Abstract Submission: Due October 25, 2024

Submit abstracts electronically via the ION Abstract Management Portal, no later than **October 25, 2024**. To submit an abstract, sign in at ion.org/abstracts. If you have not used the Abstract Management Portal before, click "Create My Account." Click on the PLANS conference and complete the form.

- Abstracts should describe objectives, anticipated or actual results, conclusions, any key innovative steps and the significance of your work.
- Authors will be notified of acceptance in late November and provided with an electronic author's kit with presentation and publication guidelines. Papers will be circulated in the public domain. Classified or ITAR restricted abstracts and papers will not be accepted.
- Authors will be required to present in person at the conference; no virtual presentation options will be made available.
- All authors attending the meeting are required to pay registration fees.

Final Manuscripts

Completed manuscripts must be uploaded to the ION's Abstract Management Portal (AMP) by **February 5, 2025**. Manuscripts will be reviewed by independent referees and designated as a primary or alternate paper in the onsite program based on peer review of the full manuscripts. Manuscripts not received by February 5 are subject to withdrawal from the program. Manuscripts will only be peer reviewed one time. Authors will have the opportunity to make corrections/revisions to manuscripts through May 9, 2025. However, manuscripts not meeting peer review standards during the first review are not re-reviewed for inclusion in the IEEE Xplore proceedings.

To be included in the conference proceedings:

1. manuscripts must be uploaded into AMP by February 5, 2025;
2. the submitted manuscript must be representative of the original abstract submitted;
3. the manuscript must meet the peer review requirements;
4. an author listed on the manuscript must present at the conference and pay the conference registration fee;
5. the presenting author must attend the mandatory speakers' breakfast the morning of their session.

PLANS manuscripts will be eligible for Best Paper Awards, including the IEEE's Walter Fried Award, PLANS Student Award and the Best Paper in Track Award. Papers will be posted on the PLANS website for eligible conference registrants to view on a complimentary basis until the electronic proceedings are circulated.

Tutorials: Monday, April 28

Pre-conference tutorials will be offered on Monday, April 28, to provide in-depth learning of specific PNT-related disciplines complementing the technical program. Tutorials will be taught in person, in a classroom setting. Additional registration fees will be required. Electronic notes will be provided to registered attendees via the meeting website and a link will be provided for advance download. Specific course offerings will be promoted on the conference website in early 2025.

Registration Information

Full registration includes all technical sessions, conference meal functions, events, and access to electronic proceedings. Registration for tutorials will be additional. Individual registration benefits are non-transferable.

Rates for attendees and presenters who are staying at the Marriott Salt Lake City Downtown City Creek:

Registration Type	By March 28	After March 28
IEEE/ION Member	$1150	$1350
Non-member	$1245	$1445
Student*	$750	$850

*To be eligible for a student rate registration, attendees must be enrolled in full-time course work at an accredited educational institution, and must send a current transcript showing full-time enrollment to registration@ion.org. Student conference badges will display the name of the university at which the student is enrolled.

Accommodations

Make your reservation online at ion.org/plans. Accommodations are offered at the Marriott Salt Lake City Downtown City Creek, Salt Lake City, Utah.

A block of rooms has been set aside for conference attendees at the discounted rate of $239 per night for single/double occupancy; rooms will be available until March 28, 2025, or until the block fills up, whichever comes first. A limited number of government rate rooms for qualified federal agencies are also available. Reservations made after March 28 will be on a space-available basis and may not be at the special conference rate. We strongly encourage you to make your hotel reservations early.

Save $300 on your registration fees by staying at the conference hotel. All attendees who stay at the Marriott Salt Lake City Downtown City Creek, and submit their hotel confirmation number at the time of conference registration, will receive a $300 discount when registering for the conference. Hotel discounts will not be applied retroactively.

Exhibits

Exhibit space is still available. Booths are sold in 10′ × 10′ increments and include one complimentary full-conference registration. For an exhibitor prospectus, or more information, go to ion.org/plans.

