

ION GNSS+2023

GNSS + Other Sensors in Today's Marketplace

SEPTEMBER 11-15, 2023

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ABSTRACT SUBMISSION REQUIREMENTS

To submit an abstract, sign into the ION Abstract Management Portal (AMP) at ion.org/abstracts. If you have not used AMP before, click "Create My Account." Once signed in, click on "ION GNSS+" and complete the form.

Authors will be given the option at the point of abstract submission to submit for either "in-person presentation in Denver, with pre-recorded video presentation for remote viewers" or "virtual presentation, with pre-recorded video presentation." A technical paper will be required for all abstracts submitted to the Research Tracks, regardless of in-person/virtual presentation. Technical papers are optional for abstracts submitted to the Commercial Tracks.

Abstracts should be submitted electronically via AMP no later than March 3.

Content: Acceptance to the ION GNSS+ conference is competitive. Extended abstracts (500-2500 words) are required. Abstracts should describe objectives, anticipated or actual results, conclusions, key innovative steps and the significance of your work.

Acceptance: Speakers will be notified of acceptance after April 28 and will be provided with an electronic presentation kit with presentation and publication guidelines.

Peer Review Option/Research Track Only: Authors whose abstracts are accepted in sessions in the Research Tracks (either as a primary, an alternate, or as a pre-recorded virtual presentation) will have the option to have their paper peer reviewed. Peer reviews will be accomplished by a minimum of two qualified reviewers, and supervised by a committee. To be designated as peer reviewed the completed manuscript must be uploaded to AMP by June 30; the manuscript must pass the initial peer review (there will be no secondary reviews); and one of the authors must be present at the conference and prepared to present the paper if accepted to the in-person program, or the author must be registered for the virtual conference if presenting virtually. While final manuscripts are required for peer-review by June 30, corrected/updated manuscripts will be accepted through September 22.

Author Presentation Requirements:

- 1) A pre-recorded video presentation will be required of all presenters. The pre-recorded video presentation and Media Authorization License Form, must be submitted to AMP by August 31 to be eligible for ION Best Presentation Awards.
- 2) All authors attending in person are required to pay registration fees. Authors presenting virtually are required to register and pay registration fees.
- 3) Authors presenting as part of the in-person program (both primary and alternate) are required to attend the Speakers' Breakfast the morning of their presentation. Failure to meet any of these requirements may result in the cancellation of your paper from the program.

Proceedings Publication: Papers meeting all the peer review requirements will be designated as "peer reviewed" in the technical conference proceedings. Papers not meeting the peer review requirements will be published in the technical conference proceedings without the peer reviewed designation. Manuscripts not representative of the original abstract submitted, or manuscripts not presented for any reason, will NOT be included in the conference proceedings. Presentations (typically the slides used for presentation) submitted through AMP by September 22 will be included in the supplemental material that accompanies the technical proceedings provided to registrants (optional for Research Tracks when full papers are provided; required for the Commercial Tracks when a paper has not been provided). All manuscripts must be uploaded to AMP by September 22 to be included in the technical conference proceedings and/or supplemental material provided to conference participants.



ION GNSS+ 2023

GNSS + Other Sensors in Today's Marketplace

Abstracts Due March 3

Non-profit
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Southern, MD



GNSS+ 2023

CONFERENCE INFORMATION

REGISTRATION INFORMATION

Register online: Go to ion.org/gnss (available summer 2023).

Full registration includes all technical sessions, access to the exhibit hall, ION meal functions and events, on-demand conference content, and proceedings. Individual registration benefits are non-transferable.

REGISTRATION RATES	In-Person*		Virtual	
	On/Before Aug. 11	After Aug. 11	On/Before Aug. 11	After Aug. 11
Full, ION Member	\$1,100	\$1,300	\$699	\$899
Full, Non-Member	\$1,180	\$1,380	\$779	\$979
Single Day	\$600	\$700	N/A	N/A
Student	\$700	\$800	\$499	\$699

*For attendees staying at an official conference hotel, and claiming hotel discount.

HOTEL RESERVATIONS

For hotel rates and reservations, go to ion.org/gnss/hotel.cfm. Click the "reserve now" button and follow the directions to reserve your room. You will receive an immediate online confirmation. Remember, make your hotel reservation (and provide your hotel confirmation number when registering) by August 11 to get the discounted ION GNSS+ conference rates! Sessions will be held at the Hyatt Regency Denver located adjacent to the Colorado Convention Center.

