 p.m. - 5:30 p.m.
LIVE STREAM This session will be live streamed for registered virtual attendees.
ON DEMAND A video of this session will be available for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Naser El-Sheimy
University of Calgary, Canada

Rui Tang
ZongMu Technology Ltd., China

The number of applications enabled by autonomous platforms is increasing rapidly. Examples are first tests of passenger transport with drone taxis and autonomous driving for personal transportation. Autonomous trains are already connecting airport terminals within the public transport infrastructure in some cities. Other applications include autonomous forklifts operating in storage halls and robots that assist in housekeeping or nursing. While some of these applications are mature, others are experimental. This panel discussion will present current and future practical scenarios for the use of autonomous platforms and address the challenges and limitations connected to these applications, technically and legally, and will predict the impact of these applications on society and daily life.

Panel Members:

1. **Dr. Guo Jishun,** Director of Autonomous Driving, Institute of R&D, GAC, China
2. **Dr. Bruno Bougard,** R&D Director, Septentrio Satellite Navigation, Belgium
3. **Mr. Rick Niles,** The MITRE Corporation
4. **Mr. Michael Zahra,** President and CEO of Drone Delivery Canada
5. **Dr. Rakesh Kumar,** Sub-systems Lead Engineer, General Motors (GM) Canada
6. **Dr. Aboelmagd Noureldin,** Professor at the Department of Electrical and Computer Engineering, Royal Military College of Canada (RMCC), Canada

B4: GNSS Applications in Space
Date: Thursday, September 24, 2020
Time: 1:45 p.m. - 5:30 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

David Chelmins
NASA

Dr. Lucilla Alfonsi
INGV, Italy

1. **Joint ESA-NASA Vision for Development and Operational Use of GNSS for Lunar Exploration,** Werner Enderle, Javier Ventura-Traveset, Pietro Giordano, Joerg Hahn, James Carpenter, European Space Agency, The Netherlands; James. J. Miller, Joel Parker, Ben Ashman, Frank Bauer, Munther Hassouneh, Jason Mitchell, Luke Winternitz, NASA
2. **GARHEO Flight Experiment to Test GPS-Galileo Interoperability to Support Launchers and Space Missions,** Riccardo Longo, Marco Bartolucci, Francesco Longhi, Marco Bergamin, Samuele Fantinato, Oscar Pozzobon, Qascom, Italy; James J. Miller, Lisa Valencia, Erik Magnuson, Paul De Leon, Brooks Flaherty, A.J.Oria, NASA; Alberto Tuozzi, Claudia Facchinetti, Mario Musmeci, Italian Space Agency (ASI), Italy
3. **GNSS Performance Models Applied to Design of Space Launcher Hybridized Navigators,** Mariano Wis, Vicente Fernández, Antonio Latorre, Jose M. Palomo, Adrián Cardeñosa, Antonio Fernández, Deimos Space, Spain; Sergio Ramírez, Nicolás Puente, Francesco Cacciatore, Silvia Díaz, SENER Aerospace, Spain; Leonardo Favilli, Alessandro Simonetti, AVIO SpA, Italy
4. **magicGNSS Precise Product Provision for LEO POD Applications,** David Calle Calle, Laura Martínez Fernández and Guillermo Tobías González, GMV, Spain
5. **Experimental Evaluation of Dynamics-Free PPP in Space using Japanese ALOS2 Dataset,** Masaya Murata, Isao Kawano, and Koichi Inoue, Japan Aerospace Exploration Agency, Japan
6. **Simulation and Analysis of GPS Multipath for the GEDI Experiment Onboard the International Space Station,** Viliam Klein Penina Axelrad
7. **Validation of an Autonomous Multi-Satellite Navigation Filter Against Precision Orbit Ephemerides,** Jennifer King, Matthew Ruschmann, George Davis, Emergent Space Technologies, Inc.
8. **Design and mission planning of Bobcat-1, the Ohio University CubeSat,** Kevin Croissant, Gregory Jenkins, Ryan McKnight, Brian C. Peters, Sabrina Ugazio and Frank van Graas, Ohio University

C4: Machine Learning in Location
Date: Thursday, September 24, 2020
Time: 1:45 p.m. - 5:30 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Andrew Neish
Stanford University

Yunxiang (Leo) Liu
University of Colorado, Boulder

1. **Designing Low-Correlation GPS Spreading Code Families via Reinforcement Learning,** Tara Yasmin Mina and Grace Xingxin Gao, Stanford University
2. **Neural Networks Based EWF Detection,** Alexis Louis, Mathieu Raimondi, Airbus Defence and Space, France
3. **Real-time Orbit Prediction for Vehicle Navigation Based on Deep Learning,** Bae, Tae-Suk, Kim, Min-Seo, and Lim, Soo-Hyeon, Department of Geoinformation Engineering, Sejong University, South Korea
4. **Zero Velocity Detection for an Un-tethered Vehicular Navigation System using Support Vector Machine,** Haiyu Lan, Yashar Balazadegan Sarvrood, Adel Moussa and Naser El-Sheimy, Profound Positioning Inc., Canada
5. **Region Adaptive Neural Network for GNSS Positioning in Diverse Urban Areas,** Po-Yu Chen, Hao Chen, MuHan Tsai, Hsien-Kai Kuo, Yi-Min Tsai, Tsung-Yu Chiou, Pei-Hung Jau, Mediatek Inc, Taiwan
6. **GNSS Multipath Detection using Embedded Deep CNN on Intel Neural Compute Stick,** Evgenii Munin, Antoine Blais, Nicolas Couellan, ENAC, Université de Toulouse, France
7. **Deep Probabilistic Estimation of LiDAR ICP Pose Transformations,** Ashwin Vivek Kanhere and Grace Xingxin Gao; Stanford University