Call for Nominations: Kershner Award

The IEEE PLANS Kershner Award is presented to recognize the outstanding lifetime achievements of an individual who has made substantial contributions in the field of navigation. Additional details can be found at ion.org/plans.

Submit nominations to meetings@ion.org by **January 21, 2025**, and include all of the following information in the nomination e-mail:

1. the name and contact information of the nominee
2. your name and contact information
3. a paragraph explaining why the individual should be considered for this award
4. a proposed citation (25 words or fewer)
5. any other relevant information

ion.org/plans

Non-Profit
U.S. Postage
PAID
Southern MD
Permit No.
425

ION® THE INSTITUTE OF NAVIGATION
8551 Rixlew Lane, STE 360
Manassas, VA 20109

Abstract Submission: Due October 25, 2024

PLANS 2025
IEEE/ION Position, Location and Navigation Symposium

Program Committee:
Program Chair: Dr. Christian Gentner, *German Aerospace Center (DLR)*
Tutorial Chair: Dr. Fabio Dovis, *Politecnico di Torino*

Program Track Chairs:
Dr. Vibhor Bageshwar, *Honeywell*
Dr. Thomas Pany, *University of the Bundeswehr Munich*
Dr. Zak Kassas, *The Ohio State University*
Dr. Mohammed Khider, *Google*

ION INSTITUTE OF NAVIGATION
IEEE
AESS

PLANS

IEEE/ION Position, Location and Navigation Symposium

April 28–May 1, 2025
Marriott Salt Lake Downtown City Creek
Salt Lake City, Utah

CALL FOR ABSTRACTS

ABSTRACTS DUE OCTOBER 25, 2024

ion.org/plans

Invited Session: Presentations/papers for this session will be invited by session chairs.

IEEE/ION PLANS 2025 SESSION TOPICS

TRACK A: Inertial Sensing and Technology

Track Chair: Dr. Vibhor Bageshwar, Honeywell

Advances in MEMS-Based Inertial Sensors and Inertial Measurement Units

The creation of low-cost, lightweight, and power-efficient MEMS inertial sensor solutions for navigation in harsh environments. Innovative designs and applications of MEMS inertial sensors to develop solutions for prolonged navigation in GNSS available and GNSS-denied environments. Applications include self-calibrating sensors, miniature timing and inertial measurement units for ubiquitous deployment, miniature atom-based inertial sensors for extended operation, IMUs/IRUs for high-dynamics, space, missiles, aircraft, weapons, and land vehicles.
Chairs: Chris Matthews, Honeywell and Tom Jakel, Veth Research Associates

Inertial-Based Pedestrian Localization

Inertial-Based localization of pedestrians in GNSS available and GNSS-denied environments. IMU-sensor based localization and fusion with GNSS, pseudolites, wireless systems like BLE, Wi-Fi, UWB, and 5G, radars, cameras, and/or lidars. Applications include hybrid IMU pedestrian including localization, foot mounted navigation, smartphone-based localization, and crowdsourced navigation.
Chairs: Dr. Valérie Renaudin, Gustave Eiffel University and Sally-Ann Keyes, Honeywell Aerospace

Inertial Vehicle Navigation

New developments in inertial navigation systems for autonomous ground vehicles; uncrewed aircraft systems; marine vessels; and vehicle swarms using tactical, navigation, and strategic grade systems. Innovative uses of inertial navigation systems to enable automatic or autonomous operations of one or more vehicles in different operating environments. Applications include inertial navigation system designs including aiding for autonomous vehicles in GNSS available and GNSS-denied environments, open system architectures for inertial navigation systems; and navigation system performance testing and calibration techniques, error modeling, and compensation.
Chairs: Dr. Demoz Gebre-Egziabher, University of Minnesota and Dr. Rajnikant Sharma, Air Force Institute of Technology

Innovations in Inertial Navigation Systems: Advanced Calibration and Precision Timing Solutions