EXHIBITOR INFORMATION

The ION GNSS+ conference is the largest GNSS-related trade show in the world! For exhibit information, contact Megan Andrews via phone at 703-366-2776, fax at 703-366-2724, or via email at mmandrews@ion.org. You can also visit ion.org/gnss.

For updated conference information, see ion.org/gnss

September 11-15, 2023

Tutorials: Sept. 12 • Show Dates: Sept. 13-14

INTERNATIONAL PARTICIPANTS

We recommend that you apply for a visa at least three months in advance. Travelers from all visa waiver program countries must present either a machine-readable passport or a U.S. Visa. For general information about visas go to <http://www.nationalacademies.org/visas/>

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

- 1) Submit the visa letter request form located at ion.org/gnss; and
- 2) Register and pay the conference registration fees before a letter of invitation will be sent. Exemptions to this policy apply only to those authors whose papers have been accepted for presentation, company personnel working in the exhibit area or trade associated press.

STUDENT PAPER AWARDS

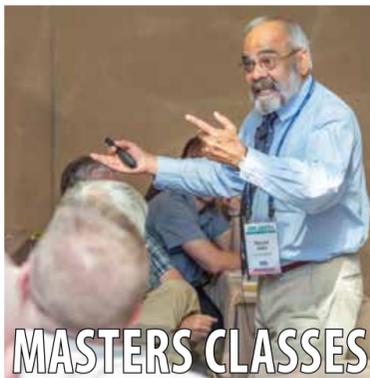
Student paper awards will be awarded on a competitive basis. Papers submitted by February 1 will be reviewed for technical content, clarity, and presentation by a selection committee. The primary student author of each paper selected for presentation will receive a travel expense stipend (payable by check, in U.S. dollars, drawn on a U.S. bank), conference registration and publication of the selected paper in the ION GNSS+ proceedings. For information on eligibility and deadlines, please visit ion.org/governance/student-paper-awards.cfm

JOURNAL PUBLICATION

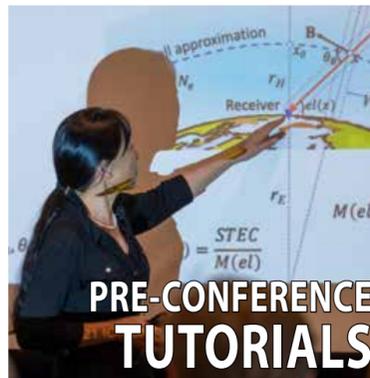
Outstanding technical papers are reviewed for possible publication in the ION's open access archival journal, *NAVIGATION: Journal of the Institute of Navigation*. *NAVIGATION* is indexed and abstracted in the Advanced Technologies & Aerospace Database (ProQuest), COMPENDEX (Elsevier), Current Contents: Engineering, Computing & Technology (Clarivate Analytics), Earth, Atmospheric & Aquatic Science Database (ProQuest), Electrical & Electronics Abstracts (IET), Google Scholar, Inspec (IET), Materials Science & Engineering Database (ProQuest), Natural Science Collection (ProQuest), Science Citation Index Expanded (Clarivate Analytics), SciTech Premium Collection (ProQuest), SCOPUS (Elsevier), Technology Collection (ProQuest), and Web of Science (Clarivate Analytics). As of 2021, it has a 2.472 Journal Impact Factor (JIF). For more information, visit www.ion.org/publications/arc.cfm.

ION GNSS+ 2023

The 36th International Technical Meeting of the Satellite Division of the Institute of Navigation



MASTERS CLASSES



PRE-CONFERENCE TUTORIALS



TECHNICAL SESSIONS AND PANELS

IN-PERSON - ON DEMAND

September 11-15, 2023

Exhibit Hall: September 13 and 14

Hyatt Regency Denver
(adjacent to the Colorado Convention Center)
Denver, Colorado

CALL FOR ABSTRACTS

Abstracts Due March 3

ion.org

COMMERCIAL AND POLICY TRACKS

Track A: Navigation for Mass Market

Track Chair: Deborah Lawrence, Federal Aviation Administration

Applications of GNSS Measurements from Smartphones

The smartphone ecosystem is now at a stage where raw GNSS measurements are widely available with the quality of the measurements improving over the years. This has spawned new innovative ideas for using these measurements to address challenging use cases. Examples include improving positioning techniques in mobile devices; jamming and spoofing detection and mitigation; and multi-sensor fusion for better indoor, outdoor, and urban-canyon positioning. Characterization of high precision positioning services using smartphone measurements and their limitations are of interest.