D4: GNSS Augmentation and Robustness for Autonomous Navigation
Date: Thursday, September 24, 2020
Time: 1:45 p.m. - 5:30 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Mathieu Joerger
Virginia Tech

Dr. Junesol Song
ENAC, France

1. **Detecting Slowly Accumulating Faults Using a Bank of Cumulative Innovations Monitors in Kalman Filters,** John David (JD) Quartararo and Steven E. Langel, The MITRE Corporation
2. **Solution Separation Based Integrity Monitoring for GNSS/INS/VO Integration,** Yawei Zhai, Shizhuang Wang, Yuanwen Fu, Xingqun Zhan, Shanghai Jiao Tong University, China
3. **A GNSS/INS/Odometer Filter Bank Using Next Generation DFMC SBAS Augmentation for Rail and Road Users,** Gabriele Ligorio, Quirin Meindl, David Rüegg, Jan Wendel, Anne Ridings, Airbus Defence and Space GmbH, Germany; Carlos Lopez, Ivan Lapin, European Space Agency, France
4. **Test of the Filter Design Effect on Evil Waveform Monitoring in SBAS for Galileo E1c and E5a Signals,** Ikhlas Selmi, Paul Thevenon, Christophe Macabiau, Ecole Nationale Aviation Civile (ENAC), France; Mikael Mabilleau, Pierre Durel, European GNSS Agency (GSA), Czech Republic; Jaron Samson, European Space Agency, France
5. **Performance Analysis of Simultaneous Tracking and Navigation with LEO Satellites,** Trier R. Mortlock and Zak (Zaher) M. Kassas; University of California, Irvine
6. **Integrity Monitoring Using ARAIM for Bridging DFMC SBAS Outages in Road Transport,** Kan Wang and Ahmed El-Mowafy, School of Earth and Planetary Sciences, Curtin University, Australia; Jizhong Wu, School of Geomatics Science and Technology, Nanjing Tech University, China
7. **A Particle Filtering Framework for Sensor Fusion Integrity Monitoring,** Adyasha Mohanty, Shubh Gupta, and Grace Xingxin Gao, Stanford University
8. **Robustness of High Accuracy GNSS-based Positioning Using GNSS Reference Stations in Urban Environments,** Daniel Haugård Olesen, Anna B. O. Jensen, Søren Skaarup Larsen, Samuel Lukac, National Space Institute, Technical University of Denmark (DTU-Space), Denmark

E4a: GNSS Receiver Technologies and Processing for Challenging Environments 2
Date: Thursday, September 24, 2020
Time: 1:45 p.m. - 3:25 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Emanuela Falletti
LINKS Foundation, Italy

Dr. Francesca Zanier
European Space Agency, The Netherlands

1. **Improving Positioning Accuracy and Availability in Urban Environments Using a New Non-line-of-sight GNSS Signal Detection Method,** Zhitao Lyu and Yang Gao, Department of Geomatics Engineering, University of Calgary, Canada
2. **NLOS Multipath Detection Using Convolutional Neural Network,** Taro Suzuki, Chiba Institute of Technology, Japan; Kusama Kazuki, Yoshiharu Amano, Waseda University, Japan
3. **A Method for LOS Detection Under the NLOS GNSS Signal Tracking,** Dmitry Kuznetsov, Broadcom Inc.
4. **Collaborative Positioning in Automated Car Driving: Accounting for Communication Channel and Multipath,** Nikolay Mikhaylov, Florian A. Schiegg, Shuo Li, Yan Jiang, Yichen Liu, Simon Ollander Robert Bosch GmbH, Hildesheim, Germany

Alternate Presentations:

1. **Analysis of Time and Space Correlations of Multipath Error from a Single Frequency GPS and Galileo Kinematic Low-cost Receiver, in Urban Environment,** Matera Eustachio Roberto, Garcia-Pena Axel, Milner Carl, Ekambi Bertrand, Abbia GNSS Technologies, France
2. **Integrating GNSS Signal Tracking and Map-Matching for Reflected and Diffracted Signals Mitigation in Urban Environments,** Nesreen I. Ziedan, Faculty of Engineering, Zagazig University, Egypt

E4b: Next Generation GNSS Positioning
Date: Thursday, September 24, 2020
Time: 3:55 p.m. - 5:30 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Mingquan Lu
Tsinghua University, China

Dr. Christoph Guenther
German Aerospace Center (DLR), Germany

1. **Navigation using Carrier Doppler Shift from a LEO Constellation: Transit on Steroids,** Mark L. Psiaki, Kevin T. Crofton Dept. of Aerospace & Ocean Engineering, Virginia Tech
2. **Blind Doppler Estimation from LEO Satellite Signals: A Case Study with Real 5G Signals,** Joe Khalife, Mohammad Neinavaie, and Zak (Zaher) Kassas; University of California, Irvine
3. **Impact of Cascading Faults on Mega-Constellation-Augmented GNSS PPP Integrity,** Danielle Racelis and Mathieu Joerger, Virginia Tech
4. **Navigation Using Doppler Shift from LEO Constellations and INS Data,** Brian McLemore and Mark L. Psiaki Kevin T. Crofton Dept. of Aerospace and Ocean Engineering, Virginia Tech

