ION GNSS+

September 16-20, 2024
Exhibit Hall: September 18 and 19
Hilton Baltimore Inner Harbor
Baltimore, Maryland

2024

ADVANCE PROGRAM

ion.org/gnss

MONDAY, SEPTEMBER 16 • PRE-CONFERENCE SHORT COURSES
(included in all full conference in-person registrations)

9:00 a.m. - 5:00 p.m. CGSIC Subcommittee Meetings - for full schedule visit www.gps.gov/cgsic/meetings

1:30 p.m. - 3:00 p.m. GPS/GNSS 101 - An Introduction Dr. Pratap Misra	1:30 p.m. - 3:00 p.m. Space Applications of GNSS Dr. Penina Axelrad	1:30 p.m. - 3:00 p.m. Signals of Opportunity Based Navigation Dr. José A. del Peral-Rosado/ Dr. Christian Gentner
3:30 p.m. - 5:00 p.m. GNSS Jamming and Spoofing – LEO as Fallback Dr. Todd E. Humphreys	3:30 p.m. - 5:00 p.m. Indoor Positioning and Indoor Navigation (IPIN) Systems Dr. Li-Ta Hsu	3:30 p.m. - 5:00 p.m. LEO PNT – Architectures and Performance Trades Dr. Tyler Reid

TUESDAY, SEPTEMBER 17 • PRE-CONFERENCE TUTORIALS
(additional registration and fee required)

9:00 a.m. - 5:00 p.m. CGSIC General Sessions - for full schedule visit www.gps.gov/cgsic/meetings

8:30 a.m. - 12:00 p.m. Multi-constellation GNSS Signals and Systems Dr. Chris G. Bartone	8:30 a.m. - 12:00 p.m. GNSS Integrity Dr. Mathieu Joerger	8:30 a.m. - 12:00 p.m. PNT for sUAVs Dr. Robert Leishman	8:30 a.m. - 12:00 p.m. Ionospheric Effects, Monitoring, and Mitigation; Dr. Y. Jade Morton	~~8:30 a.m. - 12:00 p.m.~~ **CANCELLED** ~~Dr. Kirsten Strandjord~~

Lunch on Your Own • 12:00 p.m. - 1:30 p.m.

1:30 p.m. - 5:00 p.m. The Generation and Application of Precise Time Dr. Michael J. Coleman	1:30 p.m. - 5:00 p.m. Space-Based Lunar PNT Dr. Grace Gao	1:30 p.m. - 5:00 p.m. Factor Graphs Dr. Clark Taylor/ Dr. Ryan Watson	1:30 p.m. - 5:00 p.m. Introduction to Software Defined GNSS Receivers and Signal Processing Dr. Sanjeev Gunawardena	

ION GNSS+ Plenary Session • 6:30 p.m. - 8:00 p.m.

WEDNESDAY, SEPTEMBER 18

	TRACK A Autonomous and Safety Critical Applications	TRACK B Status and Future Trends in Nav	TRACK C Navigation for Mass Market	TRACK D Multisensor and Autonomous Navigation	TRACK E Algorithms and Methods	TRACK F Advanced GNSS Technologies		
8:30 a.m. - 12:15 p.m.	A1: Augmentation Services, Integrity, and Authentication 1	B1: PANEL: Status of GPS, Galileo, BDS, QZSS, KPS, and NavIC	8:30 a.m. - 10:05 a.m. C1a: Applications of GNSS Measurements from Smartphones 10:35 a.m. - 12:15 p.m. C1b: Latest Advancement from GNSS Receiver and Localization Algorithm Manufacturers	D1: Alternative Technologies for GNSS-Denied Environments	E1: Advanced Technologies in High Precision GNSS Positioning	F1: Advanced Software and Hardware Technologies for GNSS Receivers		

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

	TRACK A	TRACK B	TRACK C	TRACK D	TRACK E	TRACK F		
1:45 p.m. - 5:30 p.m.	A2: Land-Based Applications	B2: Trends in GNSS Augmentation Systems	C2: Advances in High Accuracy Positioning	D2: PANEL: Autonomous Navigation for Ground, Seaborne, and Airborne Vehicles	E2: LEO for Positioning, Navigation, and Timing	F2: Atmospheric Effects on GNSS		

Free Time in Exhibit Hall • 5:30 p.m. - 7:00 p.m.

THURSDAY, SEPTEMBER 19

	TRACK A	TRACK B	TRACK C	TRACK D	TRACK E		TRACK F		
8:30 a.m. - 12:15 p.m.	10:35 a.m. - 12:15 p.m. A3: PANEL: Emerging Autonomous Application – Challenges and Prospects	B3: Technologies for Scientific and Sectorial Applications	8:30 a.m. - 10:05 a.m. C3: PANEL: Digital Reality and PNT	D3: GNSS Augmentation and Robustness for Autonomous Navigation (GNSS Integrity Augmentation)	8:30 a.m. - 10:05 a.m. E3a: All-Source Intelligent PNT Method 10:35 a.m. - 12:15 p.m. E3b: Advanced Processing of Terrestrial Signals of Opportunity		F3a: Lunar Positioning, Navigation, and Timing	F3b: GNSS Robustness to Vulnerabilities 1	F3c: Beyond GNSS: Emerging Trends in LEO and Terrestrial Signals of Opportunity

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

	TRACK A	TRACK B	TRACK C	TRACK D	TRACK E		TRACK F		
1:45 p.m. - 5:30 p.m.	A4: Autonomous Applications	B4: Spectrum: Protection and Optimization	C4: Positioning Technologies and Machine Learning	D4: Robust Navigation Using Alternative Navigation Sensors and Solutions	E4a: Accurate GNSS Navigation in Challenging Environments	E4b: Smartphone Decimeter Challenge (Co-sponsored by Google)	F4: PANEL: International Civilian Agency Lunar PNT Systems		

FRIDAY, SEPTEMBER 20

	TRACK A	TRACK B	TRACK C	TRACK D	TRACK E	TRACK F		
8:30 a.m. - 12:15 p.m.	A5: Aviation and Aeronautics	B5: Trends in Future Satellite Navigation Technology, System Design and Development	C5: Navigation and Positioning	D5: Indoor and Urban Navigation and Mapping	E5: PANEL: Algorithms and Methods for GNSS Cyber Physical Security	F5: Remote Sensing, Timing, Space and Scientific Applications		

Awards Luncheon • 12:15 p.m. - 1:30 p.m. • Lunch served until 12:30 p.m.; late arrivals will not be served • Special meal requests (veg./gluten-free, etc.) due at time of registration.

	TRACK A	TRACK B	TRACK C	TRACK D	TRACK E	TRACK F		
1:45 p.m. - 4:50 p.m.	1:45 p.m. - 3:20 p.m. A6a: Augmentation Services, Integrity, and Authentication 2 3:20 p.m. - 4:50 p.m. A6b: Marine Applications and Search and Rescue	B6: GNSS Applications in Space	C6: Harsh Urban and Indoor GNSS	D6: Navigation Using Environmental Features	E6: Sensor Network and Cooperative Navigation	F6: GNSS Robustness to Vulnerabilities 2		

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CELEBRATING INTERNATIONAL GNSS DAY

ION
INSTITUTE OF NAVIGATION

10.23

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Monday's short courses are provided on a complimentary basis to all paid ION GNSS+ attendees. ION Master Instructors are internationally recognized GNSS experts and educators. All ION Master Instructors have generously donated their time and talents to this effort, as a service to the GNSS community, with the ION's gratitude. Short courses are presented lecture-style. Course notes are the intellectual property of the ION Master Instructor, and are provided to registered attendees via the meeting website, at the discretion of the instructor.

1:30 p.m. - 3:00 p.m.

GPS/GNSS 101 - An Introduction
Dr. Pratap Misra

An overview of the principles of satellite navigation and the requisite technologies that matured in the second-half of the 20th century leading to the development of Transit, which became operational in 1964, followed by GPS in 1995. The principal technologies required for a Global Navigation Satellite System (GNSS) are stable space platforms in predictable orbits, global coordinate frames, spread spectrum signals and ultra-stable clocks. These technologies made GNSS possible, but it's the revolution in integrated circuits that led to a receiver chip, which adds about $1 to the cost of a smartphone and can determine, virtually instantaneously, your position within a couple of meters, velocity within 5 cm/s, and time within 50 ns. These innovations have transformed how we move about, transact commerce and fight wars.

Dr. Pratap Misra, an ION Fellow and Kepler Award recipient, has been active in the GNSS field for 30 years, starting with a project at MIT Lincoln Laboratory aimed at combining measurements from GPS and GLONASS to improve navigation for civil aviation.

Space Applications of GNSS
Dr. Penina Axelrad, *University of Colorado Boulder*

GNSS receivers have become standard equipment for near-Earth satellites, providing the onboard position, velocity, and timing information required to support real-time operations. Furthermore, precise GNSS observations from both direct and indirect paths collected onboard these platforms are used to support scientific and commercial purposes including characterization of Earth's atmosphere, measurement of ocean surface heights, and extraction of time varying features of Earth's gravity field. New advances in receiver technology and detailed modeling of the environmental influences on GNSS satellites and signals continue to expand the utility of GNSS to ever finer orbit resolution, and higher altitude missions – even to the point of being planned to support lunar exploration missions. This short course will present an overview of the many applications of GNSS in space, and describe the unique challenges and requirements for its use in the space environment.

Dr. Penina Axelrad is Joseph T. Negler Professor of Aerospace Engineering Sciences at the University of Colorado Boulder. Her research interests include technology and algorithms for position, navigation, timing, and remote sensing – especially in spaceborne applications. She is a past ION president, a Fellow of ION and AIAA, and a member of the National Academy of Engineering.

Signals of Opportunity Based Navigation
Dr. José A. del Peral-Rosado, *Airbus Defence and Space GmbH*
Dr. Christian Gentner, *German Aerospace Center (DLR)*

Signals of Opportunity (SoOP) refers to utilizing existing signals, such as radio, television, or cellular transmissions, for navigation or timing without requiring specialized transmitters. SoOP can complement, or back-up, global navigation satellite systems (GNSSs) and other dedicated positioning systems to fulfil the challenging positioning performance requirements of innovative applications, such as high-accuracy indoor positioning, autonomous driving or urban air mobility (UAM). This lecture provides a comprehensive introduction to the fundamentals and principles of SoOP-based navigation, leveraging cutting-edge technologies such as 5G networks. Through practical examples, including indoor positioning utilizing simultaneous localization and mapping (SLAM), we demonstrate the application and effectiveness of SoOPs in navigation.

Dr. José A. del Peral-Rosado is a senior R&D navigation engineer within the Future Navigation Programs Department at Airbus Defense and Space GmbH. He authored seminal works on 4G/5G positioning performance and experimentation, and currently leading pioneering demonstrators and studies for 5G/6G positioning.

Dr. Christian Gentner is working at the Institute of Communications and Navigation of the German Aerospace Center (DLR) where he directs the multi-modal personal navigation group. His research focuses on sensor fusion, urban and indoor positioning.

3:30 p.m. - 5:00 p.m.

GNSS Jamming and Spoofing – LEO as Fallback
Dr. Todd Humphreys, *The University of Texas at Austin*

Intentional jamming and spoofing of GNSS signals is by now a widespread phenomenon. Especially common near conflict regions, but not limited to these, such interference erodes trust in GNSS and compromises safety in air and marine travel and shipping.

This tutorial will examine: 1) patterns of GNSS interference across the globe; 2) its effects on GNSS receivers; and 3) techniques for its detection, source geolocation, and mitigation.

The tutorial will highlight cooperative and non-cooperative use of signals from low-Earth-orbit (LEO) mega-constellations as an especially promising fallback strategy. Compared to traditional GNSS, LEO constellations offer higher power, wider bandwidth, more rapid multipath decorrelation, and the possibility of stronger authentication and zero-age-of-ephemeris, all of which will enable greater accuracy and greater resilience against jamming and spoofing.

Dr. Todd E. Humphreys holds the Ashley H. Priddy Centennial Professorship in Engineering in the department of Aerospace Engineering and Engineering Mechanics at the University of Texas at Austin. He is director of the Wireless Networking and Communications Group and of the UT Radionavigation Laboratory, where he specializes in the application of optimal detection and estimation techniques to positioning, navigation, and timing. His awards include the UT Regents' Outstanding Teaching Award, the NSF CAREER Award, the ION Thurlow Award, the PECASE, and the ION Kepler award. He is Fellow of the ION and of the RIN. He holds a BS and MS from USU and PhD from Cornell.

Indoor Positioning and Indoor Navigation (IPIN) Systems
Dr. Li-Ta Hsu, *Google*

This course provides an overview of indoor positioning and indoor navigation (IPIN) systems. Starting from the markets and applications using IPIN, the course will introduce the popular technologies and related sensors. Single point positioning (SPP) will be introduced, followed by dead reckoning (DR). Regarding the data sources of SPP, we separate the sources into homogeneous (geometry-based) sources and heterogeneous (scene matching-based) sources. The former contain the measurement model of RSS-ranging, AOA, TOA, and TDOA; while the latter contains the fingerprint and other transformed data sources that are used to match with pre-surveyed databases. The popular DR using inertial, LiDAR, and visual sensors, namely PDR, LO, and VO, are also introduced. Finally, the pros and cons of different sensor fusion methods will be discussed.

Dr. Li-Ta Hsu, born in Taiwan, is currently an Associate Professor at The Hong Kong Polytechnic University (PolyU). Since 2023, he is a visiting research scientist at Google. He is an associate editor of NAVIGATION: Journal of the Institute of Navigation. His research interests are urban positioning and navigation for IoT and robotics applications.

LEO PNT – Architectures and Performance Trades
Dr. Tyler Reid, *Xona Space Systems*

Several emerging providers are targeting low Earth orbit (LEO) to deliver complementary and alternative position, navigation, and time (PNT) to meet the stringent requirements of certain applications. Here, we examine the system architectural elements, similarities and differences to medium Earth orbit (MEO) global navigation satellite systems (GNSS), and performance trades that result. The result is a system that takes a different form than the now familiar arrangement of around thirty satellites in MEO each with an atomic frequency standard as is the case with GNSS, as it is often driven by fundamentally different requirements. LEO-based satellite navigation has the potential to introduce new signals to complement existing GNSS in MEO to provide resilience, security, and high precision to navigation users.

Dr. Tyler Reid is a co-founder and CTO of Xona Space Systems. Previously, Tyler worked as a research engineer at the Ford Motor Company in the localization and mapping group for self-driving cars. He has also worked as a software engineer at Google and as a lecturer at Stanford University, where he co-taught the GPS course. He is a recipient of the RTCA's Jackson Award. Dr. Reid received his MSc and PhD in Aeronautics and Astronautics from Stanford University, where he worked in the GPS Research Lab.

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In-Person Attendance: *For those attending the conference in-person, AC power will not be made available for individual laptop computers; please come prepared with adequate battery power if required. It is recommended that attendees dress in layers to accommodate varying temperatures in the classroom.*

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Multi-Constellation GNSS Signals and Systems

Date: Tuesday, September 17, 2024
Time: 8:30 a.m. - 12:00 p.m.
Room: Holiday Ballroom 1 (Second Floor)

Course Registration Fee:
$450 if paid on or before August 16
$500 if paid after August 16

This course emphasizes the fundamentals of multi-constellation GNSS. The course begins with an overview of GNSS followed by presentations on each of the GNSSs 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 and datums and time
- GNSS signal structure formats: carrier, code, data
- Direct sequence spread spectrum
- GNSS antenna & receiver technologies – overview
- GPS Legacy: C/A, P(Y) code and NAV formats
- GPS Modernized: 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 MS EE from the Naval Postgraduate School, and BS EE 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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GNSS Integrity

Date: Tuesday, September 17, 2024
Time: 8:30 a.m. - 12:00 p.m.
Room: Holiday Ballroom 2 (Second Floor)

Course Registration Fee:
$450 if paid on or before August 16
$500 if paid after August 16

This course will describe (Part 1) fundamental concepts in GNSS integrity, (Part 2) successful implementations in aviation applications, and (Part 3) major challenges in future autonomous navigation for air, ground, and sea transportation. The course will emphasize Receiver Autonomous Integrity Monitoring (RAIM); it will include a handout on RAIM theory and a set of problems with solutions and MATLAB codes.

In Part 1, we will define navigation safety metrics and requirements including integrity and continuity risks, alert limit, and time to alert. We will identify the three major over-bounding methods used to derive high-integrity signal-in-space error models. We will define GNSS faults including, for example, excessive satellite clock drifts. We will outline how integrity-monitoring responsibilities can be allocated between reference-station and user receivers and how prior probabilities of satellite faults are evaluated.

In Part 2, we will briefly describe the major implementations used in aviation applications: the Ground-Based Augmentation Systems (GBAS), the Space-Based Augmentation Systems (SBAS) and the Aircraft-Based Augmentation System (ABAS). We will focus on RAIM and Advanced RAIM; we will use graphical tools of failure mode curves and parity space representations to identify differences between solution separation and chi-squared approaches. We will show recent developments in ARAIM intended to optimize ARAIM integrity and continuity monitoring performance while limiting computational load.