Chairs: Dr. Mohammed Khider, Google Inc., and Ivan Ng, Hong Kong Polytechnic University

Harsh Urban and Indoor GNSS

Methods of improving the accuracy and reliability of GNSS in dense urban areas and inside buildings, including advanced signal processing techniques, NLOS reception and multipath detection techniques, resilient multi-epoch positioning algorithms with outlier detection, aiding from 3D and 2D mapping, aiding from inertial and other sensors, and differential techniques (including RTK and PPP).

Chairs: Dr. Thomas Powell, The Aerospace Corporation and Nacer Naciri, York University

Navigation and Positioning

Navigation, localization, and map building by pedestrians and indoor robots. Collaborative pedestrian and robot navigation. Pose estimation for humans and robots. Human motion modeling. Perception of the environment for humanoid robot operations. Cell phone-based navigation systems for personal navigation. Applications to health and well-being (medical devices and sports). Cloud-sourcing vector map update for localization. All the sensors including but not limited to LiDAR, camera, INS, UWB, BLE, Wi-Fi, mmWave, magnetometer, ultrasound, used in indoor environments are welcomed.

Chairs: Brian Schipper, Honeywell and Dr. Terry Moore, University of Nottingham

New Technologies, Opportunities and Challenges

The navigation community is eager to understand the current and future trends of GNSS chipset technologies, capabilities, and potential new applications. This technical session will include new technologies, opportunities and challenges in the GNSS space in the next one, three, five, and 10 years. Topics can include size and power consumption, advanced signal processing methods, new antenna/RF techniques, IMU, camera base / visual navigation, all to improve GNSS system level performances in challenging environments; robustness against interfering signals, multi-frequency, multi-constellation design considerations and integration with other positioning technologies.

Chairs: Courtney Mario, Draper and Dr. Eric Phelts, Stanford University

Positioning Technologies and Machine Learning

The exponential development of machine learning techniques, such as deep neural networks, has impacted many fields, including navigation. This session explores the application of modern machine learning techniques to open new applications in navigation, or substantially improving existing applications. Topics of interest include signal improvement, filtering and selection, online and offline multi-sensor algorithms, detection and mitigation of spoofing and jamming, and use of novel sensors and observables. On the machine learning side, techniques not traditionally applied to navigation, including deep neural networks, boosting, graphical models, interpretable machine learning, semi- and unsupervised learning. Reproducible results and public datasets are of particular interest.

Chairs: Dr. Diana Fontanella, AirBus Defence and Space and Dr. Naser El-Sheimy, University of Calgary

Urban and Indoor Radio Positioning

In urban and indoor scenarios, satellites-based ranging systems often have reduced SNR and are affected by shadowing and multipath effects. Signals of opportunity and signals from local beacons (such as from BLE beacons, Wi-Fi-routers) may have in these scenarios the advantage of stronger signals, sometimes known locations, but often higher dispersion. As the availability of dispersion models become more prevalent, the fusion of these two complementary technologies continues to evolve. This session is focused on methods for improving urban and indoor positioning accuracy and reliability using GNSS, signals of opportunity, beacons, and combinations of these technologies.

Chairs: Ryan Dixon, Hexagon and Dr. Pai Wang, Shanghai Jiao Tong University

PANEL: Extended Reality and PNT

The next mainstream computing platform will likely be a headset that offers its wearer an immersive extended reality (XR) visual and auditory experience. Applications range from recreation to education to defense. Various 6-degree-of-freedom headset tracking techniques, including lighthouse-based tracking, inside-out systems based on visual SLAM, and GNSS-IMU-based tracking, are being developed to estimate the position and orientation of the headset accurately and with low latency. Accurate time determination and a common reference frame are required to support collaborative XR. This panel will explore the opportunities and challenges of XR as it relates to PNT.

Moderators: Dr. Andrew Hansen, DOT/Volpe-Center and Dr. Sherman Lo, Stanford University

Program Co-chair: Ernesto Etienne, Federal Aviation Administration

Track B: Autonomous and Safety Critical Applications

Track Chair: Dr. Andrew Neish, Xona Space Systems

Augmentation Services, Integrity, and Authentication

Provision of new products, services, and techniques enhancing precision, integrity, robustness, and trust for safety critical and autonomous needs. Papers on network-based techniques, integer ambiguity resolution, bandwidth efficient communication, multi-GNSS/frequency solutions, server/network-based services for authentication, integrity, and precision. Also includes, use cases and applications highlighting the benefits and challenges of PPP solutions from a user's perspective, and augmentation services for mobile applications. High performance and safety critical applications using SBAS, GBAS and ARAIM.