F4a: GNSS Vulnerabilities and Anti-jamming
Date: Thursday, September 24, 2020
Time: 1:45 p.m. - 3:25 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Steffen Thoelert
German Aerospace Center (DLR), Germany

Dr. Daniele Borio
European Commission, JRC, Italy

1. **RFI Monitoring of GNSS Signals on Norwegian Highways,** Anders Rødningsby, Norwegian Defence Research Establishment, Norway; Aiden Morrison, Nadia Sokolova, SINTEF, Norway; Nicolai Gerrard, Norwegian Communications Authority, Norway; Christian Rost, Norwegian Space Agency, Norway
2. **GPS/GNSS Interference Power Difference of Arrival (PDOA) Localization Weighted via Nearest Neighbors,** Johnathan A. Tucker, Charles Puskar, The University of Colorado Boulder; Chiawei Lee, US Air Force Test Pilot School; Dennis Akos, The University of Colorado Boulder
3. **GNSS Performance Analysis and Environment Characterization Tool for Rail,** A. Neri, A. Ruggeri, A. Vennarini, A. Coluccia, Consorzio Radiolabs, Italy; B. Brunetti, HitachiRail, Italy; M. Ciaffi, RFI, Italy
4. **Machine Learning-based Two-stage Detection and Comprehensive Characterization of Ionospheric Scintillation-Like GPS Satellite Oscillator Anomaly,** Yunxiang Liu, and Y. Jade Morton, University of Colorado Boulder

Alternate Presentations:

1. **Characterization of ADS-B Performance under GNSS Interference,** Zixi Liu, Sherman Lo, Todd Walter, Stanford University
2. **Performance Analysis of Low SWaP-C Jamming Mitigation Methods for Commercial Applications,** K. Scott Burchfield, Scott M. Martin, and David M. Bevly, Auburn University; Joshua D. Starling, IS4S

F4b: GNSS Receiver and Antenna Technologies
Date: Thursday, September 24, 2020
Time: 3:55 p.m. - 5:30 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Zheng Yao
Tsinghua University, China

Diana Fontanella
Airbus Defense and Space GmbH, Germany

1. **Synchronizing and Integrating Android Multi-GNSS/accelerometer Sensors to Capture Broadband Vibrations at Sub-centimeter Resolution,** Guangcai Li, Chiyu Long, Feng Wang, GNSS Research Center, Wuhan University, China
2. **Exploring the Ultra-high-precision Ranging Potential of BDS B1 Signal,** Yang Gao, Zheng Yao, Mingquan Lu, Department of Electronic Engineering & Beijing National Research Center for Information Science and Technology, Tsinghua University, China
3. **Retrieval of Encrypted PRN Sequences via a Self-calibrating 40-element Low-cost Antenna Array: Demonstration of Proof-of-concept,** Dominik Dötterböck, Muhammad Subhan Hameed,Thomas Pany- Universität der Bundeswehr München, Germany; Roman Lesjak, Thomas Prechtl – JOANNEUM RESEARCH, Austria
4. **A Computationally Efficient Ultra-tight GNSS/INS Integration Based on Non-consecutive GNSS Signal Tracking,** Baoyu Liu, Yang Gao, Yuting Gao, The University of Calgary, Canada

Alternate Presentations:

1. **Receiver Bandwidth Compression for Multi-GNSS Signal Processing,** Johannes Rossouw van der Merwe, Fabio Garzia, Muhammad Saad, Barbara Kreh, Alexander Rügamer, Ricardo Monroy Gonzalez Plata, and Wolfgang Felber, Fraunhofer IIS, Germany
2. **An ITAR-free Dual Frequency Antenna Array in the ARINC Footprint for Robust Aeronautical Navigation,** Veenu Kamra, Wahid Elmarissi and Stefano Caizzone, Institute of Communications and Navigation, German Aerospace Center (DLR), Germany

A5: Autonomous Applications
Date: Friday, September 25, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Enrique Domínguez Tijero
GMV, Spain

Sandy Kennedy
Hexagon, Canada

1. **Assured Precise Point Positioning Techniques Driving the Future,** D. Calle, E. Carbonell, A. Chamorro, A. González, C. Mezzera, P. Navarro, D. Rodríguez, I. Rodríguez, G. Tobías, GMV, Spain
2. **Vision-Based Collaborative Navigation for UAV-UGV-Dismounted Units in GPS Challenged Environments,** Shahram Moafipoor, Lydia Bock, Jeffrey A. Fayman, Geodetics Inc.
3. **Road Vehicle Integrity Bound Propagation Using GNSS/IMU/Odometer,** Rod Bryant, Olivier Julien, Chris Hide, u-blox, Switzerland; Ian Sheret, Polymath Insight Limited, Switzerland
4. **Ford Highway Driving RTK Dataset: 30,000 km of North American Highways,** Sarah E. Houts, Ford Autonomous Vehicles, LLC; Nahid Pervez, Ford Motor Company; Umair Ibrahim, Ford Autonomous Vehicles, LLC; Gaurav Pandey, Ford Motor Company; Tyler Reid, Xona Space Systems
5. **Analyzing Tesla's Level 2 Autonomous Driving System Under Different GNSS Spoofing Scenarios and Implementing Connected Services for Authentication and Reliability of GNSS Data,** Yoav Zangvil, Regulus Cyber Dror Katalan, Regulus Cyber Roi Mit, Regulus Cyber
6. **Radar-based Multi-Floor Localization for Automated Valet Parking,** Mostafa Sakr, Adel Moussa, Walid Abdelfatah, Mohamed Elsheikh, Aboelmagd Noureldin and Naser El-Sheimy, Profound Positioning Inc., Canada
7. **Moving Base Precise Relative Position for Drone Swarm Flight using Conventional RTK and NMEA Data,** Hyojung Yoon, Eunyeong Lee, Cheolsoon Lim, Byungwoon Park, Sejong University, South Korea
8. **A Robust Algorithm for Pseudorange-based Terrestrial Positioning Under Degraded Geometries,** Gianluca Zampieri, Shrivathsan Narayanan, Omar Garcia Crespillo and Okuary Osechas, German Aerospace Center, (DLR), Germany