In Part 3, we will review recent efforts in standard developments and performance evaluations to achieve safe navigation in aviation, maritime, railway, and automotive applications. We will discuss recent research on robust modeling of measurement error time correlation that enables high-integrity Kalman filtering of combined GNSS and inertial data. We will identify major challenges in implementing precise point positioning (PPP) and real time kinematic (RTK) to simultaneously achieve high accuracy and high integrity.

Dr. Mathieu Joerger is an assistant professor at Virginia Tech, recipient of ION's Parkinson Award (2009), Early Achievement Award (2014), Burka Award and Thurlow Award (2023). He is the senior editor on Navigation for IEEE TAES and a member of the EU/US ARAIM Working-Group-C for the FAA. He received his PhD from Illinois Institute of Technology.

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PNT for sUAVs

Date: Tuesday, September 17, 2024
Time: 8:30 a.m. - 12:00 p.m.
Room: Holiday Ballroom 3 (Second Floor)

Course Registration Fee:
$450 if paid on or before August 16
$500 if paid after August 16

Small Unmanned Aerial Vehicles (sUAVs) are becoming increasingly ubiquitous. While their utilization may not have quite hit projections offered by venture capitalists over the last decade, these vehicles have found utility and have been incorporated into products in a wide variety of ways, for example: remote-control flying, photography and videography, infrastructure/agriculture/construction site inspection, product/medical delivery, racing, mapping, intelligence, surveillance and reconnaissance (ISR), and defense.

sUAVs have been and will continue to be fantastic platforms for enabling research in GNC, PNT, and many other disciplines. A key reason is that sUAVs offer the unique constraint of coupling low size, weight, and power (SWAP) with a critical need for urgency and timeliness of PNT and control information. This class will review the consequences of this unique constraint and the influences on both sensors and algorithms.

This course is a hands-on introduction and review of PNT for sUAVs and will provide in-depth information on current sensors, autopilots, software architectures, and algorithms for PNT. One key algorithm for navigation for sUAVs has been visual-inertial odometry (VIO). This modality, often enabled by machine learning approaches, has been optimized to strike the unique balanced required for the SWAP-timeliness constraint mentioned. This class will provide a hands-on dive into VIO methods and provide python examples to promote further understanding.

This course is applicable for those wanting to utilize UAVs for research, as well as those desiring to better understand the current state of the art in PNT for sUAVs. Pre-requisites and equipment: a basic understanding of PNT topics, including estimation and sensor fusion and object-oriented programming and Python programming language familiarity for the VIO software projects. Attendees will need their own charged laptops if they want to work on the projects in-class. Relevant course materials/notes and software examples are provided to registered attendees in advance.

Dr. Rob Leishman is currently the PNT Area Lead with IS4S and the Mission Capable Navigation Lead for the Resilient Embedded GPS and INS (R-EGI) program. Formerly, he was director of the Autonomy and Navigation Technology (ANT) Center at the Air Force Institute of Technology. There Dr. Leishman led a team of researchers and students in developing cutting-edge, defense-focused autonomy and navigation technologies, primarily for sUAVs.

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Ionospheric Effects, Monitoring, and Mitigation

Date: Tuesday, September 17, 2024
Time: 8:30 a.m. - 12:00 p.m.
Room: Peale (First Floor)

Course Registration Fee:
$450 if paid on or before August 16
$500 if paid after August 16

Ionospheric effects are major threats to the availability, continuity, and accuracy of GNSS solutions. Models, global networks of GNSS stations, and LEO satellite-based radio occultation constellations have been established to monitor and predict the ionospheric effects. This course will present an overview of the current state-of-art understanding of the various ionospheric effects on GNSS-based navigation systems and their mitigation techniques. The course consists of five parts. The first part is a review of the fundamental properties of the ionosphere that impact satellite navigation signals and PVT solutions. The second part discusses the ionospheric refractive effects, their contributions to the GNSS measurement model, Total Electron Content (TEC) estimation techniques and TEC products, higher order refraction errors, and refractive effect correction techniques. Part 3 covers ionospheric scintillation effect, with a focus on climatology and morphology of scintillation occurrences, and the impact of scintillation on RTK and PPP systems. Part 4 takes a deeper look into GNSS receiver signal processing algorithms designed to combat ionospheric scintillation for ground- and LEO satellite-based receivers. Part 5 will provide an update on the latest development in ionospheric effects monitoring and forecasting using machine learning algorithms, worldwide GNSS observations, as well as the ionospheric effects on signals transmitted from LEO satellites. We will finish the course with an outlook for outstanding challenges in the field.

Dr. Jade Morton is Helen and Hubert Croft Professor in the Aerospace Engineering Sciences Department at the University of Colorado, Boulder. Her research interests lie at the intersection of satellite navigation technologies and remote sensing of Earth's ionosphere, atmosphere, and surface. Dr. Morton was a president and Satellite Division Chair of ION, and a recipient of ION Thurlow, Burka, Kepler, IEEE PLANS Kershner, and AGU SPARC award. She is a Fellow of IEEE, ION, and RIN.

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Introduction to Software Defined GNSS Receivers and Signal Processing

Date: Tuesday, September 17, 2024
Time: 1:30 p.m. - 5:00 p.m.
Room: Holiday Ballroom 1 (Second Floor)

Course Registration Fee:
$450 if paid on or before August 16
$500 if paid after August 16

This 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 a software demo that reinforces the concepts and techniques covered. By the end of this 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 receiver is fully configured using JavaScript Object Notation (JSON) files such that modification of the source code is not required. It may be further extended to support numerous advanced research applications.

Topics covered:

- Overview of satnav bands, signal structures, link budget, and receiver architecture
- FFT-based signal acquisition and adapting circular correlation to long spreading codes
- Software-based methods for correlation acceleration: bit-wise, multi-threading, SIMD
- 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: GPS, GLONASS, Galileo, BeiDou, QZSS, NavIC, and SBAS
- Internal decision making and control procedures based on signal environment and application
- Measurement computation (pseudorange, accumulated doppler range/carrierphase)
- Direct instantiation for multi-frequency tracking (e.g. Galileo E1 to E5a/b)
- Inter-frequency aiding and duty cycling techniques for low-power applications (e.g. L1/L5 smartphones)

Pre-requisites and equipment: Basic understanding of digital signal processing, object-oriented programming concepts and the Python programming language are helpful but not required to attend this course. Numerous fully-functional demo projects will be provided. If intending to run the demos during the course, attendees must supply their own laptop computers with adequate battery power. The instructor will provide relevant information to registered attendees in advance of the course.

Dr. Sanjeev Gunawardena is a research associate professor with the Autonomy & Navigation Technology (ANT) Center at the Air Force Institute of Technology (AFIT). He has 25 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.

ION GNSS+ pre-conference tutorials have been organized to provide in-depth learning of specific GNSS-related disciplines and will be taught in a classroom setting. Course notes will be provided to registered attendees via the meeting website and a link provided for advance download.

In-Person Attendance: *For those attending the conference in-person, AC power will not be made available for individual laptop computers; please come prepared with adequate battery power if required. It is recommended that attendees dress in layers to accommodate varying temperatures in the classroom.*

On-Demand Learning: *The course will be recorded. Registered students may view the recorded course one time within 30 days. Those viewing the recording will not have real-time access to instructor(s) for live chat or question and answer. Note that the on-demand learning option allows you to register for tutorials scheduled at the same time.*

Register using the ION GNSS+ Registration Form (see the registration page for additional information 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.

The Generation and Application of Precise Time

Date: Tuesday, September 17, 2024
Time: 1:30 p.m. - 5:00 p.m.
**Room:** Peale (First Floor)

Course Registration Fee:
$450 if paid on or before August 16
$500 if paid after August 16

Time and frequency are fundamental concepts in the design of many technologies, especially the Global Navigation Satellite Systems (GNSS) on which we are quite reliant for navigation. Even alternative sources of navigation and legacy approaches to geo-positioning rely upon precise clocks. Industries from utilities to financial markets are also dependent on time synchronization with ever increasing needs for precision. For these reasons, understanding the base measurements and realizations of time can be useful for a growing number of research and development areas. This tutorial aims to introduce the foundational elements of time, from its definition to its dissemination into the user segment.

The main topics this course will cover are: the definition and realization of the SI second; generic design of various atomic frequency standards; statistics and metrics quantifying clock performance; the generation of international timescales and local clock ensembles; the comparison of remote timescales or clocks; and applications of these elements to various industries as well as navigation accuracy. Since foundations of precise time are the main thrust, there will be heavier emphasis on the former topics listed above. Important time comparison techniques including two way time transfer will be covered. The material will also highlight recent findings from the timing community on important topics regarding time and frequency and their dissemination by GNSS.

This course is geared towards scientists without significant experience in time metrology or clocks who desire an introduction to these topics. It will be assumed that attendees have a high-level understanding of the role of GNSS clocks, but nothing about the specifics topics mentioned above.
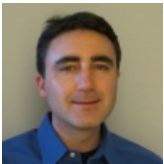
Dr. Michael J. Coleman is a research mathematician in the Naval Center for Space Technology at the US Naval Research Laboratory in Washington, DC. He is also head of the Systems Analysis Section within the Space PNT Branch. His main work at NRL has been development of the next generation GPS timescale and alternative or experimental precise time dissemination systems. Dr. Coleman chairs the Clock Products Committee of the International GNSS Service and is a delegate to the BIPM's Consultative Committee on Time and Frequency.

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Register using the ION GNSS+ Registration Form (see the registration page for additional information 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.

Space-Based Lunar PNT

Date: Tuesday, September 17, 2024
Time: 1:30 p.m. - 5:00 p.m.
Room: Holiday Ballroom 2 (Second Floor)

Course Registration Fee:
$450 if paid on or before August 16
$500 if paid after August 16

We are entering a new era of Moon exploration. There are more than forty missions planned within the next decade by ten space agencies, not even counting the efforts of private sector companies like SpaceX and Blue Origin. After more than fifty years since the Apollo program, NASA's Artemis mission will land humans on the Moon including the first woman and first person of color. Exploring the Moon also serves as a crucial stepping-stone for the success of future deep space missions. With the increase in human and robotic exploration, we must provide position, navigation, and timing (PNT) services anywhere on the Moon. In this tutorial, we will cover the following topics.

- An introduction to currently planned missions for lunar exploration
- Main lunar navigation services and Key Performance Indicators (KPIs)
- Overview of candidate orbits for lunar navigation
- End-to-end navigation architecture
- Candidate orbit determination and time synchronization (ODTS) baseline solution for lunar navigation
- Lunar reference frames
- Frequencies selected for lunar navigational signals
- Lunar PNT engine for different user missions, such as descent and landing and rover surface PNT

Dr. Grace Gao is faculty in the Department of Aeronautics and Astronautics at Stanford University. She leads the Navigation and Autonomous Vehicles Laboratory (NAV Lab). Her research is on robust and secure position, navigation and time (PNT) with applications to manned and unmanned aerial vehicles, autonomous driving cars, as well as space robotics.

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Register using the ION GNSS+ Registration Form (see the registration page for additional information 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.

Factor Graphs

Date: Tuesday, September 17, 2024
Time: 1:30 p.m. - 5:00 p.m.
Room: Holiday Ballroom 3 (Second Floor)

**Course Registration Fee:**
$450 if paid on or before August 16
$500 if paid after August 16

While the Kalman Filter (KF) family (linear KF, EKF, UKF, etc.) has been the workhorse of navigation systems for several decades, the factor graph is a generalization of the Kalman Filter that offers improved performance for non-linear systems and is more easily applied to complex systems. The goal of this tutorial is to take a practitioner who is familiar with the Extended Kalman filter and introduce them to factor graphs. By the end of the tutorial, the attendants should be able to create a simple factor graph system and will have been exposed to some of the more advanced concepts that make factor graphs an exceptional choice for navigation problems.

More specifically, this tutorial will introduce the factor graph representation of dynamic systems and how this representation is equivalent to a weighted least squares problem that can be solved with sparse matrix computational tools. We will demonstrate the (surprisingly low) computational costs of factor graphs and methods used to keep those costs low. We will also introduce popular software packages that can be used to solve factor graph problems, including GTSAM. Complex estimation problems that can be difficult to handle with other estimation frameworks will be introduced in the factor graph framework and examples solutions to these problems will be demonstrated.

Dr. Clark Taylor is the Autonomy and Navigation Technology (ANT) center director at the Air Force Institute of Technology. He received his PhD from University of California, San Diego in 2004 and previously worked as a senior research engineer with the Air Force Research Laboratory and an assistant professor in electrical engineering at Brigham Young University.
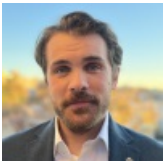
Dr. Ryan Watson currently works at Xona Space Systems enabling integrity for their LEO satellite navigation constellation. He previously worked at the NASA Jet Propulsion Laboratory and the Johns Hopkins University Applied Physics Laboratory on problems related to state estimation/data fusion for robotic and space missions. He holds a PhD from West Virginia University.

ION GNSS+ Plenary Session
Tuesday, September 17, 2024 • 6:30 p.m.–8:30 p.m.

The plenary session will be recorded and made available to registered attendees on the conference website.

Welcome, Meeting Highlights and Introduction of Technical Committee

Satellite Division Chair
Sandy Kennedy
Hexagon

Opening of the Plenary Session

Plenary Chair
Dr. Dorota Grejner-Brzezinska
The Ohio State University

Keynote Addresses

Direction Moon: A Journey of our Satellite Navigation System to the Edge of its Limits

Dr. Oscar Pozzobon
Qascom

Dr. Oscar Pozzobon is co-founder, President and CEO of Qascom. He received a bachelor in information technology from University of Padova, a Master in Telecommunication Engineering from University of Queensland, and a Phd in Aeronautics and Satellite applications from Centre of Studies and Activities for Space, University of Padova. He has been involved in the last 20 years in the design of all major European programs of satellite Navigation including Galileo and EGNOS, and has been a pioneer of GNSS Security and authentication, with more than 50 publications and 3 patents on this topic. He has been mission manager of several GNSS space missions including the SCaN testbed on the ISS with ESA-NASA, Sounding rockets with NASA-ASI, micro satellites experimentations with NASA and the recent Lunar GNSS Receiver Experiment with NASA-ASI. He is adjunct professor for Satellite Navigation and Telecommunications at the University of Padova.

Circumnavigating the Globe
Kirsten Neuschäfer
Sailor

Kirsten Neuschäfer is a professional sailor specializing in high latitude and high adventure sailing. She is the winner of the 2022 Golden Globe Race, from France, round the three great capes, and back to France, non-stop, single-handed, unassisted. She is the first woman to win that race since it started in 1968; also, the first woman to win any around the world race, including solo and fully crewed races, non-stop or with stops. She won the World Sailor of the Year award in 2023.

The Golden Globe Race prohibits competitors from using modern electronics - so all navigation is traditional - no GNSS! Kirsten studied the routes of the great Clipper Ships from the nineteenth century to plan her winning route. Come and hear her story.

A1: Augmentation Services, Integrity, and Authentication 1
Date: Wednesday, September 18, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 1

Session Chairs

Track Chair

Dr. Rui Hirokawa
Mitsubishi Electric Corporation

Dr. Thomas Pany
University of the Bundeswehr, Munich

Steffen Thoelert
German Aerospace Center (DLR)

8:35. Enhancing ARAIM Algorithm with Dynamic Satellite Ranking: An Effective Approach to Optimizing Computational Efficiency and Availability, Jianming She, The MITRE Corporation

8:57. Safe Position Bounds and Fault Detection and Exclusion for Autonomous Driving, I. Martini, O. Julien, C. Hide, H. Dorahy, M. Khaghani, M. Limberger, u-blox; I. Sheret, Polymath Insight Ltd

9:20. Nav Data bits for Increasing Sensitivity and Robustness in Mass Market Receivers, Frank van Diggelen, Google; Tim Murphy, Boeing; and John Betz, The MITRE Corporation

9:43. Models for the Effect of Integrity Monitors on GNSS user Range Error Distributions, Juan Blanch, Yu-Fang Lai, Todd Walter, Stanford University and Pedro Silva, Hexagon

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

10:40. Enhancing GNSS Pedestrian Navigation Through Artificial Intelligence-Driven Integrity Monitoring in Complex Environments, Ziyou Li, Ni Zhu, Valérie Renaudin, University Gustave Eiffel, AME-GEOLOC

11:03. PNT Trust Inference Engine Reference Architecture, Joseph Durkin, Patricia Larkoski, Joseph J. Rushanan, The MITRE Corporation

11:26. The Performance Evaluation of the QZSS Authentication Service toward the First Drone Experiment, Takahiro Yamamoto, Kazuhiro Terao, Hidehiko Araki, Sumi Daiki, Miyamoto Sho, Kengo Takahashi, Core Corporation

11:48. Navigation Performance Assessment with an Automotive Receiver Exploiting OSNMA and FDE, Antonio Angrisano, Messina University; Domenico Di Grazia, Fabio Pisoni, Giovanni Gogliettino, Domenico Rega, STMicroelectronics; Salvatore Gaglione, Parthenope University; Ciro Gioia, Independent Researcher

Alternate Presentations

1. **Experimentation and Cost Benefit Analysis on Advanced RAIM for Rail, Maritime and UAS Sectors,** Ginés Moreno, Javier de Toro, Enrique Domínguez, Carlos Sanz, Javier Fidalgo, Fulgencio Buendía, Elena Labrador, Ana Cezón, GMV; Florin Mistrapau, Roxana Clopot, GMV-RO; Merle Snijders, Heiko Engwerda, Juliette Casals, NLR; Axel Wion, Armando Luciano, Nino Bohéas, Lowie Vueghs, Paola Testa, EY; Sophie Damy, Matteo Sgammini, Juan Pablo Boyero, European Commission

2. **Frequency Domain Overbounding with Multiple Time Series and PSD Estimators,** Omar Garcia Crespillo, German Aerospace Center (DLR); Steven Langel, The MITRE Corporation, Mathieu Joerger, Virginia Tech

3. **How Galileo OSNMA Leaves the Door Open for Time-Related Attacks,** Mahyar Shariat, Wolfgang Kastner, TU Wien

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

B1: PANEL: Status of GPS, Galileo, BDS, QZSS, KPS, and NavIC
Date: Wednesday, September 18, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 6

Session Chairs   **Track Chair**

Dr. Todd Walter   **Dr. José Ángel Ávila Rodríguez**   **Dr. Sudha Vana**
Stanford University   *European Space Agency*   *Rx Networks*

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.