Chairs: Dr. Jianming She, The MITRE Corporation and Dr. Allison Kealy, Environment, Land Water & Planning

Autonomous Applications

Advances in navigation for assisted and autonomous vehicle or mobile platforms applications. Navigation cybersecurity, emerging cyber threats, and mitigations. Guided vehicle systems and pilot assistance with enhanced safety, availability, and efficiency in challenging environments. Safety, integrity, and certification requirements for autonomous navigation and guidance. Evolution of machine learning and other artificial intelligence technologies employed in autonomous navigation. Assistance and cloud-based technologies for robust and trusted autonomous systems.

Chairs: Dr. Boubeker Belabbas, Bosch and Mitch Narins, Strategic Synergies LLC

Aviation and Aeronautics

Technologies to enhance safety, robustness, assurance, and efficiency of airborne operations and space missions. Integration of RNSG technologies for aviation, rockets, and autonomous flight termination systems (AFTS). Adoption and impact assessment of modernized GNSS, SBAS, and GBAS. Uses of new signals and services. Requirements for performance monitoring and alerting. Advancing integrity, availability, accuracy, and security requirements. Airborne GNSS and sensor integrations for current and novel applications.

Chairs: Dr. Sai Kalyanaraman, Collins Aerospace and Dr. Santiago Perea, European Space Agency

Land-Based Applications

Technologies to address safety aspects of land-based vehicle navigation. Sensor fusion, new algorithms, artificial intelligence and machine learning, GNSS augmentation and multi-GNSS use to improve performance in accuracy, availability, and reliability. Integration of 5G and LEO based positioning in land applications for enhanced assurance, integrity, and robustness. Applications of GNSS authentication services in the road and railway segments. Advances in the dual and triple frequency use of GNSS for land-based applications.

Chairs: Ed Olson, John Deere and Tara Mina, Stanford University

Marine Applications, and Search and Rescue

Concepts, innovation and emerging applications in maritime navigation, and search and rescue. Autonomous vessels, vessel traffic management, and maritime surveying. Aid to navigation placement via navigational hazard location and mapping. Fishing, oceanography, and oil and gas exploration. Maritime applications of GNSS, GNSS augmentations - MF beacons and SBAS, non-GNSS satellite systems, terrestrial backup systems, and integration with vessel sensors and systems. Maritime cybersecurity authentication mechanisms. Accuracy, integrity, continuity, and availability requirements to guarantee resilient PNT.

Chairs: Dr. Alan Grant, General Lighthouse Authorities and Dr. Gregory Johnson, Serco, Inc.

PANEL: Emerging Autonomous Application – Challenges and Prospects

Experts from academia, government, and industry will discuss the technical challenges associated with emerging autonomous applications. These systems span a wide spectrum of applications from robot lawnmowers or Level 2 driver assistance, to technology under development such as SAE Level 4-5 autonomous driving. This panel discussion will look at emerging applications, their tradeoffs including cost, complexity, maturity, reliability and long-term viability, and their promise for the future.

Moderators: Dr. Tyler Reid, Xona Space Systems and Marcus Graf von Wilamowitz, u-blox

Track C: Status and Future Trends in Navigation

Track Chair: Dr. Ilaria Martini, European Commission, Joint Research Centre

GNSS Applications in Space

Space service volume; space-grade GNSS receivers for re-entering vehicles; improving spacecraft positioning using inter-satellite links; satellite laser ranging; innovative solutions for constellation build-up and maintenance; use of GNSS for orbit and attitude determination as well as precise orbit determination; moon navigation; and emerging space positioning applications. Advanced positioning techniques in space, such as snapshot-based positioning on the ground and in space, and interplanetary navigation.

Chairs: Joel Parker, NASA and Dr. Oliver Montenbruck, German Aerospace Center (DLR)

Spectrum: Protection and Optimization

Protection of GNSS RF (RNSG) spectral bands covers the effects of interference on the RNSG bands, with a focus on safety-critical applications. Interference detection, characterization, geolocation, mapping, and mitigation techniques. Effects of interference and spoofing on GNSS receivers, signal-to-noise ratio, and navigation system integrity. Civilian analysis of modern threats and challenges to GNSS systems. Civilian anti-jam and anti-spoofing methods and algorithms. Optimization of spectrum usage for future navigation solutions. Use of new frequency bands and signals (such as LEO-based broadband signals, and alternative RF signal sources) for navigation.