New developments in all grades of inertial navigation systems. Innovative designs, timing, and calibration techniques for IMUs, and inertial navigation systems. Applications include fiber optic gyros; calibration techniques; measurement error modeling and compensation; testing techniques; precision time synchronization and time transfer; cold atom sensors; and IMUs emphasizing compact, low-power, high-performance atomic clocks.
Chair: Dr. Alexander Trusov, Northrop Grumman

Quantum Inertial Sensor Technologies and Applications

Inertial navigation using quantum sensor technology. Novel sensor types and designs and performance of precision inertial navigation systems. Applications include sensors proof of concepts, evaluation of quantum inertial sensors, calibration techniques, simulations, measurements, and performance comparisons with ring laser gyros or fiber optic gyros.
Chairs: Dr. Steffen Schön, Leibniz University Hannover and Dr. Karl Nelson, Honeywell Aerospace

Resilient Inertial Navigation Systems and Alternative Sensors

Development of navigation systems resilient to different cyber and physical attacks. The design of sensors and algorithms to detect and exclude the effects of signals sent to disrupt sensor measurements or algorithms that process the signals or sensor measurements. Applications include the design of cyberphysical resilient systems including resilience of hardware and sensing systems to different attacks and the integrity of navigation systems with multiple IMUs and/or alternative sensors including GNSS, eLoran, DME/VOR, cameras, radars, and lidars.
Chairs: Dr. Jindrich Dunik, University of West Bohemia and Dr. Mathieu Joerger, Virginia Tech

ABSTRACTS DUE
OCTOBER 25, 2024
ion.org/plans

TRACK B: Global Navigation Satellite Systems (GNSS)

Track Chair: Dr. Thomas Pany, University of the Bundeswehr Munich

Frontiers of GNSS

Today, four global satellite navigation systems, several regional systems and various augmentation systems form the backbone of navigation. These systems are constantly being modernized to push the boundaries and enable new applications - either through incremental evolution or even the introduction of new disruptive approaches such as quantum technologies, artificial intelligence, etc. But where are the frontiers of GNSS and where are they going? The session will attempt to answer this question by discussing aspects such as the performance of current systems, proposed modernization/evolution of systems and their predicted performance, new technologies and system architectures, new services, applications and niche markets, innovative combinations of GNSS with sensors and augmentation systems, emerging challenges/threats, and considerations for authorized, authenticated and open signals.
Chair: Dr. Michael Meurer, German Aerospace Center (DLR) and Dr. Joanna Hinks, AFRL Space Vehicles

Integrity and Augmentation

Algorithm and requirement definition for accuracy, integrity, continuity and availability evaluation. Safety-critical applications that make use of ABAS (e.g., ARAIM), GBAS, SBAS and other safety critical GNSS technologies. Architecture and requirement allocation for augmentation systems including PPP/RTK services and LEO augmentation. Integrity of high accuracy GNSS algorithms. Nominal error modeling, classical and frequency domain over-bounding. Threat modeling and multi-measurement fault detection and exclusion. Instantaneous and sequential integrity risk bounding and protection level derivation. High-integrity sensor fusion and integrity budget allocation for individual sensors including IMU, barometers, camera or lidar. Integrity assessment of artificial intelligence algorithms. Integrity, continuity and availability of new multi-constellation systems, including using LEOs. Integrity of PNT systems that augment and complement GNSS (radar, DME/VOR/TACAN, LDACS, eLORAN, R-Mode).
Chairs: Dr. Omar García Crespillo, German Aerospace Center (DLR) and Dr. Eugene Bang, Gyeongsang National University