Panel Members:

In-Person Presentations
In-Person presentations will be presented live at the conference. Presenters will provide a pre-recorded presentation for on-demand viewing by registered attendees.

1. **GPS,** Col Matthew L. Spencer, Commander, SML PNT Systems Delta SSC/PNT SYD

2. **Galileo,** Mr. Eric Châtre, Head of EU GNSS Exploitation and Evolution, European Commission and Mr. Miguel Manteiga, Galileo Project Manager, European Space Agency

3. **BDS,** Dr. Xiaochun Lu (TBC), Deputy Director of International Cooperation Center, China Satellite Navigation Office

4. **QZSS,** Mr. Motohisa Kishimoto, Senior Coordinator, QZSS Strategy Office, National Space Policy Secretariat, Cabinet Office

5. **KPS,** Dr. Jong Yeoun Choi, Director of the KPS program Management and SE&I Division, Korea Aerospace Research Institute

6. **NavIC,** Ms. S. Nirmala, U R Rao Satellite Centre

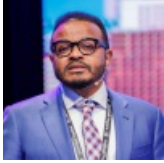12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

C1a: Applications of GNSS Measurements from Smartphones
Date: Wednesday, September 18, 2024
Time: 8:30 a.m. - 10:05 a.m.
Room: Holiday Ballroom 2
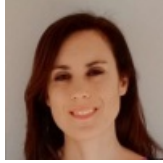
Session Chairs

Track Chair

Dr. Mohammed Khider
Google Inc.

Dr. Robert Odolinski
University of Otago

Dr. Melania Susi
Topcon Positioning System

8:35. Evaluation of Sensors Measurements in Consumer-Grade Android Wearables for Robust Positioning Applications, Antoine Grenier (TAU), Ziyou Li (UGE), Ni Zhu (UGE), Aleksandr Ometov (TAU), Elena Simona Lohan (TAU), Valérie Renaudin (UGE), Jari Nurmi (TAU)

8:57. Best Integer Equivariant Estimator for Phone-to-Phone RTK in Urban Canyon Environments, Ananya Vishwanath, Rhea Joyce Zambra, Department of Geomatics Engineering, University of Calgary; Robert Odolinski, University of Otago; Mohammed Khider, Google Inc.; Hongzhou Yang, Department of Geomatics Engineering, University of Calgary

9:20. Multi-Constellation GNSS-IR Building Model Rectification Using a Smartphone in Urban Areas, Mingda Ye, Guohao Zhang, and Li-Ta Hsu, Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University

9:43. Ionospheric Refraction Estimation From Smartphone GNSS Measurements, Caitlyn Hayden and Sunil Bisnath, York University

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

Alternate Presentations

1. **Performance Assessment of Real-Time GNSS Spoofing Detection with IMU Measurements on Android Smartphones,** Feifan Zhou, Hong Li, Hao Wang, Ziheng Zhou, Min He, Xiao Zhou, Mingquan Lu, Department of Electronic Engineering, Beijing National Research Center for Information Science and Technology (BNRist), Tsinghua University

2. **Mitigation Techniques for Error Reduction in Doppler Measurements of Wearable GNSS Receivers,** Bogeun Cho, Sunkyoung Yu, Jungbeom Kim, Jaechang Shin, Kisoo Yu, Inhyoung Kim, William Higgins, Damian Miralles(System LSI, Samsung Electronics)

3. **Android Smartphone Real-Time Instant PPP With Advanced QC Module to Mitigate GNSS Signal Blockage and Reflection,** Fei Liu, Yang Jiang, Zhitao Lyu, Farzaneh Zangenhnejad, Mohamed Elsheikh, Yang Gao, Naser El-Sheimy, Profound Positioning Inc.

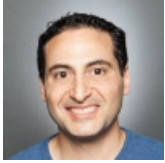**C1b: Latest Advancement from GNSS Receiver and Localization Algorithm Manufacturers (Ten-Minute Pitches to Industry Nirvana)**
Date: Wednesday, September 18, 2024
Time: 10:35 a.m. - 12:15 p.m.
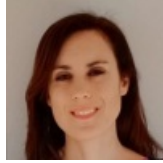**Room:** Holiday Ballroom 2

Session Chairs

Track Chair

Steve Malkos
Google Inc.

Dr. Paul McBurney
OneNav Inc.

Dr. Melania Susi
Topcon Positioning System

10:40. Galileo New I/NAV Message on the Latest MediaTek GNSS Solution, Hung-Wei Chen, Bo-Wen Tung, Yu-Chi Tien, Yu-Cheng Hsu, Wei-Jyun Chen, Yu-Chang Chen and Pei-Hung Jau, MediaTek Inc.

10:50. Processing AltBOC and ACE-BOC Signals in Automotive-Market Devices through Enhanced Meta-Signal Reconstruction, Domenico Di Grazia, Fabio Pisoni, Michele Renna, Giovanni Gogliettino, STMicroelectronics srl; Ciro Gioia, Independent Researcher; Daniele Borio, European Commission, Joint Research Centre

11:00. The StarPoint Revolution within TopNET Live: A New Era of GNSS Services, Dmitry Nikitin, Tom Morris, Melania Susi, Topcon Positioning Systems

11:10. New Product Offerings for LEO PNT User Equipment Utilizing STL Technology, Charlie Meyer, Iridium

11:20. Preliminary Insights into Xona PULSAR Signal Support on the Teseo Platform, Thyagaraja Marathe, Paul Tarantino, Tyler G. R. Reid, Xona Space Systems; Fabio Pisoni, Domenico Di Grazia, Giovanni Gogliettino, STMicroelectronics srl

11:30. Cm-Level Positioning During Solar Cycle 25 with Trimble IonoGuard, Fabian Rothmaier, Xiaoming Chen, Nick Talbot, Gang Lu, Markus Glocker, Alexandr Sokolov, Stefan Junker, Trimble

11:40. L5-First Outperforms Consumer and IoT Hybrid L1/L5 GNSS Receivers Under L1-Band Pulsed Wideband Interference in a Laboratory Reacquisition Performance Test, Kamil Grajski, Paul McBurney, Florean Curticapean, Michal Misiaszek, Drew Compston, Nagaraj Shivaramaiah, and Sunil Patel, oneNav

11:50. Empirical Assessment of Benefits of Acquisition of L5 First in a Range of Jamming Cases, Paul McBurney, Nagaraj Shivaramaiah, Paul Conflitti, Michal Misiaszek, Drew Compston, OneNav Inc.

12:00. The Integration of SoC for Real-Time GNSS-RTK/DR/VMDS on A Low-Power GNSS Chipset for Vehicle Navigation in GNSS-Challenged Scenarios, Guang-Je Tsai, Tzu-Yin Chen, Song-Ying Li, Wei-Che Hsu, Shi-Xian Yang, AIROHA Technology (Company of MediaTek Group)

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

D1: Alternative Technologies for GNSS-Denied Environments
Date: Wednesday, September 18, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 4

Session Chairs

Track Chair

Dr. John Raquet
IS4S

Dr. Joshua Morales
StarNav

Dr. Safoora Zaminpardaz
RMIT University

8:35. Radar-Aided 5G Positioning in Underground Environments, Emma Dawson, Qamar Bader, Paulo Ricardo Marques de Araujo, Queen's University; Mohamed Elhabiby, Micro Engineering Tech Inc.; Aboelmagd Noureldin, Royal Military College of Canada and Queen's University

8:57. Radar-Inertial Navigation for Unmanned Ground Vehicles in GNSS-Denied Off-Road Environments, Petar Mitrev and Mohamed Atia, Carleton University

9:20. Quantum PNT Pathfinder: Foundations for the Next Revolution in Position, Navigation, and Timing, Andrew D. Greentree, Allison Kealy, Safoora Zaminpardaz, School of Science, RMIT University

9:43. Measurement-Guided Ray Tracing: Estimation of Propagation Paths Based on Spatiotemporal Measurement Data of User-Induced Fading of Multipath Components, Martin Schmidhammer, Christian Gentner, Benjamin Siebler, Stephan Sand; German Aerospace Center (DLR)

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

10:40. Integrity with Lidar Positioning: Case Studies in Automatic Feature Extraction, Kana Nagai and Boris Pervan, Illinois Institute of Technology

11:03. How Much do Naïve and Hardware Time Synchronization Methods Affect Multi-Sensor Positioning?, Saurav Uprety, Zhitao Lyu, Zelin Zhou, Rhea Joyce Zambra, Ananya Vishwanath, Raymond Lee, Bosco Li, and Hongzhou Yang, Intelligent Navigation and Mapping Lab, Department of Geomatics Engineering, University of Calgary

11:26. The Truth is Out There: Opportunistic LEO PNT with Uncooperative Satellites, Zak (Zaher) M. Kassas, Joe Saroufim, Sharbel Kozhaya, and Samer Hayek, The Ohio State University

11:48. Pedestrian Heading Bias Correction using Low Earth Orbit Signals of Opportunity, Andrew Weir, Landon Boyd, J. Tanner Koza, and David M. Bevly, Auburn University

Alternate Presentations

1. **Evaluating Lidar-Based Collaborative Positioning, Object Tracking and Mapping,** Andrea Masiero, University of Padua; P. Trybala, Fondazione Bruno Kessler, FBK; Charles Toth, The Ohio State University; Fabio Remondino, FBK

On-Demand Presentations

1. **Enhancing Accuracy of Estimating Pedestrian Velocity and Walking Distance in the Workplace with Pose Graph Optimization,** Satoki Ogiso, Masakatsu Kourogi, Ryosuke Ichikari, Akihiro Sato, Takashi Okuma, and Takeshi Kurata, National Institute of Advanced Industrial Science and Technology (AIST)

2. **Maximum Likelihood Particle Filtering for the Fusion Direction of Arrival Beacons and IMU in Indoor Environments,** Ilyar Asl Sabbaghian Hokmabadi, Mengchi Ai, University of Calgary

3. **Multi-Lidar Extrinsic Calibration for Obtaining Optimum Coverage of the Surroundings Including GNSS Denied Environment,** Surbhi Barnwal, Salil Goel, Indian Institute of Technology Kanpur

4. **Observability of INS/OD Integration with Rotating MEMS IMU: A Global Perspective,** Wenhui Yang, Yong Li, Jianfeng Wang, Daifang Huang, University of Electronic Science

5. **Precise Location Learning Using Neighboring Cell IDs in LTE Networks: A Simple and Effective Approach,** Jin Ah Kang, Youngsu Cho, Juil Jeon, Sun Sim Chun, and Jung Ho Lee, ETRI

6. **Zero Velocity Detection using Ultra Wide Band (UWB) for Pedestrian Positioning,** Ashwani Kumar, Geomatics, Department of Infrastructure Engineering, University of Melbourne, Geoinformatics, Department of Civil Engineering, Indian Institute of Technology Kanpur; Kourosh Khoshelham, Geomatics, Department of Infrastructure Engineering, University of Melbourne; Salil Goel, Geoinformatics, Department of Civil Engineering, Indian Institute of Technology Kanpur

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

E1: Advanced Technologies in High Precision GNSS Positioning
Date: Wednesday, September 18, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 3

Session Chairs

Track Chair

Dr. Mathieu Joerger
Virginia Tech

Dr. Junesol Song
University of Suwon

Byungwoon Park
Sejong University

8:35. Galileo High Accuracy Service Reference User Algorithm Formulation and Verification, Paolo Zoccarato, Francesco Menzione, Joint Research Centre of the European Commission; Ciro Gioia, External Consultant at the EC Joint Research Centre; Joaquim Fortuny Guasch(1), Javier Ostolaza, Stefano Lagrasta, External Consultant at the EC Joint Research Centre; Matteo Paonni, Joint Research Centre of the European Commission; Javier De Blas, External Consultant at the EC Joint Research Centre; Ignacio Fernandez-Hernandez, European Commission

8:57. Analysis of HAS Performance in Pedestrian Navigation with Different Grade Devices, Antonio Angrisano, Messina University; Milad Bagheri, Politecnico di Torino; Giovanni Cappello, University of Naples Parthenope; Paolo Dabove, Politecnico di Torino; Silvio Del Pizzo, Salvatore Gaglione, Ciro Gioia, Gabriele Portelli, Salvatore Troisi, University of Naples Parthenope.

9:20. A Cascading Approach for Multi-Frequency Widelanes and Extra-Widelanes Carrier Phase Integer Ambiguity Resolution, Clément Gazzino, Nicolas Lelarge, Centre National d'Etudes Spatiales

9:43. A Factor Graph Optimization Based Multi-epoch Ambiguity Resolution for GNSS RTK and its Evaluation in Hong Kong Urban Canyons, Yuan Li, Xikun Liu, Weisong Wen, Li-Ta Hsu, Department of Aeronautical and Aviation Engineering, the Hong Kong Polytechnic University; Yilong Yuan, Guangyu Bian, Qiaoyun Chen, Tencent Technology Beijing Co. Ltd.

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

10:40. Implementation of Ambiguity-Resolved Detector for High-Precision GNSS Fault Detection, Chengyu Yin, Delft University of Technology; P.J.G. Teunissen, Delft University of Technology, Curtin University, The University of Melbourne; C.C.J.M. Tiberius, Delft University of Technology

11:03. High-Accuracy Atmospheric Correction Generation Method for Compact RTK for Expanded Area (COREA), Bu-Gyeom Kim, Changdon Kee, Department of Aerospace Engineering and SNU-IAMD, Seoul National University

11:26. The Effect of Different Receiver Types and Ionospheric Conditions on Multi-GNSS Observable-Specific-Biases, A. Hauschild, German Aerospace Center (DLR), Institute of Communication and Navigation (IKN); T. Mayer-Guerr, Graz University of Technology, Institute of Geodesy

11:48. Meta-signal Inspired Quad-Frequency GNSS Measurement Combinations, Daniele Borio, European Commission Joint Research Centre (JRC); Melania Susi, Topcon Positioning Systems Inc.; Kinga Wezka, Warsaw University of Technology

Alternate Presentations

1. **Comparative Analysis of Commercial PPP-RTK and Network RTK Services for Urban and Suburban Vehicle-Borne Kinematic Positioning in Central Italy,** Matteo Cutugno, Dept. of Science and Technology, University of Benevento Giustino Fortunato; Laura Marconi, Dept. of Engineering, University of Perugia; Giovanni Pugliano, Dept. of Civil, Architectural and Environmental Engineering, University of Naples Federico II; Fabio Radicioni, Dept. of Engineering, University of Perugia; Umberto Robustelli, Dept. of Engineering, University of Naples Parthenope; Aurelio Stoppini, Dept. of Engineering, University of Perugia

2. **The Potential of Precise Point Positioning Using Simulated Data,** Tomohiro Ozeki, Nobuaki Kubo,Tokyo University of Marine Science and Technology

3. **GNSS Positioning Safety: Probability of Positioning Failure and its Components,** Sebastian Ciuban, Peter J.G. Teunissen, and Christian C.J.M. Tiberius, Delft University of Technology

On-Demand Presentations

1. **Sequential Innovation-Based Integrity Monitoring Against Wrong Ambiguity Fixing for RTK/INS Tightly Coupled Positioning,** Jiachang Jiang, Lin Zhao, Harbin Engineering University; Jiaxiang Li, Marine Design and Research Institute of China; Chun Jia, Xin Xu, Harbin Engineering University

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

F1: Advanced Software and Hardware Technologies for GNSS Receivers
Date: Wednesday, September 18, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 5

Session Chairs

Track Chair

Dr. Rodrigo Leandro
u-blox

Dr. Haidy Elghamrawy
Royal Military College of Canada

Dr. Attila Komjathy
Jet Propulsion Laboratory

8:35. Exploiting Next-Generation Signals from Galileo in a Real Time Receiver, Freddy A. Pinto, E. Garbin, Carlos Moriana, R. Romero, F. Conde-Pumpido, G. Ortas, G. Cueto-Felgueroso, GMV; E. Shytermeja, Jose. A. Garcia-Molina, European Space Agency

8:57. GNSS Signal Correlation and Measurement Datasets for Interference Classification, David Gómez-Casco, Xurxo Otero Villamide, Luciano Musumeci, Paolo Crosta, European Space Agency

9:20. Analysis of Subcarrier-Assisted Acquisition Methods for Galileo E5 AltBOC(15,10), Elek Kozma, Bryce J. Karlins, Scott M. Martin, Auburn University

9:43. Analysis of Direct Conversion Front-End Distortions for High-Fidelity Satnav Integrity Monitoring Applications, Mark Carroll, Eric Vinande, Air Force Research Laboratory; Sanjeev Gunawardena, Air Force Institute of Technology

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

10:40. Multipath Parameter Estimation Based on Reinforcement Learning, Xin Qi and Bing Xu, Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University

11:03. A General Multi-Dimensional GNSS Signal Processing Scheme Based on Multicomplex Numbers, Daniele Borio, European Commission Joint Research Centre (JRC)

11:26. Adaptive Ultra-Tight Integration Architecture for Robust Navigation in Low Earth Orbit, Iñigo Cortés, Katrin Dietmayer, Fabio Garzia, and Alexander Rügamer, Fraunhofer IIS

11:48. Approximation of Finite-Length Bound for Binary Three-State Fading Channels with Applications to GNSS, Nuwan J. G. Kankanamge, Nghi H. Tran, The University of Akron; Khanh Pham, Air Force Research Laboratory; Dan Shen and Genshe Chen, Intelligent Fusion Technology Inc.