Chairs: Dr. Emanuela Falletti, Leonardo S.p.A. and Dr. Christophe Macabiau, ENAC

Technologies for Scientific and Sectorial Applications

Technologies for scientific and sectorial applications such as the smart/digital tachograph, road tolling systems, timing for critical infrastructures, geo-tagging of photos, emergency location, and remote sensing applications. Advances in PNT technologies for scientific and industrial applications such as road safety systems, maritime traffic monitoring, remote sensing, wildlife tracking, emergency location services, augmented reality, personal navigation, and timing for critical infrastructures. Solutions improving positioning using GNSS, inertial navigation, signals of opportunity, image-based localization, and multi-sensor fusion in the context of challenging environments, constrained platform resources and limited infrastructure availability. Alternative PNT technologies, synergies of unconventional sensors used for positioning, and innovative methods for state estimation.

Chairs: Dr. Omar Garcia Crespillo, German Aerospace Center (DLR) and Dr. Juliette Marais, Université Gustave Eiffel

Trends in Future Satellite Navigation Technology, System Design and Development

Innovations in satellite constellation design for navigation. Proposals for interoperability of GNSS constellations. Optimization of GNSS signal structure via codes and data messages. Latest technologies such as extremely stable frequency standards on-board navigation satellites. Future GNSS open and authorized services such as search and rescue, authentication or commercial services. New civil, military, and governmental user capabilities. Optimization and integration of satellite navigation with other signals of opportunity. Analysis of GNSS performance standards for new services and functionality.

Chairs: Dr. Takeyasu Sakai, National Institute of Maritime, Port and Aviation Technology and Dr. Sophie Damy, European Commission JRC

Trends in GNSS Augmentation Systems

Evolving multi-GNSS and GNSS augmentation system integrity designs (ARAIM), monitoring, fault exclusion, protection level algorithms, testing, and results are areas of interest for this session. The upcoming trends in automated navigation for aviation, automotive, rail, maritime, and other transportation applications. GNSS faults including satellite and constellation failure modes, external threats including spoofing, and the detection of various anomalies are critical to the safe and effective use of GNSS now and for emerging market needs. Dissemination of integrity support information via high and low-capacity data channels. Status and evolution of existing GBAS and SBAS (WAAS, MSAS, EGNOS, GAGAN, SDCM, AGNOS, KASS).

Chairs: Deborah Lawrence, Federal Aviation Administration and Dr. Todd Walter, Stanford University

PANEL: Status of GPS, GLONASS, Galileo, BDS, QZSS, and UK GNSS

This panel session provides an update on the world's satellite-based navigation systems. 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.

Moderators: Dr. Chris Hegarty, The MITRE Corporation and Miguel Manteiga, European Space Agency

RESEARCH TRACKS

Track D: Multisensor and Autonomous Navigation

Track Chair: Dr. Simona Circiu, European Space Agency

Alternative Technologies for GNSS-Denied Environments

New methods, systems and results from navigation systems that do not rely on GNSS. These systems may be based on LiDAR, camera and other optical sensors; IMUs; or other low-cost sensors that are applicable to ground and airborne autonomous vehicles. Topics include integration of multiple sensors, solutions and data sources; calibration and synchronization techniques for single- and multi-sensor systems, including cooperative or networked sensors; and innovative solutions and applications, such as direct georeferencing, precision agriculture, guidance and control of vehicles, deformation monitoring, directional drilling, pedestrian navigation systems, rapid mobile mapping and crowd sourced mapping.

Chairs: Paolo Crosta, European Space Agency, and Dr. Christina Selle

GNSS Augmentation and Robustness for Autonomous Navigation

Augmentation of GNSS in aviation, maritime, rail, automotive, and other transportation applications (stand alone or with additional ground infrastructure). Applications of augmentation systems to support autonomous navigation; robustness of augmentation systems to signal degradation (ionospheric scintillation, multipath, jamming, spoofing, etc.); fault mode definition and fault detection; monitoring and exclusion techniques; integrity analysis for multi-frequency and/or multi-constellation GNSS; evaluation of continuity and availability. Dissemination of integrity support information via high and low-capacity data channels from SBAS, GBAS, ABAS, PPP and other systems is also of interest.