Interference, Jamming, and Spoofing

Signal processing fundamentals of interference, jamming and spoofing. Controlled jamming/spoofing for denial of service. Robust GNSS solutions through complementary PNT (CPNT) or other means. GNSS/INS integration and antenna arrays as anti-jam/spoofing means. Applications in robust positioning and secure time transfer. Threat modeling, assessment, and mitigation. Receiver internal detection and mitigation. Terrestrial and space-based monitoring. Impact of security measures on the reliability and integrity of GNSS. GNSS signal authentication (OSNMA, CHIMERA, ACAS, commercial services).
Chairs: Dr. Jong-Hoon Won, Inha University and Dr. Sanjeev Gunawardena, Air Force Institute of Technology

LEO-PNT: Concepts, Systems and Use Cases

LEO-PNT is considered to increase accuracy, availability and robustness of existing GNSS significantly exploiting the multi-layer concept (MEO/LEO/terrestrial/sensors) of navigation. This session covers ideas to extend, augment or replace existing GNSS while meeting similar or better performance metrics. LEO-PNT with GNSS-like signal structures. Fusion of communication and navigation signals. Exploitation of 3GPP standards. Link budget, regulative and interference considerations. Transmitter synchronization to GNSS time scales and considerations for high-accuracy (code/phase biases) and integrity. New space concepts, operations, inter-satellite-links. Benefits at the user sector. Ground-segment and operations concepts.
Chair: Dr. Bernd Eissfeller, University of the Bundeswehr Munich and Aliac Jojaghaian, OHB SE

Precise Positioning and Atmosphere

Precise positioning with carrier phase-based techniques with/without multi-sensor setups (e.g., IMU). Multi-frequency, multi-constellation PPP/RTK. Low-cost single frequency PPP/RTK. Modeling of ionospheric and tropospheric effects. Use of single- and multi-frequency receivers for atmospheric studies. Novel signal processing and machine learning methods for characterization and mitigation of atmospheric effects. Forecasting, now-casting, kriging. New application scenarios and mapping functions.
Chairs: Dr. Y. Jade Morton, University of Colorado Boulder and Dr. Sandra Verhagen, Delft University of Technology

Receiver Design, Signal Processing, and Antenna Technology

Receivers, antenna, and processing methods for improving accuracy, reliability, or robustness of GNSS observables. Advanced filtering and estimation methods including (vector) tracking loops, (suboptimal) multi-antenna systems, beamforming (real/synthetic), use of polarization, and direction-of-arrival methods. Methods to minimize SWaP, and software-defined implementations. Methods that incorporate machine learning techniques to enhance receiver designs. Multi-constellation and multi-frequency receiver methods specific for GNSS, LEO-PNT and fused signals. Synergies with communication receivers. GNSS/INS integration to increase sensitivity, accuracy and robustness.
Chairs: Dr. Justin D. Kuric, The Ohio State University and Dr. Nesreen Ziedan, Zagazig University

TRACK C: Integrated and Opportunistic Navigation

Track Chair: Dr. Zak Kassas, The Ohio State University

Frontiers of Radionavigation: Signals of Opportunity, 5G, LEO, and Beyond

Beyond GNSS is a frontier of radionavigation technologies that may dramatically change the way we and our machines navigate. Non-cooperative positioning based on terrestrial radio systems, enable both outdoor and indoor coverage. Cooperative wireless positioning systems based on Wi-Fi, Bluetooth, or ultra-wideband transceivers could further enhance indoor positioning coverage. With the advent of 5G cellular systems, fine timing measurements in Wi-Fi systems, millimeter wave transceivers (for both cellular and Wi-Fi systems), and low Earth orbit (LEO) megaconstellations, there are many new opportunities for improving the performance of these systems. This session will focus on non-GNSS radio technologies, explore the vast possibilities for positioning which significantly enhance coverage, reduce cost, or improve accuracy compared to the current state of the art.
Chairs: Amy-Marie Dykstra, Naval Surface Warfare Center Dahlgren and Dr. John Janeski, The Aerospace Corporation