Alternate Presentations

1. **Implementation of GPS L1C in an Open-Source Software-Defined Receiver,** Into Pääkkönen, Mohammad Zahidul H. Bhuiyan, Sanna Kaasalainen, Finnish Geospatial Research Institute

2. **Multi-Constellation GNSS IF Signal Generator for Testing of SSV in Geostationary Orbit,** Seung-Gyu Yang, Young-Jin Song, Jong-Hoon Won, Inha University / Autonomous Laboratory

3. **Selective Coherent Integration-Based Optimal Acquisition to Enhance Anti-Jam for Low SWaP-C MGUE,** Dan Shen, Genshe Chen, Intelligent Fusion Technology, Inc.; Khanh Pham, AFRL/RVBYC

On-Demand Presentations

1. **A GNSS Interference Signal Identification Scheme Based on Meta-Learning for Few-Shot Conditions,** Yunhao Liu, University of Electronic Science and Technology of China; Sicun Han, Rensselaer Polytechnic Institute; Chengjun Guo, University of Electronic Science and Technology of China; Jiangyan Chen, University of Electronic Science and Technology of China

2. **Adaptive Notch Filter Based Interference Characterization and Mitigation for GNSS Receivers,** Nabeel Ali Khan and Luis Enrique Aguado, GMV UK

3. **Identification of GNSS Interference Signals through a Multimodal Progressive Fusion Learning Approach,** Yunhao Liu, Chengjun Guo, and Jiangyan Chen, University of Electronic Science and Technology of China

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

A2: Land-Based Applications
Date: Wednesday, September 18, 2024
Time: 1:45 p.m. - 5:30 p.m.
Room: Holiday Ballroom 1

Session Chairs

Track Chair

Dr. Ali Hassani
Sierra Space

Dr. Juliette Marais
Université Gustave Eiffel

Steffen Thoelert
German Aerospace Center (DLR)

1:50. Railway GNSS Multipath Error Modelling Approach with Both Train-Side and Operational Environment Characterization, Ana Kliman, Florian Roessl, Anja Grosch, Omar Garcia Crespillo, German Aerospace Center (DLR)

2:12. DFMC Multi-Sensor Safe Positioning Platform for Railway Safety of Life Applications, Puccitelli Marco, Manno Chiara, Siniscalco Luca, Marradi Livio, Thales Alenia Space Italy; Tobie Anne Marie, Al Bitar Hanaa, Thales Alenia Space France; Guidi Rodolfo, MERMEC; Martinelli Alessio, Telespazio Italy; Lopour Daniel, EUSPA

2:35. Map-Based Solution Separation RAIM for Train Localisation, Andreas Wenz, Swiss Federal Railways

2:58. Prediction of Integrated Accuracy of GNSS/IMU/Speed Sensor by Machine Learning, Kaito Kobayashi, Tomohiro Ozeki, Nobuaki Kubo, Tokyo University of Marine Science and Technology

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

4:00. Uncertainty Quantification for Radar/Inertial Pose Estimation in GNSS-Denied Areas, Jonathan Becker, Mathieu Joerger, Virginia Tech

4:23. Performance Assessment of Fault Free Recursive SBAS Users with High-Integrity Time-Correlated Measurement Error Models, Elisa Gallon, Alejandro Rodriguez Veiga, Airbus Defence and Space

4:46. A GNSS Anti-Spoofing Method Based on Matching Matrix Deviation for IMU-Equipped Vehicles, Yimin Ma, Hong Li, Ziheng Zhou, Xiao Zhou, Yimin Deng, Mingquan Lu, Department of Electronic Engineering, Beijing National Research Center for Information Science and Technology, Tsinghua University

5:08. GNSS Navigation Message Authentication with the Trimble RTX GNSS Correction Service, Markus Brandl, Ralf Schmid, Ulrich Weinbach, Christian Pagels, Ramzi El Khayat and Stefan Junker, Trimble Inc.

Alternate Presentations

1. **Enhancing Automotive Positioning Security and Robustness using Trimble's RTX Navigation Message Authentication (RTX-NMA),** Ramzi El Khayat, Manish Maruthi, Johannes Traugott, Markus Brandl, Alexandr Sokolov, Juan Castro Arvizu, Trimble Inc.
2. **The Strategy and Solutions to Introduce a GNSS-Based Automatic Train Protection System in ERTMS/ETCS,** Mauro Cardone, ASI, Agenzia Spaziale Italiana
3. **A Low-cost Multi-purpose Localization Design for Land Vehicles,** Hien Nguyen, Kerry Sun, Ghazaale Leylaz Mehrabadi, Bhuvanesh Sainath, Rivian Automotive

Free Time in Exhibit Hall • 5:30 p.m. - 7:00 p.m.

B2: Trends in GNSS Augmentation Systems
Date: Wednesday, September 18, 2024
Time: 1:45 p.m. - 5:30 p.m.
Room: Holiday Ballroom 4

Session Chairs

Track Chair

Dr. Nacer Naciri
Jet Propulsion Laboratory

Dr. Anurag Raghuvanshi
York University

Dr. Sudha Vana
Rx Networks

1:50. Deepening Understanding of the ARAIM Algorithm Environment: A Multi-Parameter Sensitivity Analysis Perspective, Jianming She, The MITRE Corporation

2:12. Monitoring and Advanced Performance Assessment for SBAS, Fernando Bravo, Daniel Calzada, Juan R. Campano, Ignacio Sanz, GMV

2:35. Towards Cyber-Secure GBAS: Initial Experimental System Validation, D. Gerbeth, M. Caamano, German Aerospace Center (DLR)

2:58. Constellation Fault Monitoring to Support a Precise Point Positioning (PPP) Integrity Service, Rebecca Wang, Juan Blanch, Todd Walter, Stanford University

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

4:00. Impact of Phase Transitions due to Ionospheric Scintillation on GBAS Integrity, Andrew K. Sun, Jiyun Lee, Korea Advanced Institute of Science and Technology; Sam Pullen, Stanford University

4:23. JPL's Proposed High Accuracy Service and Comparison to Galileo HAS and IGS Products, Nacer Naciri, Attila Komjathy, Larry Romans, Bela Szilagyi, Mark Miller, NASA Jet Propulsion Laboratory, California Institute of Technology; Sunil Bisnath, York University; Yoaz Bar-Sever, NASA Jet Propulsion Laboratory, California Institute of Technology

4:46. Development of RTCM SC-134 Messages for High-Integrity Precise Positioning: Progress and Challenges, Roberto Capua, Sogei; Mathieu Joerger, Virginia Tech; Sam Pullen, Stanford University; Ilaria Martini, u-Blox; Alessandro Neri, Università Roma Tre; Edmond Leahy, Hexagon

5:08. PPP-RTK with SSR-Based Corrections via Digital Audio Broadcasting in Germany, Thomas Krawinkel, Steffen Schön, Leibniz University Hannover, Institute of Geodesy; Jens Schroeder, RFmondial GmbH; Christopher Perschke, Geo++ GmbH; Christoph Wallat, Markus Vennebusch, Landesamt für Geoinformation und Landesvermessung Niedersachsen; Christoph Knöfel, Bundesamt für Kartographie und Geodäsie

Alternate Presentations

1. **Isolating Multiple Faulty GNSS Measurements with the Jackknife Residual: An Incrementally Expanding Approach,** Penggao Yan, Weisong Wen, and Li-Ta Hsu, Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University
2. **Enabling Satellite-Based Nationwide High Precision GNSS Positioning Through Homogeneous Network RTK and Comprehensive Residual Error Modeling,** Byungwoon Park, Yongrae Jo, Sungik Kim, Yebin Lee, Sejong University; Yunho Cha, Sejong University, Hanwha Aerospace ; Cheolsoon Lim, Sejong University, LIGNex1

On-Demand Presentations

1. **EGNOS V3 DFMC Demonstrator (EDD) - A Representative Live Simulation Capability for the Future EGNOS Services,** Renaud Fabre, ADS; Peter Claes, François Dufour, David Thomas, European Space Agency; Andreas Breitenacher, Nathan Balblanc, Luca Carlin, Rémi Demortier, Thomas Fuhrmann, Florent Jambou, Florian Lautier, Daniel Munoz, Jean-Philippe Maillot, Pierre Noirat, François Tranchet, ADS

Free Time in Exhibit Hall • 5:30 p.m. - 7:00 p.m.

C2: Advances in High Accuracy Positioning
Date: Wednesday, September 18, 2024
Time: 1:45 p.m. - 5:30 p.m.
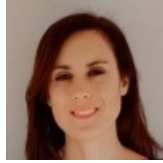**Room:** Holiday Ballroom 2

Session Chairs   Track Chair

Dr. Simon Banville   **Dr. Ignacio Fernández Hernández**   **Dr. Melania Susi**
Xona Space Systems   *European Commission*   *Topcon Positioning System*

1:50. Towards a 24/7 Performance Monitoring of the Galileo HAS Service, Johann Furthner, Marios Smyrnaios, German Aerospace Center (DLR), Galileo Competence Center

2:12. Evaluation of the Galileo/GPS High Accuracy Service (HAS) Performance for Enhanced Navigation Precision, Alexandre Ramos, Nicolas Lelarge, Clément Gazzino, Elodie Bernadotte, CNES; Victor Raviart, THALES SERVICES NUMERIQUES

2:35. PPP Performance Assessment for Galileo HAS Phase 2, Javier Miguez, Filipe De Oliveira Salgueiro, Elena Galletti, Daniel Blonski, Jose Antonio Garcia-Molina, European Space Agency

2:58. Enhanced Precise Point Positioning Using all Operational Satellite-Based SSR Data, Cheng-Wei Wang, National Cheng Kung University; Nobuaki Kubo, Tokyo University of Marine Science and Technology; Shau-Shiun Jan, National Cheng Kung University

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

4:00. Transportation of RTCM3 Data via MQTT in onocoy's Dense and Global GNSS RTK Correction Network, Daniel Ammann, onocoy Association, and Lucy Icking, Paulo Felicio, onocoy Services AG

4:23. High Accuracy GNSS Augmentation With PointPerfect – A New Approach for Enabling Mass Market cm-Level Positioning, Rodrigo Leandro, u-blox

4:46. Ephemeris Error Correction for Improved Differential Navigation and LEO Satellites Tracking, Joe Saroufim, Samer Hayek, and Zak (Zaher) M. Kassas, The Ohio State University

5:08. RTK Performance of the Ultra-low Bandwidth-PLL With Simulated GPS/Galileo L1/L5 Signals and Real-world Urban Signals (TEXCUP), Mohamed Bochkati, Jürgen Dampf, Benedikt Schulz, Thomas Pany; Institute of Space Technology and Space Applications, Space Systems Research Center, University of the Bundeswehr Munich

Alternate Presentations

1. **Spherical Harmonics Ionospheric Modelling, a Lever for Regional and Global High-Accuracy Services,** N. Pérez, J. Durán, L. Martinez, E. Carbonell, A. Chamorro, D. Calle, I. Rodriguez GMV

2. **Improving the Single Point Positioning Accuracy in a Multi-Frequency Context with the Estimation of the Ionosphere Elongation,** Clément Gazzino, Nicolas Lelarge, Centre National d'Etudes Spatiales Alissa Kouraeva, Marion Laymand, CS GROUP

3. **PPP Performance Assessment for Galileo HAS Mobile Users in Different Environments,** Javier Miguez, Filipe De Oliveira Salgueiro, Elena Galletti, Daniel Blonski, Jose Antonio Garcia-Molina, European Space Agency (ESA)

4. **Enabling Metasignal Processing Technology for GNSS Signals for Highly Accurate and Resilient PNT Solution in Harsh Environments,** A. Emmanuele, L. Danelli, A. Ferrario, M. Libertone, L. Scaciga, Thales Alenia Space Italia

Free Time in Exhibit Hall • 5:30 p.m. - 7:00 p.m.

D2: PANEL: Autonomous Navigation for Ground, Seaborne, and Airborne Vehicles
Date: Wednesday, September 18, 2024
Time: 1:45 p.m. - 5:30 p.m.
Room: Holiday Ballroom 6

Session Chairs

Track Chair

Dr. Clark Taylor
Air Force Institute of Technology

Dr. Grace Gao
Stanford University

Dr. Safoora Zaminpardaz
RMIT University

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 uncrewed 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, sea-borne, and airborne vehicles.

Panel Members:

In-Person Presentations
In-Person presentations will be presented live at the conference. Presenters will provide a pre-recorded presentation for on-demand viewing by registered attendees.

1. **Dr. Akshay Shetty,** Robotics Researcher at Supernal for building aerial taxis

2. **Dr. Zak Kassas,** The Ohio State University

3. **Dr. Rajnikant Sharma,** U.S Air Force Institute of Technology

4. **Dr. Sriramya Bhamidipati,** Robotics Technologist at NASA Jet Propulsion Lab for being part of the Mars ingenuity helicopter team, and for building a swarm of robots to explore the Moon surface

5. **Mr. Brandon Jones,** Director of Engineering for Flight Systems at Wing Aviation, an Alphabet Company

6. **Mr. Udam Silva,** Program Manager for the Army Research Lab's (ARL) Artificial Intelligence for Maneuver & Mobility (AIMM) Essential Research Program (ERP), Army Research Laboratory
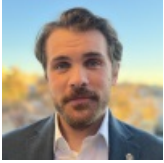
Free Time in Exhibit Hall • 5:30 p.m. - 7:00 p.m.

E2: LEO for Positioning, Navigation, and Timing
Date: Wednesday, September 18, 2024
Time: 1:45 p.m. - 5:30 p.m.
Room: Holiday Ballroom 5

Session Chairs

Track Chair

Dr. Ryan Watson
Xona Space Systems

Dr. Rui Zuo
OneWeb

Byungwoon Park
Sejong University

1:50. Starlink for PNT: A Trick or Treat?, Sharbel Kozhaya and Zak (Zaher) M. Kassas, The Ohio State University

2:12. A New Paradigm of Commercial GNSS Services: The Case for LEO PNT at C-Band, Part 1, Paul Anderson, George Schmitt, Furqan Ahmed, Patrick Shannon, TrustPoint, Inc.