Chairs: Dr. Michael Felux, Zurich University of Applied Science (ZHAW) and Dr. Maria Caamano Albuerne, German Aerospace Center (DLR)

Indoor and Urban Navigation and Mapping

Benefits of your proposed HW/SW architecture and algorithms. Dealing with the synchronization delays and other relevant application limitations. Overview of the minimum sensor configuration to reach your targeted key performance indicator. Opportunistic navigational updates, integration with virtual, augmented or mixed reality systems, use of semantics, high-precision indoor localization and orientation for industrial applications, mapping of vehicles and targets in warehouses, robust estimation techniques to handle these challenging environments. Vehicles with a minimum sensor setup using e.g., parking sensors and standard position solution to enable automatic parking in indoor and outdoor scenarios.

Chairs: Dr. Jason Gross, West Virginia University and Irma Rodriguez Pérez, GMV

Navigation Using Environmental Features

New navigation techniques using natural and man-made features of the surrounding environment that may be used for position updates, orientation updates, dead reckoning, or all of the above. This includes visual features, terrain height, magnetic and gravitational fields, celestial objects, microclimate, acoustic features, odors and particulates. We encourage the development of new feature classes, feature extraction and matching methods, new sensors and algorithms for feature processing. Topics include new signal processing techniques for environmental features; feature extraction, tracking, classification and recognition; cooperative data distribution and mapping; managing ambiguity; new algorithms for position, orientation and velocity solutions; and navigation using multiple classes of environmental features.

Chairs: Dr. Clark Taylor, Air Force Institute of Technology and Dr. Zhen Zhu, East Carolina University

Robust Navigation Using Alternative Navigation Sensors and Solutions

New navigation sensors and systems that improve robustness and reliability of navigation solutions in GNSS-challenged environments, for pedestrian users, watercraft, as well as ground and airborne vehicles. We seek answers to the following questions: How to define performance requirements for position, orientation, and velocity for these applications? How to quantify the robustness and reliability of a multi-sensor system? How to model, estimate and monitor the integrity of these navigation solutions? How to improve the robustness for systems of or incorporating LiDAR and vision-aided navigation sensors, low-cost IMUs, and signals of opportunity? How can new radionavigation systems, such as signals from LEO satellites or terrestrial sources or signals of opportunity, complement GNSS for improved performance? How to address the new challenges in system robustness of using these new signals?

Chairs: Dr. Okuary Osechas, German Aerospace Center (DLR) and Dr. Yang Wang, University of Colorado at Boulder

PANEL: Autonomous Navigation for Ground, Seaborne, and Airborne Vehicles

How will automated vehicles transform our lives in the future? What are the remaining challenges that hold back autonomous vehicles, from self-driving cars to unmanned aerial vehicles to autonomous transit, from the mass market? How much can we trust the autonomous navigation and guidance of these cyber-physical systems? What sensors/signals should we use that provide continuous, trustworthy, and secure flow of information needed for autonomous navigation? How is the robustness and integrity addressed by different stakeholders and industries? Seek answers to these questions, and ask more, in this panel on ground, seaborne, and airborne vehicles.

Moderators: Dr. Dorota Grejner-Brzezinska, The Ohio State University and Dr. Zak Kassas, The Ohio State University

Track E: Algorithms and Methods

Track Chair: Dr. Li-Ta Hsu, The Hong Kong Polytechnic University

Advanced Processing of Signals of Opportunity for Positioning, Navigation and Timing

Developments in the use of signals of opportunity for PNT. Fusion of new-generation communication system signals with GNSS. Alternative location methods based on received signal strength estimation, ToA, TDoA, DoA, or advanced RF propagation models. Signal processing techniques to improve receiver synchronization to terrestrial signals; hybrid positioning techniques; and fine synchronization of terrestrial networks. The signals of interest include but are not limited to: Wi-Fi, cellular (3G, 4G, 5G), RFID, Bluetooth, NFC, HD Radio/DAB, Digital TV, LEO satellites, etc.

Chairs: Dr. Kirsten Strandjord, The University of Minnesota and Dr. Yiran Luo, University of Calgary

All-Source Intelligent PNT Methods

Intelligent PNT with new techniques for sensing, measurement, data processing, and fusion. Participating PNT sources: GNSS, RNSG, UWB, Wi-Fi, and opportunistic radio signals. Intelligent PNT systems make use of diverse sensors, including inertial sensors, odometers, magnetometers, altimeters, radar, LiDAR, cameras, etc. in order to provide reliable measurements under challenging or variable conditions. Topics include intelligent PNT data filtering and integration, stochastic model optimization, advances in uncertainty representation, real-time critical information perception, interpretation and smart fusion, reinforcement learning, cloud-based computing, trustworthy navigation in urban and smart urban areas, etc. Innovative ideas about close integration between machine learning and Bayesian inference.