Alternate Presentations:

1. **Demonstrating Profound-IP3/DR Performance for Automated Level 2 Driving Applications in Various Operating Conditions,** Haiyu Lan, Ahmed Wahdan, Mohamed Elsheikh, Fei Liu, Hongzhou Yang, Walid Abdelfatah, Aboelmagd Noureldin, and Naser El-Sheimy. Profound Positioning Inc., Canada

B5: GNSS Augmentation Systems and Integrity 2
Date: Friday, September 25, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Eugene Bang
German Aerospace Center (DLR), Germany

Dr. Qian Meng
The Hong Kong Polytechnic University, China

1. **GBAS Anomalous Ionosphere Mitigation Via EGNOS Integration,** Matej Kucera, Honeywell International, Czech Republic; Bruce G. Johnson, Honeywell International, USA; Martin Walczysko, Pavel Ptacek, Honeywell International, Czech Republic
2. **Australia and New Zealand SBAS and PPP Testbed: Achievements After Three Years of Service,** Julián Barrios, José Gabriel Pericacho, Victor Manuel Esteban, Guillermo Fernández, Alessandra Calabrese, Miguel Ángel Fernández, Fernando Bravo, Jesús David Calle, Borja Torres Minaya, José Caro, GMV, Spain; Robert Jackson, Lockheed Martin; Patrick E. Reddan, Deane Bunce, Zeta Associates; Claudio Soddu, INMARSAT
3. **Performances Monitoring, Analysis and Demonstration for SBAS for Africa and Indian Ocean (A-SBAS),** G. Greze, T. Authié, C. Renazé, S. Trilles, X. Berenguer, H. Delfour, Thales Alenia Space, France; L. Bakienon, J. Lapie, A. Dembelé, V. Dovonon, ASECNA; Sénégal; H. Ngaya, EGNOS in Africa Joint Programme Office, Sénégal
4. **Signal Quality Monitoring Using a Chip Shape Deformation Metric for Global Navigation Satellite System Signals,** Nicholas C. Echeverry, J. Addison Betances, Sanjeev Gunawardena, and Michael A. Temple, Air Force Institute of Technology
5. **Prototyping of Galileo URA Determination with TGVF and Extended Galileo Performance Characterisation for SoL Applications,** ESA: G. Galluzzo, S. Wallner GMV Spain: J.G. Pericacho, O. Criado, C. García, F. J. Sobrero Airbus: P. Brieden, K. Binder, G. Battista, M. Odriozola, A. Nuckelt Thales: D. Joly, E. Canestri, C. Stallo EC: M. Sgammini, I. Martini GSA: M. Mabilleau, N. Castrillo

C5: PANEL: UAV Package Delivery
Date: Friday, September 25, 2020
Time: 8:30 a.m. - 12:15 p.m.
LIVE STREAM This session will be live streamed for registered virtual attendees.
ON DEMAND A video of this session will be available for on-demand viewing by all registered attendees.

Session Chairs:

Karen Van Dyke
U.S. DOT/OST-R

Brandon Jones
Google, Inc.

Representatives from commercial entities, regulatory bodies, and UAV manufacturers will discuss the technical, logistical, and legal considerations of automated package delivery on a broad scale. Panelists will discuss the practical challenges of safe UAV operation in urban areas; allocation of airspace and coexistence with other aircraft; capacity planning and scaling considerations; and potential regulatory challenges, including liability for delayed or dam-aged goods.

1. **Ms. Margaret Nagle,** Wing
2. **Ms. Anne Swanson,** Wilkinson Barker Knauer LLP / DC Chapter Leader of the Association for Unmanned Vehicles International (AUVSI)
3. **Mr. Basil Yap,** North Carolina DOT/UAS Integration Pilot Program
4. **Ms. Lisa Ellman,** Hogan Lovells LLP / Executive Director of Commercial Drone Alliance
5. **Ms. Rachel Keating-Carlstrom,** SLT Program Manager for North Carolina and Memphis IPP Portfolios at Federal Aviation Administration

D5: Alternative Technologies for GNSS-Denied Environments 2
Date: Friday, September 25, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Ramsey Faragher
Focal Point Positioning, UK