2:35. Xona PULSAR User Performance Assessment, Thyagaraja Marathe, Tyler G.R. Reid, Andrew Neish, Kazuma Gunning, Simon Banville, Xona Space Systems

2:58. High Performance Streamlined On-Board ODTS for LEO-PNT Based on COTS, Carlos Catalán Catalán, Adrián Chamorro Moreno, Jaime Fernández Sánchez, Jesus David Calle Calle, Aitor Aúz Gómez, Carlos Fernández Martín , Andrés Juez Muñoz, GMV

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

4:00. Exploring the Utility of Doppler Shift Measurements for Enhanced GNSS Positioning, Lennon Headlee, Sherman Lo, Todd Walter, Stanford University

4:23. Integrity Monitoring and Augmentation of GNSS from Low Earth Orbit Constellations, Omar Garcia Crespillo, Michael Meurer, German Aerospace Center (DLR), Can Oezmaden, Marius Brachvogel, Chair of Navigation, RWTH Aachen University

4:46. Mixing Real and Simulated Observables to Assess the Performance of Hybrid GNSS/LEO-PNT Precise Positioning, Raul Orus Perez, Miguel Cordero Limon, Pietro Giordano, and Roberto Prieto-Cerdeira, European Space Agency ESA/ESTEC

5:08. HOOC-EM: Fast Beam Sweeping for LEO Mega-Constellation Networks, Samuel C. Morgan and Todd Humphreys, The University of Texas at Austin

Alternate Presentations

1. **A Systematic Approach to LEO-Based PNT Error Source and Performance Analysis,** Ahmad Mouri Sardarabadi, Vincent van der Knaap, Eva Fernandez Rodriguez, Detmer Bosma, Hanno Hildmann, TNO - Netherlands Organization for Applied Scientific Research
2. **Simulation Based Tropospheric Error Estimation Performance Analysis with Low Earth Orbit (LEO) Satellites,** Yunho Cha, Hanwha Aerospace CO., LTD. and Sejong University; Yongrae Jo, Hyunwoo Kim, Byungwoon Park, Sejong University
3. **Doppler Positioning with LEO Satellites Using Unscented Kalman Filter,** Yoji Takayama, Furuno Electric Co., Ltd.; Takateru Urakubo, Kobe University
4. **Implementation and Accuracy of Doppler Navigation with LEO Satellites,** Ariel Baron, Pini Gurfil, Technion, Israel Institute of Technology; Hector Rotstein, Rafael, Advanced Defense Systems Ltd.

On-Demand Presentations

1. **Impact of Gaps in Real-time GNSS Satellite Clocks on LEO Satellite POD,** Kan Wang, National Time Service Center (NTS), Chinese Academy of Sciences (CAS), University of Chinese Academy of Sciences (UCAS), Key Laboratory of Time Reference and Applications; Hang Su, NTS, CAS, Key Laboratory of Time Reference and Applications; Ahmed El-Mowafy, School of Earth and Planetary Sciences, Curtin University; Xuhai Yang, NTS, CAS, UCAS, Key Laboratory of Time Reference and Applications
2. **Proof of Concept of User Segments Technologies for Complementary Low Earth Orbit System,** Rami Ali Ahmad, Romain Crapart, Lea Castel, Simon Naws, Thales Alenia Space France; Miguel Cordero Limon and Enik Shytermeja, European Space Agency

Free Time in Exhibit Hall • 5:30 p.m. - 7:00 p.m.

F2: Atmospheric Effects on GNSS
Date: Wednesday, September 18, 2024
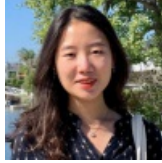**Time:** 1:45 p.m. - 5:30 p.m.
Room: Holiday Ballroom 3

Session Chairs

Track Chair

Dr. Vincenzo Romano
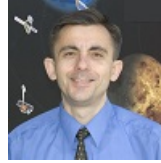*Istituto Nazionale di Geofisica e Vulcanologia*

Hyeyeon (Ann) Chang
University of Colorado Boulder

Dr. Attila Komjathy
Jet Propulsion Laboratory

1:50. A Controlled Experiment on Ionospheric Effects on VHF Signals Transmitted from A NOAA Weather Satellite, Y. Jade Morton, Harrison Bourne, Steve Taylor, University of Colorado Boulder; Chun Yang, QuNav; Madeleine Naudeau, Air Force Research Laboratory

2:12. GNSS Anomaly Detection and Direction of Arrival Estimates of Acoustic-Gravity Waves in the Ionosphere, Fiona Luhrmann and Jihye Park, Oregon State University

2:35. Ionospheric TEC Estimations Using Single-Frequency Wideband Low Elevation GNSS Signals, Madeline C. Evans, Brian Breitsch, and Jade Morton, University of Colorado Boulder

2:58. Characterization of Xona PULSAR-Augmented Ionosphere Tomographic Imaging: A Simulation Study, Susan Skone, Emma Spanswick, University of Calgary; Thyagaraja Marathe, Simon Banville, Bryan Chan, Tyler G. R. Reid, Xona Space Systems

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

4:00. Back Propagation Method for the Determination of the Vertical Location of Ionospheric Irregularities, Carles Quilis Alfonso, Blekinge Institute of Technology; Vinícius Ludwig-Barbosa, Danish Meteorological Institute; Joel Rasch, Anders Carlström, Beyond Gravity Sweden AB; Mats I. Pettersson, Viet Thuy Vu, Blekinge Institute of Technology

4:23. Exploiting the Galileo High Accuracy Service Under Equatorial Ionospheric Scintillation, Haroldo Marques, São Paulo State University (UNESP); Melania Susi, Topcon Positioning System Inc.; Daniele Borio, European Commission, Joint Research Centre; Joao Francisco Galera Monico, São Paulo State University (UNESP); Jihye Park, Oregon State University

4:46. Maintaining High RTK Availability and Accuracy Throughout the Maximum of Solar Cycle 25, Frank Kleijer, Frank Boon, Masoud Arash, Cyrano Vaseur, Septentrio

5:08. Evaluating Amplitude Scintillation Severity in the Early Night Hours Using Fading Coefficients, Victor Di Santis, João Galera Monico, Renan Ruan Sarmento, Alison Moraes, Jonas Sousasantos, Victor Di Santis, Instituto Tecnológico de Aeronáutica, São José dos Campos – SP; João F.G. Monico, Universidade Estadual Paulista Júlio de Mesquita Filho; Alison O. Moraes, Renan R. F. Sarmento, Instituto de Aeronáutica e Espaço, São José dos Campos – SP; Jonas Sousasantos, William B. Hanson Center for Space Sciences, The University of Texas, Dallas

Alternate Presentations

1. **Convolutional Neural Networks for Time Series Classification of Ionospheric Scintillation,** Rubem Vasconcelos Pacelli, Federal University of Ceará (UFC); Angela Aragon-Angel, Adrià Rovira García, Universitat Politècnica de Catalunya; André Lima Ferrer de Almeida, UFC; and Felix Dieter Antreich, Aeronautics Institute of Technology

2. **Enhancing GNSS Positioning Safety Through Overvounding Residual Tropospheric Zenith Delay by LSTM Networks,** Xuejie Hou, Yiping Jiang, Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University

3. **Ionospheric Modeling by Using Self-Organizing Map (SOM) Under the Disturbed Condition,** Kazue Murai, The University of Tokyo; Yuki Sato, Seigo Fujita, Yuichiro Tsukamoto, Rui Hirokawa, Mitsubishi Electric Corporation; Shinichi Nakasuka, The University of Tokyo

On-Demand Presentations

1. **Analysis of GNSS Receiver Tracking during High-Latitude Ionospheric Scintillations,** Andrew Ludwig, and Xiaoqing Pi, Jet Propulsion Laboratory, California Institute of Technology

2. **Global Ionosphere TEC Modeling With A Novel STM-GAN Framework,** Kunlin Yang, School of Instrumentation and Optoelectronic Engineering, Beihang University; Yang Liu, School of Instrumentation and Optoelectronic Engineering, Beihang University, The Abdus Salam International Centre for Theoretical Physics;

3. **Model the Ionospheric Gradients Between Satellites in Network RTK,** Tong Liu, Xiaolong Mi, Yang Yang, Duojie Weng, Wu Chen, The Hong

Kong Polytechnic University

4. **Research on GNSS-R Snow Depth Inversion Based on Deep Learning Method,** Sijia Li, Hang Guo, Hangfei Zhu, School of Information Engineering, Nanchang University; Min Yu, College of Computer Software, Jiangxi Normal University; Jian Xiong, School of Advanced Manufacturing, Nanchang University

5. **Research on Prediction of Heavy Rainfall BasedonBDS-2/3,** Longfei Lv, Hang Guo, School of Information Engineering, Nanchang University; Min Yu, College of Computer Software, Jiangxi Normal University; Jian Xiong, School of Advanced Manufacturing, Nanchang University; Qun Tian, Guangzhou Institute of Tropical and Marine Meteorology; Ting Ni, School of Information Engineering, Nanchang University; Sai Du, Meteorological Bureau of Chenghai; Wenjing Kong, School of Information Engineering, Nanchang University

Free Time in Exhibit Hall • 5:30 p.m. - 7:00 p.m.

A3: PANEL: Emerging Autonomous Application – Challenges and Prospects
Date: Thursday, September 19, 2024
Time: 10:35 a.m. - 12:15 p.m.
Room: Holiday Ballroom 6

Session Chairs

Track Chair

Dr. Dorota Grejner-Brzezinska
University of Wisconsin–Madison

Dr. Allison Kealy
Swinburne University of Technology

Steffen Thoelert
German Aerospace Center (DLR)

Would you trust an autonomous car or uncrewed aerial vehicle to handle your daily commute, make critical decisions, and ensure the safety of you and your family? In this panel, industry and academic experts will discuss the latest developments in self-driving cars, drones, and AI-powered systems, shedding light on opportunities and challenges. They will delve into safety and security enhancements, the most recent technological advancements, and the complex landscape of regulations. Are the technology and regulations sufficiently advanced for the era of autonomous cars and aerial mobility? What is Digital Flight (DF) and what are the challenges and benefits of DF as a new flight operations capability? What about privacy and other ethical concerns in the age of autonomy? Whether you're a tech enthusiast, a forward-thinking entrepreneur, or a policymaker shaping the future, this panel guarantees an exciting exploration of autonomous applications. Don't miss this exhilarating opportunity to stay at the forefront of innovation!

Panel Members:

In-Person Presentations
In-Person presentations will be presented live at the conference. Presenters will provide a pre-recorded presentation for on-demand viewing by registered attendees.

1. **Dr. James L. Farrell,** VIGIL, Inc.

2. **Edward J. Walters,** Chief Strategy Officer, vLex and co-founder of Fastcase; Adjunct Professor, Georgetown Law and Cornell Law School

3. **Prof. Anahid Basiri,** Chair of Geospatial Data Science and Director of Centre for Data Science and AI, University of Glasgow

4. **Mr. Anil 'Neil' Chaudhry,** Senior Advisor, Artificial Intelligence, Highly Automated Systems Safety Center of Excellence (HASS COE), U.S. Department of Transportation

5. **Mr. Simon Reynolds,** Engineering Manager for SouthPan at Geosciences Australia

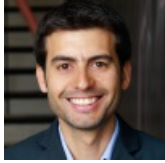12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

B3: Technologies for Scientific and Sectorial Applications
Date: Thursday, September 19, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Peale (1st Floor)

Session Chairs

Dr. Omar García Crespillo
German Aerospace Center (DLR)

Dr. Elisa Gallon
Airbus Defence and Space

Track Chair

Dr. Sudha Vana
Rx Networks

8:35. Towards Integrity Monitoring for GNSS-Based Time Synchronization in Technical Applications, Qianwen Lin, Jingyao Su, Steffen Schön, Institut für Erdmessung, Leibniz Universität Hannover

8:57. G2 System Test Bed: The Forerunner for Real-Time Monitoring of the Future Galileo Timing Service, Gaetano Galluzzo, Santiago Perea, Bernardino Qaranta, ESA-ESTEC; Juan Pablo Boyero, European Commission; Alejandro Leiro, Francisco Javier Sobrero, Cristina García, Adrián García, GMV; Nicola Rana, Erich.Strazzer, Daouda Coulibaly, Thales Alenia Space; Rodi Giovanna Chiara Rodi, Aizoon Group

9:20. First Standard for Galileo Timing Receivers, Héctor Llorca, Javier Fidalgo, Esteban Garbin, Ricardo Píriz, GMV; Javier Bárcena, Alter; Francisco Luis Arribas, UNE; Valeria Catalano, EUSPA; Joaquim Fortuny, Matteo Sgammini, Beatrice Motella, Javier Tegedor, Joint Research Centre, (JRC); Juan Pablo Boyero, European Commission; Tom Willems, European Commission advisor

9:43. European GNSS for UAS Operations: Positioning and Integrity Performance Analysis in Urban Environment, Inmaculada Armengol Moreno, Antonio Ramón Martín Morilla, Ginés Moreno López, Marcos López Cabeceira, GMV; Julia Batista Darias, Estela Guerrero García, FADA-CATEC; Axel Wion, Rik Neirynck, Dennis Heatubun, E&Y; Anna Masutti, RP Legal & Tax; Pietro Nisi, RP Legal & Tax; Carla Bonacci, RP Legal & Tax; Alessandro Bartolini, Logos; Sophie Damy, European Commission, Joint Research Centre, (JRC); Ciro Gioia, External Consultant for the EC/JRC

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

10:40. Study on the Uncertainty Propagation of Feature-Based Visual Navigation for Critical Flight Phases of Urban Air Mobility, Young-Hee Lee and Chen Zhu, Institute of Communications and Navigation, German Aerospace Center (DLR)

11:03. On-Orbit Performance of the TRITON GNSS-R Payload, Jyh-Ching Juang, Department of Electrical Engineering, National Cheng Kung University

11:26. A Near Real-Time Performance Monitoring Dashboard for Galileo and Beyond, B. Röttgers, K. Lutz, Galileo Competence Center, German Aerospace Center (DLR); R. Brydon, L. Spataro, Institute for Software Technology, DLR; W. Dilg, L. Greda, J. Furthner, Galileo Competence Center, DLR

11:48. Validation of Precipitable Water Vapor Products From Fengyun-4A Meteorological Satellite and GNSS Using Radiosonde, Zhikang Fu, Rong Wan, Yang Yu, Jing Ren, Liang Leng, Lingli Zhou, China Meteorological Administration Basin Heavy Rainfall Key Laboratory and Warning Research, Institute of Heavy Rain, China Meteorological Administration & Three Gorges National Climatological Observatory

On-Demand Presentations

1. **3D Water Vapor Tomography Advanced Algorithm by GNSS and 3D-Grid Water Vapor Density Data Assimilated Into the Numerical Model for Rainstorm Forecast,** Rong Wan, Zhikang Fu, Hongli Li, Institute of Heavy Rain, China Meteorological Administration

2. **Evaluation of GNSS Positioning Strategies for e-tolling on Highways,** Vimalkumar Bhandari, Girish Khare, Raksha Rai, Puneet Kumar Agrawal, Kalpesh Kumar Borsadiya, Afjal Das, Ghanshyam J. Doshi, Indian Space Research Organization (ISRO)

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

C3: PANEL: Digital Reality and PNT
Date: Thursday, September 19, 2024
Time: 8:30 a.m. - 10:05 a.m.
Room: Holiday Ballroom 6

Session Chairs   ### Track Chair
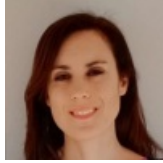

Dr. Charles Toth   **Dr. Valérie Renaudin**   **Dr. Melania Susi**
The Ohio State University   *Université Gustave Eiffel*   *Topcon Positioning System*

Digital reality, including augmented, virtual and mixed reality, is becoming widespread in different fields such as entertainment, sports, health, first responder, autonomous driving, indoor/urban navigation, and space applications. This technology can assist in enhancing perception skills, offering immersive visualization experiences, acquiring visual information from the environment, and identifying obstacles in challenging and dynamic scenarios. Digital information can also be overlayed to a live im-age enhancing the user operation capabilities and decision-making. This panel explores the advancements, opportunities, and challenges of digital reality in relationship to positioning and navigation.

Panel Members:

In-Person Presentations
In-Person presentations will be presented live at the conference. Presenters will provide a pre-recorded presentation for on-demand viewing by registered attendees.

1. **Dr. Todd Humphreys,** Ashley H. Priddy Centennial Professorship in Engineering, The University of Texas at Austin

2. **Dr. Pierre Fite-Georgel,** Niantic Director of Engineering for Augmented Reality (AR) Mapping, Niantic, Inc.

3. **Dr. John Raquet,** Director of IS4S
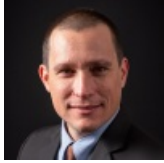
10:05-10:35, Break. Refreshments in Exhibit Hall

D3: GNSS Augmentation and Robustness for Autonomous Navigation (GNSS Integrity Augmentation)
Date: Thursday, September 19, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 4

Session Chairs

Track Chair

Dr. Okuary Osechas
ZHAW – Zurich University of Appl. Sci.