Multisensor Integrated Systems and Sensor Fusion Technologies

Systems and algorithms involving innovative ways of integrating traditional aiding sensors or new aiding sources into multisensory integrated navigation systems. Test results showing the expanded use or improvement of the accuracy, availability, and/or integrity performance of multisensory navigation systems. Processing algorithms and methods for multisensory systems. Simulation programs for performance predictions and algorithms for multisensory fault detection and isolation.
Chair: Dr. Charles Toth, The Ohio State University

Navigation Using Environmental Features

New navigation techniques using natural and man-made features of the surrounding environment including visual and acoustic features, magnetic and gravitational fields, celestial objects, stars, microclimate, shadows, occlusions, etc. Topics on new feature classes, new sensors, and/or new algorithms including new signal processing techniques for environmental features; feature classification, recognition and association; cooperative data distribution and 3-D mapping; new positioning algorithms using proximity, pattern matching, ranging, and/or angular positioning; and navigation using multiple classes of environmental feature and context detection.
Chairs: Tucker Haydon, Sandia National Labs and Benjamin Siebler, German Aerospace Center (DLR)

Non-terrestrial Signals of Opportunity-Based Navigation Systems

Developments and techniques for utilizing non-terrestrial signals of opportunity (SOPs) for positioning, navigation, and timing (PNT). Emerging low Earth orbit (LEO) satellite mega-constellation, established LEO constellations, high-altitude platform systems (HAPS), other satellite constellations in MEO or GEO. Dual-purposed LEO PNT and opportunistic LEO PNT approaches. Differential and collaborative approaches. Theoretical developments, simulation studies, and experimental demonstrations.
Chair: Dr. Joe Khalife

Terrestrial Signals of Opportunity-Based Navigation Systems

New or improved terrestrial-based navigation systems through the use of cellular (4G, 5G, and beyond), RFID, BLE, Bluetooth, Wi-Fi, HD Radio/DAB, Digital TV, or other terrestrial signals of opportunity (SOPs). New sensor fusion schemes for combining SOPs with other technologies (e.g., All-Source Navigation Filters). Initialization, calibration, and training methods for improving the performance of SOP systems, including approaches utilizing machine learning. Hybrid fusion of terrestrial and non-terrestrial navigation systems, including SOPs.
Chair: Dr. Kimia Shamaei

Vision, Radar and Lidar-Based Navigation System

Systems and advanced algorithms related to emerging vision, lidar or radar-based navigation applications in GNSS-challenged environments. Integration of data from multiple sensors for combined situational awareness and navigation. Vision sensor modeling, calibration, data processing and image feature extraction.
Chair: Dr. Hadi Wassaf, U.S. Department of Transportation

TRACK D: Applications of Localization Technologies

Track Chair: Dr. Mohammed Khider, Google

AI-Enhanced Navigation

This session covers, among others, the following topics: the use of AI techniques for navigation system performance improvement; algorithms for integrity assurance of AI-enhanced multi-sensor integrated navigation system output; concepts and procedures for AI-enhanced navigation systems certification; AI-enhanced algorithms for state estimation, data fusion, fault detection, and system identification; big data analysis to support (semi-) autonomous vehicles navigation; and current and envisioned applications of AI techniques in navigation.
Chairs: Dr. Michael Veth, Veth Research Associates and Dr. Tobias Feigl, Fraunhofer IIS

Ground, Aerial, and Maritime Navigation

Guidance, navigation, and perception systems are crucial for aerial, ground, and underwater vehicles. For UAVs, this includes collaborative navigation, map building, tele-operation, GNSS-denied/challenged environment navigation, and sense-and-avoid capabilities. Specific UAV applications present unique challenges, requiring validation and verification of their navigation systems. Ground vehicle operations involve sensing, perception, and map building for single and multiple vehicles, with guidance, navigation, and control (GNC) systems supporting autonomous and semi-autonomous functions, driverless car navigation in challenging environments, and visual interfaces for driver-assistance systems. These systems require validation, verification, global path planning, and local obstacle avoidance. Surface and underwater navigation advances include inertial, terrain-based, and geomagnetic field navigation, acoustic devices for bathymetry and position measurement, bio-inspired navigation, and new broadband sonar technology. Collaborative navigation of surface and unmanned underwater vehicles, along with transponder localization and SLAM-type approaches, further enhance navigation capabilities.
Chair: Dr. Camila Françolin, Draper and Dr. Maarten Uijt de Haag, Technical University of Berlin (Invited)