Chairs: Dr. Weisong Wen, The Hong Kong Polytechnic University and Dr. Ryan Watson, The Johns Hopkins University APL

High Precision and High Integrity Navigation Algorithm

High-precision and high-integrity navigation algorithms designed for safety-critical applications of GNSS and other sensors. Precise Point Positioning (PPP), Real-Time Kinematic (RTK) and other precise positioning techniques; integrity monitoring and performance evaluation of multi-GNSS PPP/RTK/PPP-RTK correction services; end-user integrity monitoring, fault detection and exclusion algorithms for GNSS or multi-sensor integrated high-precision navigation systems; satellite- and ground-based integrity augmentation techniques and performance evaluation.

Chairs: Dr. Sriramya Bhamidipati, Stanford University and Dr. Jianghui Geng, Wuhan University

Navigation in Challenging Environments

Developments and technologies improving the performance and efficiency of receivers and sensors in challenging environments: in urban or indoor areas with multipath interferences; or in the presence of ionospheric/tropospheric scintillations, for ground-based or satellite-based platforms. Receiver behavior under deep amplitude fading or fast phase fluctuations in signals, jamming, spoofing, highly dynamic conditions, signal anomalies, etc. Fusion algorithms, signal processing and receiver designs, machine learning and neural network approaches, and potential improvements to the signals themselves, with an emphasis on robustness, adaptation, multi-signal/multi-sensor capabilities, and sensor aiding. Vision-based modelling, 3D city map assistance, ray tracing, non-line-of-sight ranging for multipath detection, or simulation and mitigation in urban environments. Experimental tests and new models in real environments.

Chairs: Dr. Nesreen Ziedan, Zagazig University and Dr. Paul Groves, University College London

Sensor Network and Cooperative Navigation

Cooperative navigation applies techniques from the field of multi-agent systems to improve navigation performance and reduce hardware costs by exploiting network connectivity. Modeling of sensor network topologies, data transfer and sharing, multi-node collaborative information processing, non-linear optimization, relative navigation, centralized and distributed estimation, and fault detection and exclusion in cooperative navigation. Other techniques helping to achieve highly accurate, efficient, and reliable cooperative and networked positioning in dynamic and uncertain environments such as methods enabled by connected vehicles and infrastructure aiding.

Chairs: Dr. Taro Suzuki, Chiba Institute of Technology and Dr. Alex Minetto, Politecnico di Torino

Smartphone Decimeter Challenge (Co-sponsored by Google)

Teams compete using a pool of GNSS datasets collected from smartphones and accompanied with high accuracy ground truth. Technical paper with results, formatted according to ION GNSS+ conference standards, required by June 30. Winners/paper selection for conference presentation will be based on review of the technical paper/accuracy of the results. Winners must present at the conference in order to receive prizes. Details can be found at: g.co/gnssTools

Chairs: Dr. Michael Fu, Google Inc. and Justyna Redelkiewicz, EUSPA

PANEL: Algorithms and Methods for GNSS Cyber Physical Security

Networked or cooperative applications of GNSS have become pervasive in low-cost devices such as smartphones, wearables, and geolocated Internet of Things (IoT) devices, and similar needs are rapidly growing in aerial and automotive settings. The potential vulnerability of PNT networked connectivity may be inherent in centralized large-network processing; in the use of heterogeneous and potentially untrustworthy sources of data for inference; and in the development of cyber-physical institutions for sensor certification, fraud prevention, and cooperative use of network resources. What new security challenges will arise in networked deployments of PNT technology for IoT, aerial, and vehicular applications? And what are the right coping strategies or methods to ensure cyber physical security?

Moderators: Dr. Ramsey Faragher, Focal Point Positioning and Dr. Pau Closas, Northeastern University

Program Co-chair: Dr. Juan Blanch, Stanford University

Track F: Advanced GNSS Technologies

Track Chair: Dr. Seebany Datta-Barua, Illinois Institute of Technology

Advanced Software and Hardware Technologies for GNSS Receivers

Developments that improve the performance and efficiency of GNSS receiver technology. Wide-band GNSS antennas, high-sensitivity/high-dynamic range RF front ends, robustness to multipath and interference, use of assistance data, multi-constellation receiver algorithms, innovative and efficient software for GNSS receivers and new/existing applications, machine learning and deep learning algorithms for signal processing, experimental tests in real environments, software-defined GNSS receivers and associated processing methods, low power-consumption techniques, open source projects, and the use of software radio standards and tools.