Dr. Yiping Jiang
The Hong Kong Polytechnic University

Dr. Safoora Zaminpardaz
RMIT University

8:35. An Integrity Concept for GNSS-IMU-Tacho Based Train Localization, Carl Milner, Axelle Biale, Ecole Nationale de l'Aviation Civile; Nicolas Mendoza Pila, Elisa Gallon, Airbus Defense and Space; Junesol Song, Suwon University

8:57. GOOSE-VTL: GNSS/INS Deep Coupling with Fault Detection Strategy for Automotive Markets, Katrin Dietmayer, Szu-Jung Wu, Fraunhofer Institute for Integrated Circuits (IIS); Mohamed Bochkati, University of Bundeswehr; Daniel Seybold, TeleOrbit GmbH; Himanshu Gupta, IIS; Thomas Pany, University of Bundeswehr; Inigo Cortés, Matthias Overbeck, IIS

9:20. Jackknife Test for Faulty GNSS Measurements Detection Under Non-Gaussian Noises, Penggao Yan, Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University

9:43. Integrity of PPP-RTK with Regional Slant Ionospheric Grid Model and Error Bounds, Tiantian Tang, Yan Xiang, Sijie Lyu, Ling Pei, Wenxian Yu, Shanghai Jiao Tong University

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

10:40. State Determination in EKF using Singular Value Decomposition for PPP Integrity Monitor System, Yu-Fang Lai, Juan Blanch, Todd Walter, Stanford University

11:03. Intensive Test Campaign for SBAS Service Extension in Equatorial Regions, L. Siniscalco, A. Emmanuele, N. Pastori, R. Colombo, C. Manno, F. Bosia Thales Alenia Space Italia

11:26. Updated Airborne Multipath Models for Dual-Frequency Multi-Constellation GBAS, Maria Caamano, Daniel Gerbeth, Stefano Caizzone, German Aerospace Center, (DLR); Matteo Sgammini, European Commission, Joint Research Centre (JRC)

11:48. Ground Subsystem Error Contribution of a Multi-Constellation GBAS Based on a CORS Network in the Vicinity of Airport Areas, Efren Martin Alban Cuestas, Pornchai Supnithi, Jirapoom Budtho, School of Engineering, King Mongkut's Institute of Technology Ladkrabang; Susumu Saito, Electronic Navigation Research Institute, National Institute of Maritime, Port and Aviation Technology

Alternate Presentations

1. **Effects of GBAS/SBAS Precision Approach Guidance on fuel Consumption and CO2 Emissions,** Michael Felux, Manuel Waltert, Sophie Jochems, Valentin Fischer, Centre for Aviation of the Zurich University of Applied Sciences; Thomas Dautermann, Oliver Meyer, German Aerospace Centre, Institute of Flight Guidance

On-Demand Presentations

1. **Autonomous Railway Track Detection Using Innovative Satellite Signal Map Matching Technique,** Jeffrey Yu, Kirusshanth Thavarajah, Loïc Boyer, Philippe Laviron, Hitachi Rail; Pierre Louvé, SII Group; Sébastien Vichard, Hitachi Rail

2. **Effect of Temporal Correlation on ARAIM, an Analysis on the Number of Effective Samples,** Matteo Sgammini, Sophie Damy, Joint Research Center – European Commission; Juan Pablo Boyero, European Commission; Ettore Canestri, Mikael Mabilleau, EUSPA

3. **Impact of Outlier Monitoring on Confidence Regions: GNSS Positioning Examples,** Safoora Zaminpardaz, School of Science, RMIT University; Peter JG Teunissen, GNSS Research Centre, Curtin University of Technology; Dept. of Geoscience and Remote Sensing, Delft University of Technology, Dept. of Infrastructure Engineering, The University of Melbourne

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

E3a: All-Source Intelligent PNT Methods
Date: Thursday, September 19, 2024
Time: 8:30 a.m. - 10:05 a.m.
Room: Holiday Ballroom 3

Session Chairs

Track Chair

Dr. Francesco Basile
u-blox

Dr. YuXiang (Phillip) Peng
Qualcomm Technologies Inc.

Byungwoon Park
Sejong University

8:35. Reinforcement Learning Framework for Robust Navigation in GNSS Receivers, David Contreras Franco, Iñigo Cortés, Georgios Kontes, Tobias Feigl, Christopher Mutschler, and Alexander Rügamer, Fraunhofer IIS

8:57. Seamless Positioning and Mapping Using an Adaptive GNSS/INS/LIDAR/Wheel Odometry Integration Based on Factor Graph Optimization, Eva Buchmayer, Fabian Theurl, Christoph Schmied, Karin Mascher, Franziska Hübl, Institute of Geodesy, Graz University of Technology

9:20. Closed-Loop Machine Learning for Improved Satellite Orbit Prediction of Noncooperative LEO Satellites, Zak (Zaher) M. Kassas and Samer Hayek, The Ohio State University

9:43. Multi-Sensor PVT Solution for Android Devices using Interacting Multiple Model Filter, Dong-Kyeong Lee, Benon Gattis, Dennis Akos, University of Colorado Boulder

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

Alternate Presentations

1. **Surveying GNSS Carrier Offset Modulations: Investigating Gabor Uncertainty Principle for Precise Time Delay and Frequency Offsets Estimation,** Luca Morichi, Alex Minetto, Andrea Nardin, Fabio Dovis, Department of Electronics and Telecommunications, Politecnico di Torino

On-Demand Presentations

1. **FE-GUT: Factor Graph Optimization Hybrid with Extended Kalman Filter for Tightly Coupled GNSS/UWB Integration,** Qijia Zhao, Department of Precision Instrument, Tsinghua University; Shaolin Lü, State Key Laboratory of Precision Space-time Information Sensing Technology, Tsinghua University; Jianan Lou, Department of Precision Instrument, Tsinghua University; Rong Zhang, State Key Laboratory of Precision Space-time Information Sensing Technology, Tsinghua University

2. **Vehicle Positioning and Integrity Monitoring Based on GNSS/5G/IMU Fusion System in Urban Environments,** Lu Yin, Wenfang Guo, Yuan Sun, Tianzhu Song, Beijing University of Posts and Telecommunications; Qiang Zhang, China Telecommunications Corporation

E3b: Advanced Processing of Terrestrial Signals of Opportunity
Date: Thursday, September 19, 2024
Time: 10:35 a.m. - 12:15 p.m.
Room: Holiday Ballroom 3

Session Chairs   ### Track Chair

Tucker Haydon   **Dr. David W.A. Taylor**   **Byungwoon Park**
Sandia National Labs   *Setter Research, Inc.*   *Sejong University*

10:40. Sub-Meter Hybrid Positioning with Flying 5G Networks and Synchronization Corrections, José A. del Peral-Rosado, Susanne Schlötzer, Esat Ince, Patric Nolle, Airbus Defence and Space; Florian Kaltenberger, Eurecom; Niilo Sirola, Exafore; Stefano Garlaschi, Luca Canzian, Qascom; Ivan Lapin, European Space Agency; Detlef Flachs, Airbus Defence and Space

11:03. Analyzing 5G NR Ranging Capabilities for Aiding Multi-GNSS SPP, Kai-Niklas Baasch, Steffen Schön, Leibniz University Hannover, Institut für Erdmessung (IfE)

11:26. Commercial Radio Phase Difference of Arrival (PDOA) for GNSS-independent PNT – Carrier Phase Results, David W.A. Taylor, Setter Research, Inc.

11:48. Opportunistic Positioning with Beamformed 5G Signals, Shaghayegh Shahcheragh, Justin Kuric, and Zak (Zaher) M. Kassas, The Ohio State University

On-Demand Presentations

1. **Localization with Multidimensional Channel Fingerprints of Multiband Cellular Signals,** Zhinan Hu, Xin Chen, Shande Du, and Qiming Yang, School of Electronic Information and Electrical Engineering, Shanghai Jiao Tong University

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

F3a: Lunar Positioning, Navigation, and Timing
Date: Thursday, September 19, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 1

Session Chairs

Track Chair

Juan Crenshaw
NASA GSFC

Danielle Mortensen
JHU Applied Physics Lab

Dr. Attila Komjathy
Jet Propulsion Laboratory

8:35. Multi-Sensor Fusion and Resilient PVT Techniques for Safe Lunar Landing Missions, Giuseppe Tomasicchio, Luca Andolfi, Marco Brancati, Arsenio Maria Di Donna, Simone Giannattasio, Telespazio S.p.A.; Roberto Del Prete, Luca Ostrogovich, Alfredo Renga, Michele Grassi, Department of Industrial Engineering, University of Naples Federico II; Michele Ceresoli, Stefano Silvestrini, Michèle Lavagna, Aerospace Science and Technology Department, Politecnico di Milano

8:57. High Performance PNT in the Lunar Environment Based on Future LCNS, Ramin Moradi, Steven Kay, Danilo Forte, Matteo De Benedetti, Karl Buckley, Angus Cameron, Jorge Eduardo Martínez Esmeral, Florin-Adrian Stancu, Daniel Betco, GMV; Floor Thomas Melman, Richard Dennis Swinden, Martin Azkarate, Javier Ventura-Traveset, European Space Agency

9:20. Autonomous Navigation of a Lunar Relay Using GNSS and Other Measurements, Ben Ashman, Luke Winternitz, Munther Hassouneh, Sun Hur-Diaz, Nathan Stacey, Andrew Liounis, and Grant Ryden, NASA GSFC

9:43. Modular Power, PNT, and Communication Infrastructure Development Options for Cislunar Space Exploration, Taehwan Kim, Theodore Jaeger, Michael Larsen, Emmanuel Austin, Northrop Grumman Space Systems

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

10:40. Lunar Node – 1: Initial Flight Results and the Role of Surface Psuedolites in Lunar Navigation, Evan Anzalone, Tamara Statham, NASA/MSFC

11:03. Analysis of Orbit Perturbation and Atmospheric Effects for Advanced ODTS Services in Elliptical Lunar Frozen Orbits, Eleonora Antonietti (1), Gabriele Lambiase (1), Andrea Sesta (2), Daniele Durante (2), Carlo Albanese (1), Luciano Iess (2), Filippo Rodriguez (1), Giuseppe Tomasicchio (1). (1) Telespazio S.p.A ; (2) University of Rome – La Sapienza, Rome;

11:26. Markov Decision Processes for Scheduling Lunar PNT Services, Guillem Casadesus Vila and Grace Gao, Stanford University

11:48. Single-Satellite Lunar Navigation via Doppler Shift Observables for the NASA Endurance Mission, Kaila M. Y. Coimbra, Marta Cortinovis, Tara Mina, and Grace Gao, Stanford University

Alternate Presentations

1. **Orbit Determination of Lunar Radio Navigation Satellites Using MEMS Accelerometers and Microwave Tracking,** Luciano Iess and Andrea Sesta, Sapienza University of Rome

2. **Advancing Autonomous Navigation: GNSS-Based Orbit Determination in Deep Space,** Oliviero Vouch, Andrea Nardin, Alex Minetto, Simone Zocca, Fabio Dovis, Department of Electronics and Telecommunications (DET), Politecnico di Torino; Lauren Konitzer, Joel J.K. Parker, Goddard Space Flight Center (GSFC) National Aeronautics and Space Administration (NASA); Fabio Bernardi, Simone Tedesco, Samuele Fantinato, Qascom s.r.l.

3. **E2E LCNS Navigation System Architecture: Overview and Performance Analysis Evaluation,** C. Stallo, M. Marinelli, M. Gotta, TASI; F. Rodriguez, G. Lambiase, C. Albanese, TPZ

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

F3b: GNSS Robustness to Vulnerabilities 1
Date: Thursday, September 19, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 2

Session Chairs

Wim De Wilde
Septentrio

Dr. Sophie Damy
European Commission

Track Chair

Dr. Attila Komjathy
Jet Propulsion Laboratory

8:35. Galileo Signal Authentication Service (SAS), Ignacio Fernandez-Hernandez, Jon Winkel, Cillian O'Driscoll, Gianluca Caparra, Rafael Terris-Gallego, José A. López-Salcedo, Gonzalo Seco-Granados, Beatrice Motella, Daniel Blonski, Javier de Blas, European Commission

8:57. SBAS Data Authentication Scheme on Q-Channel Based on Digital Signatures, Ivan Lapin, Matthew Dibb, Gianluca Caparra, Jaron Samson, Jean-Christophe Denis, European Space Agency; Cyrille Boulanger, Centre National d'Études Spatiales; Mikael Mabilleau, Ettore Canestri, European Union Agency for Space Programme

9:20. Comparison of Methods for the Mitigation of Spoofing Attacks in a Vector Tracking Based Software Receiver Architecture, C. Anderson Givhan & Scott Martin, Auburn University

9:43. Dual-Stage Deep Learning Approach for Efficient Interference Detection and Classification in GNSS, Iman Ebrahimi Mehr, Politecnico di Torino; Outi Savolainen, Laura Ruotsalainen, University of Helsinki; Fabio Dovis, Politecnico di Torino

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

10:40. RFI Detection and Impact Characterization in Various Interference Environments using Low-Cost Receivers, Argyris Kriezis, Yu-Hsuan Chen, Stanford University; Dennis Akos, University of Colorado Boulder; Sherman Lo, Todd Walter, Stanford University

11:03. GNSS Interference Monitoring and Detection Based on the Swedish CORS Network SWEPOS, Kibrom Ebuy Abraha, Anders Frisk, Peter Wiklund, Lantmäteriet, the Swedish mapping, cadastral and land registration authority

11:26. Simultaneous Classification and Searching Method for Jammer Localization in Urban Areas Using KNN-GSA and Ray-tracing, Zhe Yan, Outi Savolainen, Xinhua Tang, Laura Ruotsalainen, Department of Computer Science, University of Helsinki

11:48. A Novel RF Interference Detection and Geolocation Algorithm by LEO Satellites, Tasneem Yousif, Ben Wadsworth, Peter Christopher, Paul Blunt, University of Nottingham

Alternate Presentations

1. **Radio Frequency Interference (RFI) Analysis on GNSS Signals and Effects on Positioning Errors,** Somkit Sophan, Pornchai Supnithi, Lin M. M. Myint, Jirapoom Budtho, School of Engineering, King Mongkut's Institute of Technology Ladkrabang; Susumu Saito, Navigation Systems Department, Electronic Navigation Research Institute, National Institute of Maritime, Port and Aviation Technology

2. **The In-Depth Investigation of Matched-Spectrum Jamming Signals,** Xinhua Tang, Kepeng Luan, Key Laboratory of Micro-inertial Instrument and Advanced Navigation Technology of Ministry of Education, Southeast University; Zhe Yan, Laura Ruotsalainen, University of Helsinki

On-Demand Presentations

1. **A Hybrid Method for Interference Mitigation in GNSS Signals,** Nabeel Ali Khan and Luis Enrique Aguadoa, GMV UK

2. **Assessing GNSS Spoofing Impact on A Safety-Critical Land Transportation Localization Function Within a Cooperative Fleet: An End-Users Focused Experimental Study,** Zaynab El Mawas, CRIStAL Laboratory of University of Lille; Nourdine Ait Tmazirte, COSYS-LEOST of the University of Gustave Eiffel; Cindy Cappelle, Maan El Badaoui El Najjar, University of Lille

3. **Enhanced Tracking with Improved Code Autocorrelation Function via Fractional Fourier Domain,** Yiran Luo, AUROXAT Inc., University of Calgary; Yi-Fen Tseng, AUROXAT Inc.; Naser El-Sheimy, University of Calgary

4. **Galileo Open Service Navigation Message Authentication (OSNMA) Benefits, Challenges, and Limitations,** Ali Pirsiavash, Ali Broumandan, and Sandy Kennedy, Hexagon | NovAtel

5. **MFFNet: Multimodel Feature Fusion Networks for GNSS Interference Identification,** Qiongqiong Jia, Lixin Zhang and Renbiao Wu, Tianjin Key Lab for Advanced Signal Processing, Civil Aviation University of China

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

F3c: Beyond GNSS: Emerging Trends in LEO-Based and Terrestrial Signals of Opportunity for PNT
Date: Thursday, September 19, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 5

Session Chairs

Track Chair

Dr. Zak Kassas
The Ohio State University

Dr. Aurore Sibois
Xona Space Systems

Dr. Attila Komjathy
Jet Propulsion Laboratory

8:35. Comprehensive Assessment of Tropospheric Effects at a Wide Range of Frequencies Transmitted by LEO Satellites, Sonth Neeti, Yu Morton, Satellite Navigation and Sensing (SENSE) Lab at the University of Colorado at Boulder; Scott Logan, LS Consulting and GeoCodex

8:57. On the Integration of Tone-Like Signals-of-Opportunity Within a Geodetic Grade GNSS SDR, Christian A. Lichtenberger, Markel Arizabaleta, Florian Binder, Francis Soualle, Clovis Maia, Thomas Pany, University of the Bundeswehr Munich

9:20. Analogue Beamforming Antenna for Tracking Starlink Constellation, Noori BniLam, Paolo Crosta, ESA/ESTEC; Alessio Curzio, Elisa Sbalchiero, Samuele Fantinato, Qascom; Lionel Tombakdjian, Sophia Antipolis, France Fabien Ferrero, UCA, LEAT

9:43. Analysis of Combining Communication and Navigation Signals for Emerging LEO Constellations, Dominik Dötterböck, Himanshu Sharma, Thomas Pany Universität der Bundeswehr München

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

10:40. Performance Limits for Signals of Opportunity-Based Navigation, Francesco Zanirato, Francesco Ardizzon, Laura Crosara, University of Padova; Alessio Curzio, Luca Canzian, Qascom; Stefano Tomasin, and Nicola Laurenti, University of Padova, CNIT

11:03. Time-Diverse Doppler-Only PNT: Initial Solution, Megan O. Moore, Virginia Tech; Mark Psiaki Virginia Tech, R. Michael Buehrer, Wireless@VT; William C. Headley, Virginia Tech National Security Institute

11:26. LSTM-Driven Prediction of Orbital Parameters for Accurate LEO Opportunistic Navigation, Md Sahat Mahmud, Zihong Zhou and Bing Xu, Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University