Dr. Christina Selle
Apple

1. **Hybrid Least Squares for Collaborative Localization with Integrated Outlier Detection,** Ali Khalajmehrabadi, Samsung Semiconductor Inc.; Nikolaos Gatsis, Department of Electrical and Computer Engineering, University of Texas at San Antonio; Daniel Pack, Department of Electrical Engineering, The University of Tennessee at Chattanooga; David Akopian, Department of Electrical and Computer Engineering, University of Texas at San Antonio
2. **Integrity Monitoring for A-PNT Using Barometric Measurements Aided Multi-DMEs,** Xiao Liang, Carl Milner, Christophe Macabiau, Ecole Nationale de l'Aviation Civile (ENAC), France; Philippe Estival, Direction des services de la navigation aérienne de la DGAC (DSNA), France
3. **Data-Driven Protection Levels for Camera and 3D Map-based Safe Urban Localization,** Shubh Gupta and Grace Xing Gao, Stanford University
4. **ZUPT-based Inertial Pedestrian Navigation System Aided by a Shoe-mounted Hybrid Ultrasonic/Barometric Altimeter,** Chi-Shih Jao, Yusheng Wang, Yu-Wei Lin, and Andrei M. Shkel, University of California, Irvine
5. **Robust Long-Term Visual-Inertial Navigation with Infrared Cameras,** Matthew Boler, Scott Martin, David Bevly, Howard Chen, Auburn University; William Travis, Leo Richard, IS4S
6. **Deployable Cold Atom Interferometry Sensor platforms Based on Diffractive Optics and Integrated Photonics,** Jongmin Lee, Grant Biedermann, Hayden McGuinness, Daniel Soh, Justin Christensen, Roger Ding, Patrick S. Finnegan, Gregory A. Hoth, Will Kindel, Bethany Little, Randy R. Rosenthal, Joel R. Wendt, Tony Lentine, Matt Eichenfield, Michael Gehl, Ashok Kodigala, Aleem Siddiqui, Erik J. Skogen, Gregory A. Vawter, Aaron Ison, David Bossert, Kyle H. Fuerschbach, Daniel Paul Gillund, Charles A. Walker, Dennis J. De Smet, Connor Brashar, Joseph Berg, Prabodh M. Jhaveri, Tony G. Smith, Shanalyn A. Kemme, Peter Schwindt, Sandia National Laboratories
7. **POSITRINO: Positioning, Navigation and Timing with Neutrino Particles,** J. Fidalgo, S. Melis, A. Cezón, C. Prajanu, F.J. Mata, M. Azaola, GMV, Spain; Constantinos Andreopoulos, Chris Barry, Julia Tena Vidal, Marco Roda, University of Liverpool, UK; Florin-Catalin Grec, ESA - ESTEC, Directorate of Navigation; Luis Mendes, ESA - ESAC, Directorate of Science
8. **Assessing Real 5G Signals for Opportunistic Navigation,** Ali A. Abdallah, Kimia Shamaei, and Zak (Zaher) M. Kassas; University of California, Irvine

Alternate Presentations:

1. **Swarm Navigation with a Multi-Mode Antenna: First Measurement Results from a Moon-Analogue Mission on Mt. Etna,** Robert Pöhlmann, Emanuel Staudinger, Stefano Caizzone, Siwei Zhang, Armin Dammann, German Aerospace Center (DLR), Germany; Peter A. Hoeher, University of Kiel (CAU), Germany
2. **Integrated Navigation for Tracked Compost Turners Using GNSS, INS, Odometers, Stereo Camera and 3D Map,** Eva Reitbauer and Christoph Schmied, Institute of Geodesy, Graz University of Technology, Austria; Michael Schedler, Institute of Logistics Engineering, Graz University of Technology, Austria
3. **Low-cost Indoor Vision-Based Navigation for Mobile Robots,** Shaza Kaoud Abdelaziz, Queen's University, Canada; Aboelmagd Noureldin, Royal Military College of Canada, Canada; Georgia Fotopoulos, Queen's University, Canada

E5: GNSS Receiver Signal Processing for Degraded Signal Conditions
Date: Friday, September 25, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Heidi Kuusniemi
University of Vaasa & Finnish Geospatial Research Institute, Finland

Dr. Pai Wang
University of Colorado Boulder

1. **Conception of a Post-correlation RFI Mitigation Approach Based on RFI Impact Estimation to the Correlators and Comparison with the Classical Pre-correlation FDAF Method,** Thomas Kraus, Thomas Pany, Universität der Bundeswehr München, Germany
2. **Data Bit Assisted Adaptive IMM Filter for Carrier Phase Tracking Through Interference,** Wengxiang Zhao and Boris Pervan, Illinois Institute of Technology
3. **A Uniform Framework Semi-analytic Model for STL and VTL Performance Evaluation,** Qiongqiong Jia and Renbiao Wu, Tianjin Key Lab for Advanced Signal Processing, Civil Aviation University of China
4. **Mitigation of Carrier Phase Distortions Induced by Spatial Filtering using Antenna Arrays,** T. Bamberg, German Aerospace Center (DLR), & Chair of Navigation, RWTH Aachen University, Germany; A. Konovaltsev, DLR, Germany; M. Meurer, DLR, & Chair of Navigation, RWTH Aachen University, Germany
5. **Performance of Cycle Slip Filtering Algorithm During Ionosphere Scintillation,** Brian Breitsch, Yang Wang, Yu Morton, University of Colorado, Boulder
6. **Analysis and Pre-Processing of Raw Measurements from Smartphones in Realistic Environments,** Ganga Shinghal and Sunil Bisnath, York University, Canada
7. **A Subspace-based Spatial and Temporal Multipath Mitigation for GPS Signal,** Xi Hong, Tian Gan, Ning Chang, Menghan Lin, Wenjie Wang, Qinye Yin, Xi'an Jiaotong University, China
8. **Deeply Coupled Integration of a Software Defined GNSS Receiver and a Vibratory MEMS Rate Gyroscope Based Software Defined IMU,** Baoyu Liu, Kaixiang Tong, Yang Gao, The University of Calgary, Canada

Alternate Presentations:

1. **Performance Analysis of a Vector Tracking Software Defined Receiver for GPS L5,** Charles Anderson Givhan, David Bevly, Scott Martin, Auburn University

F5: GNSS Authentication and Anti-Spoofing 2
Date: Friday, September 25, 2020
Time: 8:30 a.m. - 12:15 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Ranwa Haddad
The Aerospace Corporation

Dr. Sanjeev Gunawardena
Air Force Institute of Technology

1. **A Tool for Furthering GNSS Security Research: The Oak Ridge Spoofing and Interference Test Battery (OAKBAT),** Austin Albright, Oak Ridge National Laboratory; Sarah Powers, Oak Ridge National Laboratory; Jason Bonior, Red Wire Technologies; Frank Combs, Oak Ridge National Laboratory
2. **Characterization of Meaconing and its Impact on GNSS Receivers,** Maxandre Coulon, Alexandre Chabory, Axel Garcia-Pena, Jeremy Vezinet, Christophe Macabiau, ENAC/TELECOM, France; Philippe Estival, Pierre Ladoux, Benoit Roturier, DGAC/DSNA, France
3. **Galileo OSNMA Preliminary Implementation in the GIANO GNSS Receiver,** Ricardo Prata, Filipe Carvalho, Rui Nunes, Deimos Engenharia, Portugal; Livio Marradi, Gianluca Franzoni, Marco Puccitelli, Roberto Campana, TAS-I; Valeria Catalano, European GNSS Agency; Ciro Gioia, European Commission Joint Research Centre, Italy
4. **Mapping Bit to Symbol Unpredictability in Convolutionally Encoded Messages with Checksums, with Application to Galileo OSNMA,** Cillian O'Driscoll, Independent Consultant, Ireland; Ignacio Fernandez-Hernandez, European Commission, Belgium
5. **Receiver Protocol and Pitfalls of NMA and SCA Processing Under Spoofing Conditions for Future GNSS Signals Authentication,** Markel Arizabaleta, Thomas Pany, Universität der Bundeswehr München, Germany; Tommaso Scuccato, Andrea Dalla Chiara, Qascom, Italy; Cillian O'Driscoll, Neil Hanley, Queen's University Belfast, Ireland
6. **GPS Chimera: A Software Profiling Analysis,** Micaela Troglia Gamba, Mario Nicola, Beatrice Motella, LINKS Foundation, Italy
7. **Resilient Methods for Position and Attitude Determination in a Spoofed Environment Using an Uncalibrated Multi-Antenna-System,** Soeren Zorn, Michael Niestroj, Marius Brachvogel, Chair of Navigation, RWTH Aachen University, Germany; Michael Meurer, Chair of Navigation, RWTH Aachen University & German Aerospace Center (DLR), Germany
8. **Post-Quantum Authentication Schemes,** Andrew J. Binder, James T. Gillis, Mark Mendiola, The Aerospace Corporation

Alternate Presentations:

1. **Authenticated Time for Detecting GNSS Attacks,** Marco Spanghero, Kewei Zhang, Panagiotis Papadimitratos, KTH Royal Institute of Technology, Sweden
2. **Message Authentication Scheme for Satellite Navigation System,** Jae Hee Noh, Department of Electronic Engineering, Chungnam National University, Republic of Korea; Deok Won Lim, Satellite Navigation Team, Korea Aerospace Research Institute, Republic of Korea; Gwang Hee Jo, Jin Hyuk Lee, Sang Jeong Lee, Department of Electronic Engineering, Chungnam National University, Republic of Korea
3. **New and Existing Signal Quality Monitoring Metrics Tested Against Simulations and Time Synchronized Signal Generator Attacks,** Ronny Blum, Nikolas Dütsch, Institute of Space Technology and Space Applications, Universität der Bundeswehr München, Germany; Carsten Stoeber, Rohde & Schwarz GmbH & Co. KG, Germany; Jürgen Dampf,Thomas Pany, Institute of Space Technology and Space Applications, Universität der Bundeswehr München, Germany
4. **GNSS Time Synchronization Attack Detection and Discrimination Based on Correlations of Calculated Clock Drift Time-Differences,** Weiyu Gao, Hong Li, Jianfeng Li and Mingquan Lu, Department of Electronic Engineering,BNRist, Tsinghua University, Beijing 100084, China

A6: Marine Applications and Search and Rescue
Date: Friday, September 25, 2020
Time: 1:45 p.m. - 4:50 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Alan Grant
General Lighthouse Authorities, UK