Lunar, Mars and Space Navigation

A comprehensive look at lunar position, navigation, and timing (PNT) methods and technologies vital for the exploration of the Moon (or other planets like Mars), topics include lunar PNT service-providing satellites' orbit and constellation designs, precise orbit determination, and time synchronization for lunar missions, discussions on modulation techniques, and specifics of navigation messaging systems in support of lunar radionavigation services. Participants will elaborate on fault-tolerant sensor fusion methods, associated analysis of end-user performance, PNT algorithms suitable for different lunar contexts, the application of GNSS to lunar missions, emerging navigation technologies, and the role of lunar surface PNT augmentation systems. Algorithms and hardware for guidance, navigation, and control for space vehicles. Novel methods for terrestrial testing of space navigation systems and algorithms. GPS-denied orbital navigation. Future space navigation applications. Ground monitoring and observation of space objects.
Chairs: Dr. Cosimo Stallo, Thales Alenia Space (invited)and Dr. Tyler Reid, Xona Space Systems

Navigation in Challenging Environments

Innovations for improving urban and indoor positioning accuracy and reliability: navigation, localization, and map building by indoor robots; simultaneous localization and mapping (SLAM); collaborative robot navigation; pose estimation for humans and robots; smartphone-based localization in challenging scenarios like indoor and human motion modeling; semantics for robot navigation; perception of the environment for humanoid robot operations; cell phone-based navigation systems for personal and indoor navigation; systems for emergency responder navigation; applications of raw GNSS measurements from smart phones; applications for health and well-being (medical devices and sports); inertial-based localization; IMU-sensor fusion; and wearable-based localization.
Chair: Dr. Adyasha Mohanty, Harvey Mudd College and Dr. Siwei Zhang, German Aerospace Center (DLR)

Optimization for PNT and Sensor Fusion

Exploration of the latest advancements and methodologies in optimization techniques for enhancing GNSS positioning and sensor fusion. Factor graph optimization and advanced Bayesian filter with considerations on robust estimation, constraint optimization, or sparse optimization. Leveraging advanced optimization and Bayesian filtering for enhancing GNSS positioning accuracy, reliability, and robustness. PPP, RTK, PPP-RTK, urban navigation, resilience to interference, spoofing, jamming, multipath and NLOS. Combining GNSS with inertial sensors, cameras, lidar, and other sensor modalities to improve navigation performance in challenging environments. Applications in autonomous vehicles, connect vehicles, mobile mapping systems, pedestrian, and drone navigation.
Chair: Dr. Li-Ta Hsu, The Hong Kong Polytechnic University and Dr. Clark Taylor, Air Force Institute of Technology

Smartphone-Based Localization

Smartphone-based localization utilizing: GNSS, Wi-Fi, BLE, terrestrial and inertial sensor-based positioning; sensor fusion; augmented reality (AR); multi-constellation dual and multi-frequency raw GNSS measurements; measurements from a variety of sensors including inertial sensors to enhance GNSS-based positioning solutions in complex environments; enhanced positioning techniques in smartphones such as real time kinematic (RTK) algorithms; precise point positioning (PPP) algorithms; improved stochastic modeling for GNSS smartphone observables; algorithms and multi-sensor fusion for better indoor, outdoor, and urban-canyon positioning; integration with applications requiring reliable positioning solutions, jamming and spoofing detection and mitigation; use of smartphone raw GNSS measurements for scientific applications such as geosciences; and smartphone GNSS antenna quality assessment, SLAM, crowdsourcing.
Chair: Dr. Sunil Bisnath, York University and Dr. Robert Odolinski, University of Otago