11:48. Machine Learning for LEO and MEO Satellite Orbit Prediction, Kannan Selvan, Akpojoto Siemuri, School of Technology and Innovations, University of Vaasa, Finland; Fabricio S. Prol, School of Technology and Innovations, University of Vaasa, Finland, Finnish Geospatial Research Institute, National Land Survey, Finland; Petri Välisuo, School of Technology and Innovations, University of Vaasa, Finland, Heidi Kuusniemi, School of Technology and Innovations, University of Vaasa, Finland, Finnish Geospatial Research Institute, National Land Survey, Finland

Alternate Presentations

1. **Single-Chip Versatile Signal Generator for Navigation,** Sashidharan Manickam, GMV-UK; Rubén Domingo Torrijos, Arturo Pérez García, GMV-ESP; Gokhan Guner, Liji Joy, Ramin Moradi, GMV-UK; Damian Duraj, Lukasz Kulas, Gdansk University of Technology; Francesco Richichi, European Space Agency

2. **Carrier Phase Properties of the Starlink Downlink Signal,** Wenkai Qin, Aerospace Engineering and Engineering Mechanics, The University of Texas at Austin; Zacharias M. Komodromos, Electrical and Computer Engineering, The University of Texas at Austin; Todd E. Humphreys, Aerospace Engineering and Engineering Mechanics, The University of Texas at Austin

12:15 p.m. - 1:15 p.m., Buffet Lunch in Exhibit Hall • 1:15 p.m. - 1:45 p.m., Free Time in Exhibit Hall

A4: Autonomous Applications
Date: Thursday, September 19, 2024
Time: 1:45 p.m. - 5:30 p.m.
Room: Holiday Ballroom 1

Session Chairs		Track Chair
Dr. Li-Ta Hsu	**Laura Norman**	**Steffen Thoelert**
The Hong Kong Polytechnic University	*Hexagon*	*German Aerospace Center (DLR)*

1:50. Fundamental Architectures for High-Integrity Georeferenced Lidar Positioning, Jason H. Rife, Tufts University; Samer Khanafseh and Boris Pervan, Illinois Institute of Technology; Hadi Wassaf, USDOT Volpe Center

2:12. Wrong Association Risk Bounding Using Innovation-Projections for Landmark-Based LiDAR/Inertial Localization, Mathieu Joerger, Virginia Tech, Ali Hassani, Sierra Space, Matthew Spenko, Illinois tech, Jonathan Becker, Virginia Tech

2:35. Self-Supervised Tight Coupling of GNSS with Neural Radiance Field Maps for UAV Navigation, Adyasha Mohanty, Harvey Mudd College, and Grace Gao, Stanford University

2:58. Clock Drift Monitoring Based GNSS Spoofing Detection Method for Autonomous Vehicles, Ziheng Zhou, Hong Li, Yimin Deng, Mingquan Lu, Department of Electronic Engineering, Beijing National Research Center for Information Science and Technology (BNRist), Tsinghua University

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

4:00. Demonstration of a Functionally Safe GNSS/INS Positioning Software Library for Autonomous Land Vehicles, Eduardo Infante, Laura Norman, and Rudi Gaum, Hexagon's Autonomy and Positioning Division

4:23. High-Accuracy and Resilient GNSS Receiver for an Autonomous Vehicle, Filipe Carvalho, Ricardo Prata, Bruno Cardeira, Carlota Cardoso, Rui Nunes, Antonio Fernández, Deimos Engenharia

4:46. Introducing the VMPS: Empowering Automated Driving with Bosch, Markus Langer, Robert Bosch GmbH

5:08. u-Safe: A Holistic Approach to Boost Advanced Driver Assistance Systems, A. González, A. Chamorro, L. Martinez, E. Carbonell, D. Calle, I. Rodriguez, GMV M. Limberger, A. Athmanathan, P. Kalinowski, u-blox, Switzerland

Alternate Presentations

1. **Active Guidance for Cooperative Navigation in a GPS-Denied Environment,** He Bai, Shahbaz P. Qadri Syed, Oklahoma State University, Stillwater; Kevin Brink, Air Force Research Laboratory; Clark Taylor, Air Force Institute of Technology; Ryan Sherrill, Air Force Research Laboratory

B4: Spectrum: Protection and Optimization
Date: Thursday, September 19, 2024
Time: 1:45 p.m. - 5:30 p.m.
Room: Peale (1st Floor)

Session Chairs   Track Chair

Stefan Wallner   **Dr. Zeynep Andreotti**   **Dr. Sudha Vana**
European Space Agency   *Hexagon*   *Rx Networks*

1:50. Assessment of GNSS Jamming on the Border of a XXI Century Conflict, Antonia Ivan, Ileana Mihu, Alexandru Pandele, Mihnea Ion, Marius Trusculescu, Claudiu Cherciu, Romanian InSpace Engineering S.R.L. (RISE); Théotim Hentzien, IPSA

2:12. GNSS Interference Detection and Geolocation from LEO Satellites – Satellite Formation and Payload Design Specific Considerations and Their Impact on the Detection Sensitivity and Geolocation Accuracy, Nikolas Dütsch, Hepzibah Ernest, Thomas Pany, University Bundeswehr Munich; Alberto Prada Campello, Dustin Borheck, Jan Speidel, Hacer Sunay, OHB

2:35. Detection and Localization of Radio Frequency Interference Sources, Valentin Fischer, Sophie Jochems, Michael Felux, Zurich University of Applied Sciences

2:58. GPS Jamming: A Historic Record from Global Radio Occultation Observations, Dong L. Wu, NASA Goddard Space Flight Center; Cornelius Csar, Jude H. Salinas, NASA Goddard Space Flight Center and GESTAR-2 University of Maryland Baltimore

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

4:00. Precise Interference Localization with Commercial GNSS Receiver Modules, Wim De Wilde, Jean-Marie Sleewaegen, Bruno Bougard, Septentrio NV

4:23. GNSS Spoofing Detection and Localization Using ADS-B Data, Zixi Liu, Sherman Lo, Juan Blanch, Todd Walter, Stanford University

4:46. Enhancements and Extensions to a Cyclostationary GNSS Self-Interference Model, Christopher Hegarty, Brady O'Hanlon, The MITRE Corporation

5:08. Implementation and Performance Evaluation of SSC for High-Power GNSS Spoofing Attacks, Zhenyang Wu, Hong Li, Ziheng Zhou, Mingquan Lu, Department of Electronic Engineering, Beijing National Research Center for Information Science and Technology (BNRist), Tsinghua University

Alternate Presentations

1. **Super-Pilots and Flexible Meta-Signals,** J.A. Garcia-Molina, C. Vazquez, Miguel Cordero, European Space Agency (ESA)
2. **GNSS Receiver Test Vector Distribution Methodology,** Brady O'Hanlon, Christian Moomaw, The MITRE Corporation
3. **An FD-DEFLATE Data Compression Scheme for C/N0 Estimation in GNSS Interference Monitoring,** Wenhao Li, Lingtao Wang, Minghan Zhong, Mingquan Lu, Hong Li, Department of Electronic Engineering, Beijing National Research Center for Information Science and Technology (BNRist), Tsinghua University

On-Demand Presentations

1. **GNSS Spoofing Localization with Moving Dual Antennas via Particle Filter,** Hao Wang, Hong Li, Ziheng Zhou, Zhenyang Wu, Mingquan Lu, Department of Electronics, Tsinghua University
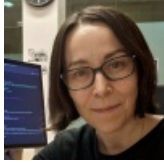
C4: Positioning Technologies and Machine Learning

Date: Thursday, September 19, 2024
Time: 1:45 p.m. - 5:30 p.m.
Room: Holiday Ballroom 2
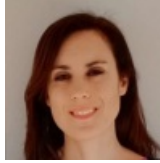
Session Chairs   Track Chair

Kinga Wezka
Warsaw University of Technology

Dr. Tara Mina
Stanford University

Dr. Melania Susi
Topcon Positioning System

1:50. Deep Learning Assisted Kalman Filter for GNSS/MEMS IMU Integration in GNSS Denied Environments, Shuo Li, Bosch, Universität der Bundeswehr München; Thomas Pany, Universität der Bundeswehr München; Maxim Mikhaylov, ETH Zurich; Nikoaly Mikhaylov, Fugro Innovation &Technology

2:12. Artificial Intelligence and Machine Learning for Inertial Measurement Unit Noise Estimation and Denoising, Andrew Isaacson and Garrett Payne, Safran Federal Systems

2:35. AI-Enhanced Smartphone-Based GNSS/INS Integration: Improved Vehicular/Pedestrian Navigation in Challenging Scenarios Using Machine Learning, An-Lin Tao, Yu-Kai Lin, Hau-Hsiang Chan, Li-Min Lin, Pie-Shan Kao, Mediatek Inc.

2:58. Improving Smartphone Positioning by Adapting Measurement Noise Covariance using Machine Learning, Anurag Raghuvanshi, Karolina Tchilinguirova, Soroush Sasani, Sunil Bisnath, York University

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

4:00. Evaluation of (Un-)Supervised Machine Learning Methods for GNSS Interference Classification with Real-World Data Discrepancies, Lucas Heublein, Nisha L. Raichur, Tobias Feigl, Tobias Brieger, Fraunhofer Institute for Integrated Circuits IIS; Fin Heuer, Lennart Asbach, German Aerospace Center (DLR); Alexander Rügamer, Felix Ott, Fraunhofer Institute for Integrated Circuits IIS

4:23. GNSS Positioning Uncertainty Estimation in Challenging Environments Using Voting Ensemble Learning, Ni Zhu, Syed Haseeb Ahmad, Valérie Renaudin, AME-GEOLOC, University Gustave Eiffel

4:46. Reinforcement Learning-Based Optimization of GSHARP PPP for Multipath Mitigation in GNSS Positioning, A. Tena, A. Chamorro, E. Carbonell, D. Calle, GMV

5:08. Real Time Feature Detection and Localization Using a Fisheye Camera, Richard Nyquist, Ryan Raettig, Clark Taylor, Scott Nykl, Autonomy and Navigation (ANT) Center

Alternate Presentations

1. **Enhanced GNSS Multipath Map in Urban Canyon using User Data Clouding,** Yongjun Lee, Byungwoon Park, Sejong University

2. **Deep Learning-Based Transition Detection for Seamless Indoor-Outdoor Localization,** Chanyeong Ju, Jaeho Jang, Jaehyun Yoo, IPIN LABS

On-Demand Presentations

1. **An ORB-Based SLAM Using Deep Learning for Dynamic Environments,** Yiheng Zhao and Hongyang Yu, Research Institute of Electronic Science and Technology, University of Electronic Science and Technology of China(UESTC)

2. **Carrier Phase Availability Classification in Harsh Environment from GNSS Dual-Antenna Low-Cost Receiver Using Machine Learning Models,** Rong Yuan, Xiaowei Cui and Mingquan Lu, Department of Electronic Engineering, Tsinghua University; Zhenya Li, Huayuen Technology Co. Ltd; Zhenni Li, School of Automation, Guangdong University of Technology

3. **Enhancing GNSS Positioning Using Transformer-Based Correction Network,** Changyi Zhu, Yan Na, Xidian University; Xueyong Xu, Dingcheng Wu, Kefan Wei, North Information Control Research Academy Group CO., LTD; Cheng Ji, Nanjing University of Science and Technology

4. **Performance Analysis of Spoofing Detection Methods Based on Neural Networks,** Muhammad Jalal, Chao Sun, Shuai Zhang, Lu Bai, ZiChao Qin, An Wang, Yingzhe He, Beihang University

5. **Potential Problem Analysis and RF-Based Improvement of RPM on Android Devices,** Min He, Hong Li, Hao Wang, and Mingquan Lu, Department of Electronic Engineering, Tsinghua University

D4: Robust Navigation Using Alternative Navigation Sensors and Solutions
Date: Thursday, September 19, 2024
Time: 1:45 p.m. - 5:30 p.m.
Room: Holiday Ballroom 4

Session Chairs

Track Chair

Dr. Samer Khanafseh
Illinois Institute of Technology

Dr. Jason N. Gross
West Virginia University

Dr. Safoora Zaminpardaz
RMIT University

1:50. Position Uncertainty Reduction in Visual-Inertial Navigation Systems using Multi-ML Error Compensation, Tarafder Elmi Tabassum, Ivan Petrunin, Zeeshan A. Rana, Cranfield University

2:12. Certifiability Analysis of the Global Optimality in Camera-Based Positioning with SEC-PnP Algorithm, Antonino Triolo, Chen Zhu, Institute of Communications and Navigation, German Aerospace Center (DLR); Michael Meurer, DLR & Chair of Navigation, RWTH Aachen University

2:35. Characterizing Lidar Point-Cloud Adversities Using a Vector Field Visualization, Daniel Choate and Jason H. Rife, Tufts University

2:58. Bayesian Overbounding Filter Using Gaussian-Pareto Distributions, Yingjie Hu, University of Minnesota, Twin Cities

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

4:00. Towards Navigation with Non-Cooperative LEO Satellites: Resolving Spatiotemporal Errors, Samer Hayek, Joe Saroufim, and Zak (Zaher) M. Kassas, The Ohio State University

4:23. IEEE Working Group for Resilient User Equipment in Positioning, Navigation, and Timing (P1952), Cristina Seibert, NextNav LLC; Shelby Savage, Patricia Larkoski, and Steve Bedrosian, Homeland Security Systems Engineering & Development Institute (HSSEDI) operated by The MITRE Corporation; Douglas Arnold, Meinberg USA; David Sohn, Safran; Marc Weiss, Marc Weiss Consulting; Pat Diamond, Diamond Consulting; Mitch Narins, Strategic Synergies; Magnus Danielson, Net Insight.

4:46. Incrementally Smoothed Radio SLAM: A Factor Graph Approach to Opportunistic Radio Navigation, Matt Boler, Connor Brashar, Sandia National Labs; Scott Martin, Auburn University

5:08. Reliable Overbounding for Stochastic IMU Error Models Using Interval Analysis, Jingyao Su, Steffen Schön, Leibniz University Hannover; Elisa Gallon, Airbus Space and Defense

Alternate Presentations

1. **UWB-Aided Hybrid Navigation System in Degraded GNSS Environments,** Sorin Andrei Negru, Patrick Geragersian, Ivan Petrunin, Weisi Guo, Cranfield University
2. **Hybrid Camera-Lidar Trilateration with Lens Distortion Correction,** Travis W. Moleski and Jay P. Wilhelm, Ohio University

E4a: Accurate GNSS Navigation in Challenging Environments
Date: Thursday, September 19, 2024
Time: 1:45 p.m. - 5:30 p.m.
Room: Holiday Ballroom 5

Session Chairs

Track Chair

Dr. Nobuaki Kubo
Tokyo University of Marine Science and Technology

Dr. Jungbeom Kim
Samsung Inc.