Dr. Manuel Lopez Martinez
European GNSS Agency (GSA), Czech Republic

1. **A Study to Determine the Future of DGPS in Canada,** Jean Delisle, Valcom Consulting Group, Canada; Caroline Huot, Canadian Coast Guard, Canada
2. **EGNOS Performance Along Finnish Coast,** R. González, E. Lacarra, European Satellite Services Provider (ESSP), Spain; M. López, GSA, Czech Republic; K. Heikonen, Väylä, Finland
3. **Maritime Environment GNSS Multipath Analysis in the Framework of the MARGOT Project,** Alexandru Pandele, Antonia Croitoru, Institute of Space Science, Romania; Andrei Hulea, Romanian InSpace Engineering, Romania; Costi Cherciu, Institute of Space Science, Romania; Alina Radutu, Irina Stefanescu, Romanian Space Agency, Romania; Katarzyna Urbanska, ESA; Dumitru Andrescu, Romanian Maritime Hydrographic Directorate, Romania; Claudiu Dragasanu, Marius Trusculescu, Mugurel Balan, Institute of Space Science, Romania
4. **Type Approval of SBAS Enabled Maritime Navigation Receivers,** Per Erik Kvam, Kongsberg Seatex, Norway
5. **Spoof Detection in the Maritime Domain Using Multiple Bearing Measurements,** Peter F Swaszek, University of Rhode Island; Richard J Hartnett, U.S. Coast Guard Academy; Martin Bransby, Alan Grant, The General Lighthouse Authorities of the U.K. and Ireland
6. **MarRINav – Supporting Maritime CNI,** Martin Bransby Paul Williams George Shaw, General Lighthouse Authorities of the UK and Ireland
7. **R-Mode Positioning System Demonstration,** Gregory Johnson, Kenneth Dykstra, Sophie Ordell, Serco, Inc.; Peter Swaszek, University of Rhode Island
8. **The Galileo Return Link Service Provider in Operation,** Xavier Maufroid, European Commission, Belgium; Jesús Cegarra, Alicia Álvarez, Ignacio Moreno, GMV, Spain; Maxime Fontanier, CNES, France

Alternate Presentations:

1. **Galileo Adoption in Shipborne Equipment,** L. Cucchi, C. Gioia, J. Fortuny-Guasch, European Commission, Joint Research Centre (JRC), Italy; M. Lopez Martinez, European GNSS Agency (GSA), Czech Republic
2. **GALILEO and GPS Performance in the Maritime Environment,** Alexandru Pandele, Antonia Croitoru, Institute of Space Science, Romania; Andrei Hulea, Romanian InSpace Engineering, Romania; Costi Cherciu, Institute of Space Science, Romania; Alina Radutu, Romanian Space Agency, Romania; Marco Porretta, Peter Jacob Buist, GSA, Czech Republic; Dumitru Andrescu, Lucian Dutu, Romanian Maritime Hydrographic Directorate, Romania; Claudiu Dragasanu, Marius Trusculescu, Mugurel Balan, Institute of Space Science, Romania
3. **Revision of RAIM Implementation for Maritime,** F. Blázquez, A. Cezón, G. Moreno, GMV, Spain; T. Tavares, K. Callewaert, VVA, Spain

B6: Spectrum: Protection and Optimization
Date: Friday, September 25, 2020
Time: 1:45 p.m. - 4:50 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Fabio Dovis
Politechnico di Torino, Italy

Connor Brashar
Sandia National Laboratories

1. **Detection of GNSS Interference in Safety Critical Railway Applications Using Commercial Receivers,** Alessia Vennarini, Andrea Coluccia, Radiolabs, Italy; Daniel Gerbeth, Omar Garcia Crespillo, Institute of Communication and Navigation German Aerospace Center (DLR), Germany, Alessandro Neri, Radiolabs, Italy
2. **A GNSS Jamming/Spoofing Test Suite for Smart Tachograph Applications,** L. Cucchi, J. Fortuny, European Commission, Joint Research Centre (JRC), Italy; I. Fernandez, European Commission, DG Defence Industry and Space, Belgium; G. Baldini, European Commission, Joint Research Centre (JRC), Italy; B. Martinez, European Commission, DG MOVE, Belgium; G. Vecchione, Rhea Group, Belgium
3. **Robust Spoofing Detection Using a Dual-Antenna High Precision GNSS Receiver,** Ali Broumandan, Thomas Taylor, Darrell Anklovitch, Sandy Kennedy, NovAtel Inc., Canada
4. **An Assessment of GNSS Receiver Behavior in Laboratory Conditions When Subject to GPS Meaconing or Spoofing Scenarios,** Francesca Filippi, Mark Hunter, Guy Buesnel, Spirent Communications, UK
5. **Hardware-In-the-Loop GPS and PMU Integrated Datasets for the Power Grid Under GPS Spoofing Attacks,** Shubhendra Vikram Singh Chauhan, University of Illinois at Urbana-Champaign; Grace Xingxin Gao, Stanford University
6. **I am Not Afraid of the Jammer: Navigating with Signals of Opportunity in GPS-Denied Environments,** Zak (Zaher) M. Kassas, Joe Khalife, and Ali Abdallah; University of California, Irvine; and Chiawei Lee; US Air Force Test Pilot School
7. **Smoothing the Way for Satellite Outage Reporting: Implementing the Satellite Outage File,** John W. Lavrakas, Advanced Research Corporation

C6: The Spectrum of Autonomy in Navigation
Date: Friday, September 25, 2020
Time: 1:45 p.m. - 4:30 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Sarah Houts
Ford AV LLC

Dr. Gary Fay
Rivian Automotive

1. **SPARTN: The First Open GNSS Data Standard that Enables Safe and Accurate GNSS Localization for Automotive Applications,** Landon Urquhart and Rodrigo Leandro, Sapcorda
2. **End-to-End Functional Safety Solution for High-precision Autonomous Driving,** Shuai Jing, Ziwei Song, Jianhong Wu, Minjie Chen, Qianxun Spatial Intelligence Inc., China
3. **The Data Exchange Format Supporting Autonomous Driving,** Masaaki Hayashi, SEIKO EPSON Corporation, Japan; Koki Asari, Satellite Positioning Research and Application Center, Japan; Naoya Suzuki, TECKS Inc., Japan; Izumi Mikami, Satellite Positioning Research and Application Center, Japan

D6: Navigation Using Environmental Features
Date: Friday, September 25, 2020
Time: 1:45 p.m. - 4:50 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Joseph Curro
Air Force Institute of Technology