Chairs: Dr. Yu (Joy) Jiao, Trimble and Dr. Roohollah Parvizi, Hemisphere GNSS

Atmospheric Effects on GNSS

Tropospheric and ionospheric modeling, measurements, and algorithms to compensate for atmospheric errors. Novel methods for data collection, processing and analysis. Characterization of propagation environments. Ionospheric scintillation studies and impacts on GNSS services and applications. GNSS signatures and impact of travelling ionospheric disturbances including applications. Space weather and terrestrial weather applications. New ground-based and space-based GNSS networks and experiments.

Chairs: Dr. Susan Skone, University of Calgary and Dr. Endawoke Yizengaw, The Aerospace Corporation

GNSS Robustness to Vulnerabilities

Algorithms and techniques for improving the resilience of GNSS PNT. GNSS signal authentication, including approaches such as signal design, receiver based anti-spoofing techniques, and use of external infrastructure. This includes signal anomaly detection algorithms and metrics, GNSS threat modeling as well as intentional and unintentional sources of signal interference and spectrum issues. Topics include characterization, detection, mitigation and localization of: interference sources such as multipath, scintillation, and solar storms; jamming, repeaters and spoofers; impact analysis, trials and test results across a range of navigation application domains; and methods for authenticating map and data base information. Also, time certification technology and applications.

Chairs: Dr. Anna B. O. Jensen, AJ Geomatics and Dr. Brady O'Hanlon, The MITRE Corporation

Lunar Positioning, Navigation, and Timing

Systems, techniques, and algorithms for navigation to the Moon and on the Moon: Lunar navigation satellite orbit design and trade-offs; satellite constellation design; end-to-end system architectures and performance analysis; precise orbit determination and timing synchronization techniques for Moon navigation; reference frames suitable for precise lunar radionavigation; signal modulations techniques for one-way and two-way one-service; lunar radio navigation message definition; sensor fusion techniques and PNT algorithms for low lunar orbits, landing, navigation on the surface of the Moon GNSS use for lunar navigation; enabling lunar navigation technologies; and lunar beacons.

Chairs: Dr. Cosimo Stallo, Thales Alenia Space and Erin E. Fowler, Johns Hopkins University APL

Remote Sensing, Timing, Space and Scientific Applications

GNSS Earth observation techniques; radio occultation measurements of the troposphere and ionosphere; reflectometry for environmental remote sensing of land, ocean and ice; and GNSS remote sensing for detecting geophysical events such as earthquakes, tsunamis, volcanic eruptions, and man-made events. Search and rescue application based on GNSS search and rescue payload (MEOSAR). GNSS metrology and its applications; advances in precision timing; multi-GNSS for timing applications; GNSS receivers for space applications; high sensitivity signal processing algorithms; integration solutions with sensors and orbital filters; precise orbit determination algorithms; antenna technologies for space; multi-GNSS receivers, technical advances of both COTS and specialized systems for space applications; topics in constellation navigation and attitude determination; GNSS for LEO, GEO and HEO satellites; and lunar GNSS technologies.

Chairs: Dr. Rebecca Bishop, The Aerospace Corporation and Dr. Sebastian Mrak, University of Colorado Boulder

PANEL: Beyond GNSS: Emerging Trends in LEO-Based Satnav and Signals of Opportunity for PNT

The rapid deployment of LEO-based mega constellations for broadband has given us a myriad of signals from space with unprecedented availability and frequency diversity. Early research has shown that these signals can be used opportunistically for navigation. Furthermore, several entities are working on LEO-based constellations that are purpose built for PNT. Other terrestrial signal sources offer promising navigation performance – in some cases potentially outperforming space-based sources. Together, these technologies represent the exciting future of radionavigation-based technologies for PNT. They promise to augment the pros and overcome the cons of GNSS. Our panel of experts will describe these technologies, their expected performance, technical and policy challenges yet to overcome, and when we can expect operational capabilities.

Moderators: Dr. Sanjeev Gunawardena, Air Force Institute of Technology and Dr. Joanna Hinks, AFRL Space Vehicles Directorate