Dr. Andrey Soloviev
QuNav

1. **Machine Learning-based Visual Odometry Uncertainty Estimation for Low-cost Integrated Land Vehicle Navigation,** Hany Ragab, Shaza Kaoud Abdelaziz, Queen's University, Canada; Mohamed Elhabiby, Ain Shams University, Egypt; Sidney Givigi, Queen's University, Canada; Aboelmagd Noureldin, Royal Military College, Canada
2. **High-precision Infantry Training System (HITS),** Stephen DelMarco, Simone Bortolami, Helen Webb, Justin Delva, David Chen, BAE Systems - FAST Labs™; Frank Tucker, and Travis Hillyer, CCDC Soldier Center STTC
3. **LiDAR-based Terrain Recognition in Off-road Mobile Robot,** Xinao Wang and Joseph G. Walters, Nottingham Geospatial Institute, University of Nottingham, UK
4. **Carrier Phase Tracking Architecture for Positioning in LTE Networks Under Channel Fading Conditions,** Pai Wang and Y. Jade Morton, University of Colorado Boulder
5. **Digital Track Map Aided Track Occupancy Identification Method in Railway Stations,** Tao Yang, Debiao Lu, Baigen Cai, Jian Wang, Jiang Liu, Beijing Jiaotong University, China; Philippe Laviron, Thales (China) Enterprises Management Co., Ltd., China
6. **High-Precision Positioning and Mapping using Feature-based RTK/LiDAR/INS Integrated System for Urban Environments,** Wenyi Li, Xiaowei Cui, Mingquan Lu, Department of Electronic Engineering, Beijing National Research Center for Information Science and Technology, Tsinghua University, China

Alternate Presentations:

1. **Dynamic User Test and Evaluation System for Korean Regional Navigation Satellite System,** Jung-Hoon Lee, Sangwoo Lee, Jongsun Ahn, Sunghyuck Im, Joo Jung Min, Moon-Beom Heo, Korea Aerospace Research Institute, South Korea

E6: PANEL: Redoing Global Satellite Navigation Systems from Scratch - The Perfect System
Date: Friday, September 25, 2020
Time: 1:45 p.m. - 4:50 p.m.
LIVE STREAM This session will be live streamed for registered virtual attendees.
ON DEMAND A video of this session will be available for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Chris Hegarty
The MITRE Corporation

Marco Falcone
ESA, The Netherlands

If we had to do it all over again – what would the perfect global satellite navigation system look like? Assume you could design the system with no need for backward-compatibility to existing technology, but rather only to satisfy the needs and expectations of the future. The laws of physics are the primary limit and you could make use of all knowledge in the field of navigation accumulated so far. Listen to the visionary ideas of our panelists and join in for a controversial discussion.

Panel Members:

1. **Karl Kovach,** Principal Engineer, Aerospace Corporation
2. **Dr. Mingquan Lu,** Professor, Tsinghua University, China
3. **Dr. Tyler Reid,** Co-Founder & CTO, Xona Space Systems
4. **Lionel Ries,** Head of Section, European Space Agency (ESA), The Netherlands
5. **Dr. Frank van Diggelen,** Principal Engineer, Android Context, Google

F6: Remote Sensing; Space Applications; Timing and Scientific Applications
Date: Friday, September 25, 2020
Time: 1:45 p.m. - 4:50 p.m.
ON DEMAND Audio and slides from this session will be recorded for on-demand viewing by all registered attendees.

Session Chairs:

Dr. Javier Tegedor
Fugro, Norway

Dr. Sunil Bisnath
York University, Canada

1. **Precise On-Board Navigation of LEO Satellites with GNSS Broadcast Ephemerides,** A. Hauschild, O. Montenbruck German Aerospace Center (DLR), German Space Operations Center (GSOC), Germany
2. **Improved Single Frequency Orbit Determination for the CYGNSS Spacecraft,** Alex Conrad, Penina Axelrad, University of Colorado Boulder; Cinzia Zuffada, Bruce Haines, Jet Propulsion Laboratory/California Institute of Technology; Andrew O'Brien, The Ohio State University
3. **Preliminary Assessment of CICERO Radio Occultation Performance by Comparing with COSMIC I Data,** Hyeyeon Chang and Jiyun Lee, Korea Advanced Institute of Science and Technology, South Korea; Yang Wang, Brian Breitsch and Y. Jade Morton, University of Colorado Boulder
4. **Application of GNSS-Reflectometry for Vertical Datum Determination in Alaska,** Su-Kyung Kim and Jihye Park, Civil and Construction Engineering, Oregon State University
5. **Coherent and Semi-coherent Spaceborne GNSS-R for Land Surface Altimetry Applications,** Yang Wang, Y. Jade Morton, Smead Department of Aerospace Engineering Sciences, University of Colorado Boulder
6. **Surface Reflectivity Variations of GNSS Signals from a Mixed Ice and Water Surface,** Roohollah Parvizi, Shahrukh Khan, Li Pan, and Seebany Datta-Barua, Illinois Institute of Technology
7. **GPS Spoofing Mitigation and Timing Risk Analysis in Networked PMUs via Stochastic Reachability,** Sriramya Bhamidipati, University of Illinois at Urbana-Champaign, and Grace Xingxin Gao, Stanford University
8. **A Performance Assessment of Secure Wireless Two-Way Time Transfer,** Cillian O'Driscoll, Independent Consultant, Ireland; Shane Keating, Independent Consultant, Ireland; Gianluca Caparra, European Space Agency, Netherlands