Byungwoon Park
Sejong University

1:50. Why Some Cycle Slip Detection Methods do not Work for Smartphones: Investigation, Explanation and Solutions, Jiahuan Hu, York University

2:12. A Deep Learning Approach for the Classification of Multipath Ranging Errors in Challenging Urban Environments, Christian Phillips, Department of Geomatics Engineering, University of Calgary; Ali Broumandan, Hexagon's Autonomy & Positioning Division; Kyle O'Keefe, Department of Geomatics Engineering, University of Calgary

2:35. Single Difference Code-Based Technique for Direct Position Estimation, Shuo Tang, Dept. of Electrical and Computer Engineering, Northeastern University; Haoqing Li, Department of Geomatics Engineering, University of Calgary; Pau Closas, Dept. of Electrical and Computer Engineering, Northeastern University

2:58. Application of Adaptive Kalman Filtering on Smartphone Positioning, Naman Agarwal, Kyle O'Keefe, Department of Geomatics Engineering, University of Calgary

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

4:00. A State-Based Method to Jointly Estimate Code Delay and Carrier Phase of Short Segment GNSS Signals Using Complex Waveforms from Open-Loop Tracking: A Simulation Study, Jiawei Xu and Y. Jade Morton, University of Colorado Boulder

4:23. Data-Driven Stochastic Modeling of Dual-Frequency GNSS Measurements using Cycle Slip Parameter Variance, Brian Weaver, Oregon State University

4:46. Real-Time Multipath Mitigation with Sensor-Aided Long Coherent Integration (SALI), Zhenlan Cheng, Maxim Koehler, Alessandro Biason, Robert Lluis Garcia, Gregor Dumphart, Konstantinos Arkoudogiannis, Christian Bischof, Duarte Dias, Sebastian Carreno, u-blox AG

5:08. AutoW: Self-Supervision Learning for Weighting Estimation in GNSS Positioning, Penghui Xu and Li-Ta Hsu, Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University

Alternate Presentations

1. **A GPS/Galileo/Beidou Satellite Navigation Software-Defined Radio Receiver for Long-Coherent Snapshot Positioning,** Chin Lok Tsang, Yiran Luo, Li-Ta Hsu, The Hong Kong Polytechnic University

On-Demand Presentations

1. **Improving GNSS Positioning Using Deep Reinforcement Learning with Self-Supervised Learning Based Data Augmentation,** Peili Li, Zhenni Li, Kexian Hou, Jianhao Tang, Shengli Xie, Guangdong University of Technology

E4b: Smartphone Decimeter Challenge (Co-sponsored by Google)
Date: Thursday, September 19, 2024
Time: 1:45 p.m. - 5:30 p.m.
Room: Holiday Ballroom 3

Session Chairs   ### Track Chair

Dr. Michael Fu   **Dr. Frank van Diggelen**   **Byungwoon Park**
Google Inc.   *Google Inc.*   *Sejong University*

[Read more about the Smartphone Decimeter Challenge (Sponsored by Google) here.](#)

1:50. Enhanced Smartphone Positioning in Urban Environments: GNSS Fault Detection and Mitigation through Integrated Navigation System, Jeonghyeon Yun, Byungwoon Park, Sejong University

2:12. DGNSS Corrected Pseudorange and Time-Differenced Carrier Phase Measurements Using Differentiable Factor Graph Optimization (DFGO), Hoi-Fung Ng, Penghui Xu, Yihan Zhong, Guohao Zhang, Weisong Wen, Li-Ta Hsu, Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University

2:35. Application of the Galileo High Accuracy Service Reference User Algorithm to Smartphone Positioning, Zoccarato Paolo, Menzione Francesco, Joint Research Centre of the European Commission; Gioia Ciro, External Consultant at the EC Joint Research Centre

2:58. Integration of SVM-Based NLOS Classification and Solution-Separation Test for Accurate Smartphone RTK and PPP-RTK Positioning in Dense Urban Areas, Yang Jiang, Zhitao Lyu, Yan Zhang, Yang Gao, University of Calgary

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

4:00. Optimal Robust Positioning Using Factor Graph, Akpojoto Siemuri, Elham Ahmadi, Mahmoud Elsanhoury, Kannan Selvan, Petri Välisuo, Heidi Kuusniemi, Mohammed S. Elmusrati, School of Technology and Innovations, University of Vaasa; Heidi Kuusniemi, Finnish Geospatial Research Institute, National Land Survey

4:23. Third Place Winner of the Smartphone Decimeter Challenge: Improving Smartphone Accuracy with a Two-step Accurate Velocity Estimation, Jeonghyeon Yun, Suyeol Kim, Taejin Youn, Gyeongmin Kim, Wonwoo Park, Byungwoon Park, Sejong University

4:46. Second Place Winner of the Smartphone Decimeter Challenge: An Open-Source Factor Graph Optimization Package for GNSS and IMU Integration in Smartphones, Taro Suzuki, Chiba Institute of Technology

5:08. First Place Winner of the Smartphone Decimeter Challenge: Optimized GNSS/INS Integration Approach for Smartphone Positioning, Norizumi Motooka, Mitsubishi Electric Corporation

Alternate Presentations

1. **Empirical Noise Modeling of Android GNSS Using Machine Learning for PVT Improvement,** Dong-Kyeong Lee and Dennis Akos, University of Colorado Boulder

F4: PANEL: International Civilian Agency Lunar PNT Systems
Date: Thursday, September 19, 2024
Time: 1:45 p.m. - 5:30 p.m.
Room: Holiday Ballroom 6

Session Chairs

Track Chair

Dr. Masaya Murata
Japan Aerospace Exploration Agency

Dr. Cosimo Stallo
Thales Alenia Space Italia S.p.A.

Dr. Attila Komjathy
Jet Propulsion Laboratory

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. Our panel of experts will describe these technologies, emerging trends, international collaborations and expected outcomes.

Panel Members:

In-Person Presentations
In-Person presentations will be presented live at the conference. Presenters will provide a pre-recorded presentation for on-demand viewing by registered attendees.

1. **Dr. Javier Ventura-Traveset,** European Space Agency (ESA)

2. **Mr. Juan M. Crenshaw,** National Aeronautics and Space Administration (NASA)

3. **Dr. Masaya Murata,** Japan Aerospace Exploration Agency (JAXA)

4. **Dr. Cosimo Stallo,** Thales Alenia Space

5. **Dr. Mauro Cardone,** Italian Space Agency (ASI)

6. **Ms. S. Nirmala,** UR Rao Satellite Centre, ISRO

7. **Dr. Jungmin Joo,** Korea Aerospace Research Institute (KARI)

A5: Aviation and Aeronautics
Date: Friday, September 20, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 1

Session Chairs

Track Chair

Dr. Maria Caamano Albuerne
German Aerospace Center (DLR)

Dr. Sam Pullen
Stanford University

Steffen Thoelert
German Aerospace Center (DLR)

8:35. Real-Time Characterization of the Collins GNSS RFI Mitigation Techniques in Flight and Lab Environments, Angelo Joseph, Joseph Griggs, Vikram Malhotra, George Cook, Bernard Schnaufer, and Huan Phan, Collins Aerospace

8:57. Update on Galileo Performance Characterization and Integrity Support Message Definition for H-ARAIM, S. Perea, S. Wallner, The European Space Agency; A. Lemke, M. Odriozola, Airbus Defense and Space GmbH; F. Belmonte, Deimos Space, Madrid, Spain M. Sgammini, J.P. Boyero, European Commission; E. Canestri, European Union Agency for the Space Programme

9:20. Advancements in DFMC SBAS Techniques for CAT II Autoland, Antoine Plainard, Thomas Fuhrmann, Nicolás Mendoza Pila, Keerthi Narayana, Airbus Defence and Space; Jaron Samson, European Space Agency

9:43. Enhancing GAST D Availability by Using the Ionospheric Field Monitor, Susumu Saito, Takayuki Yoshihara, ENRI, MPAT

10:05-10:35, Break. Refreshments served outside of session rooms

10:40. Impact of Onboard Meaconers on Aircraft GNSS Receivers, Mathieu Hussong, Emile Ghizzo, Carl Milner, Axel Garcia-Pena, Julien Lesouple, Fédération ENAC ISAE-SUPAERO ONERA, Université de Toulouse

11:03. Predictive Analysis of GNSS Signal Reception on Aircraft Amid In-Flight Jamming, Veenu Tripathi and Stefano Caizzone, Institute of Communications and Navigation, German Aerospace Center (DLR)

11:26. Characterization of Anomalies in Reported Aviation ADS-B Data from GPS Interference, Wayne W. Cooper, Ralf H. Mayer, The MITRE Corporation; Timothy S. Wallace, Federal Aviation Administration; Rick Niles, The MITRE Corporation

11:48. Identification and Analysis of GNSS Spoofing Using ADS-B Data, Benoit Figuet, Okuary Osechas, Michael Felux, ZHAW

Alternate Presentations

1. **FAA - Challenges or Integration of Newer Operations into the National Airspace System (NAS),** Sally Frodge, Jennifer Kandel, Joel Cavaros, Jason Brez, Federal Aviation Administration (FAA) Air Traffic Organization (ATO) Strategy
2. **Integrating Open-Source ADS-B and GNSS Data for a Comprehensive Assessment of Recent Aviation Navigation Disruptions Over Europe,** Javier Tegedor, European Commission JRC; Ciro Gioa, External consultant; Joaquim Fortuny-Guasch, Matteo Paonni, European Commission JRC
3. **UKSBAS Testbed: A Comprehensive Performance Review Over two Years of Operations,** Javier González Merino, Fernando Bravo Llano, Madeleine Easom, Juan Ramón Campano Hernández, Ignacio Sainz Palomar, GMV; David Hill, Viasat George Newton, Viasat

On-Demand Presentations

1. **Evaluating Embedded GPS for Next-Gen Flight Computers With Hybrid Neural Networks,** Gokul Nathan and Sep Makhsous, Electrical and Computer Engineering, University of Washington

Awards Luncheon • 12:15 p.m. - 1:30 p.m. • Lunch served until 12:30 p.m.; late arrivals will not be served.

B5: Trends in Future Satellite Navigation Technology, System Design and Development
Date: Friday, September 20, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 5

Session Chairs   Track Chair

Dr. Vijaykumar Bellad   **Tim Murphy**   **Dr. Sudha Vana**
Rx Networks   *Boeing*   *Rx Networks*

8:35. System and Service Volume Simulation Environment (S^{2}VSE), Sebastian Bernhardt, Florian Eiselbrecher, Andreas Schmidt, German Aerospace Center (DLR) Galileo Competence Center

8:57. Comparison of Different Parametrizations to Minimize the Ephemeris Fitting Error for LEO Satellites, Carlos Gómez, Aitor Auz, Adrián Monreal, Alejandro Muñoz, Carlos Catalán, Andrés Juez, GMV

9:20. New Generation of PNT User Terminals Exploiting Hybridization with LEO Constellations, Francis Soualle, Markel Arizabaleta, Christian Lichtenberger, Thomas Pany, University of the Bundeswehr Munich; Jose A. del Peral-Rosado, Xavier De Vaucorbeil, Gabriele Ligorio, Airbus Defence and Space GmbH; Luca Canzian, Federica Rozzi, Marco Rotoloni, Stefano Garlaschi, Qascom; Francesco Menzione, Ottavio Picchi, Juan Pablo Boyero, European Commission

9:43. Verification of Two-Way Time Transfer Accuracy Through a Closed-Loop Topology of Inter-Satellite and Ground-Satellite Optical Links, Manuele Dassié, German Aerospace Center (DLR), Technical University of Berlin (TUB); Gabriele Giorgi, and Grzegorz Michalak, DLR

10:05-10:35, Break. Refreshments served outside of session rooms

10:40. All-in-one High-Accuracy Service for Both PPP-AR and RTK Techniques, L. Martínez, L. Pinilla, A. Souto, E. Carbonell, A. Chamorro, G. Tobías, D. Calle, I. Rodríguez, GMV

11:03. Large-Scale GNSS Spreading Code Optimization, Alan Yang, Tara Mina, Stephen Boyd, and Grace Gao, Stanford University

11:26. Optimized Multilevel CDMA Chip Design With Respect to Payload and User Constraints, Florian C. Beck, German Aerospace Center (DLR) & RWTH Aachen University; Christoph Enneking, DLR; Steffen Thölert, and Michael Meurer, DLR & RWTH Aachen University

11:48. The Galileo Open Service Navigation Message Authentication (OSNMA): The Pioneer Data Authentication Service, Javier Simon, Tomas Rodriguez, Andrea Scorzolini, Philippe da Silva, Flavio Sbardellati, EUSPA; Ignacio Fernandez-Hernandez, European Commission; Sophie Damy, European Commission; David Ibanez, European Space Agency

Alternate Presentations

1. **Unveiling the use of a Cloud-Native Architecture for Galileo G2 Monitoring and Prototyping: The G2STB Case,** Jorge Rocamora, Daniel Rodriguez , Alejandro Leiro, Francisco Javier Sobrero, Cristina García, Adrián García, GMV; Gaetano Galluzzo, Simona Circiu, Santiago Perea, Andrea Melara, Javier Miguez, Gustavo Lopez, ESA-ESTEC

Awards Luncheon • 12:15 p.m. - 1:30 p.m. • Lunch served until 12:30 p.m.; late arrivals will not be served.

C5: Navigation and Positioning
Date: Friday, September 20, 2024
Time: 8:30 a.m. - 12:15 p.m.
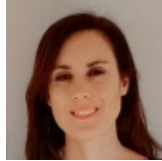**Room:** Holiday Ballroom 2

Session Chairs

Dr. João Francisco Galera Monico
São Paulo State University (UNESP)

Dr. Heidi Kuusniemi
University of Vaasa

Track Chair

Dr. Melania Susi
Topcon Positioning System

8:35. A Novel Height Estimation Approach Considering Barometer Sensors for 3D Indoor Positioning, Philipp Hager, Susanna Kaiser, and Christian Gentner, German Aerospace Center (DLR)

8:57. Observability and Estimability Analysis of an Error State Multi-Sensor Navigation Filter Using Numerical Observability Methods, Nicolai Ben Weddig and Steffen Schön, Leibniz Universität Hannover, Institut für Erdmessung

9:20. NAVFEST – 20 Years of Cost-Effective GPS NAVWAR Testing, Geneva Quinn, Nicholas George, Raymond Johnson, Orlando Padilla, Sean Abrahamson, and Kalyn Jones, 746th Test Squadron

9:43. Unlocking Precision: Implementation and Evaluation of UWB-Based Indoor Positioning System on iPhones, Tomoaki Takewa, Jin Matsuoka, Mitsubishi Electric Corporation

10:05-10:35, Break. Refreshments served outside of session rooms

10:40. A GNSS Navigation Filter Based on Maximum Correntropy Criterion with Variational Bayesian for Robustness and Adaptivity, Dah-Jing Jwo and Yi Chang, National Taiwan Ocean University

11:03. VALLE - Privacy Preserving PNT Processing Techniques Concept Demonstrator, Andra Mihaela Sararu, Florin Mistrapau, Vlad Gabriel Olteanu, GMV RO; Daniel Hurtado Ramirez, GMV ES; Sepideh Rahimian, Inmaculada Perea Fernandez, Jedrzej Mosiezny, Miguel Tejedor Munoz, Max Hering, GMV DE; Alexandru Budianu, European Space Agency

11:26. UWB RTL System Development for Multipath Environment and Field Test Results, Dinesh Manandhar, Center for Spatial Information Science, The University of Tokyo; Wataru Ohira, LocationMind Inc.; Ryosuke Shibasaki, Reitaku University

11:48. High-Precision GNSS Augmented by data-driven NLOS Detection with Fisheye Cameras, Jianghui Geng, Innovation Academy for Precision Measurement Science and Technology, Chinese Academy of Sciences; Feng Wang, GNSS Research Center, Wuhan University

11:48. Magnetic Calibration for Navigation Interpretation and Applicability, Brandon Blakely, Jonnathan Bonifaz, and Aaron Nielsen, AFIT/ANT Center

Alternate Presentations

1. **Robust GNSS Positioning Based on Data Association in NLOS Environment,** Qiongqiong Jia, Yueying Zhou and Renbiao Wu, Tianjin Key Lab for Advanced Signal Processing, Civil Aviation University of China
2. **Deep Learning-Based Wi-Fi Signal Fingerprinting Indoor Positioning Technology,** JinLong Li, Jiabin Dong, Lila Rana, Jun Gyu Hwang, Ryu Hosung,Joon Goo Park, Kyungpook National University

On-Demand Presentations

1. **Design, Implementation and Performance Analysis of Dual-Constellation Vector Receiver Using Combinations of GPS L1 and BDS B1C Signals,** Qiongqiong Jia, Hongjin Chen, Tianjin Key Lab for Advanced Signal Processing, Civil Aviation University of China
2. **Inertial Navigation Using Low-Cost Sensors,** Patrick Grates, Arizona State University
3. **Performance Analysis of 5G Positioning Based on Uplink-SRS Signal and Downlink-PRS Signal,** Syed Shahid Shah, Chao Sun, Yingzhe He, Lu Bai, Xin Wen, Shuai Zhang, Beihang University

Awards Luncheon • 12:15 p.m. - 1:30 p.m. • Lunch served until 12:30 p.m.; late arrivals will not be served.

D5: Indoor and Urban Navigation and Mapping
Date: Friday, September 20, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 4

Session Chairs   Track Chair

Dr. Guohao Zhang
The Hong Kong Polytechnic University

Dr. Chi-Shih (Chico) Jao
Apple

Dr. Safoora Zaminpardaz
RMIT University

8:35. WiFi-RTT Posterity SLAM for Pedestrian Navigation in Indoor Environments, Khalil Jibran Raja and Paul D. Groves, University College London

8:57. Hybrid Multipath Assisted Positioning and Fingerprinting using Transformer Models, Markus Ulmschneider, Christian Gentner, Armin Dammann, German Aerospace Center (DLR)

9:20. Smartphone HD Map Updates Using Monocular-Inertial ORB-SLAM3 and Gaussian Splatting, Rhea Joyce Zambra, Saurav Uprety, Raymond Lee, and Hongzhou Yang, Department of Geomatics Engineering, University of Calgary

9:43. Opportunistic Navigation with On-Demand 5G Downlink Signals, Faezeh Mooseli, Sharbel Kozhaya, and Zak (Zaher) M. Kassas, The Ohio State University

10:05-10:35, Break. Refreshments served outside of session rooms

10:40. Deep Learning Multipath Error Estimation for 3DMA-Based Positioning Algorithm in High Dynamics Environments, Nesreen I. Ziedan, Faculty of Engineering, Zagazig University

11:03. 3DMA GNSS Positioning with Multipath Signals in Urban Areas: Methodology and Preliminary Results, Mingda Ye, Guohao Zhang, and Li-Ta Hsu, Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University

11:26. GNSS Measurement Performance in Vegetation Environments: Assessment and Analysis in Signal Processing Level, Di Hai, Chin Lok Tsang, Guohao Zhang and Li-Ta Hsu, Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University

11:48. Enhanced Urban Localization Techniques Using GraphSLAM: Precision Improvements for Pedestrian and Underground Scenarios, Aicha Karite, Christian Gentner and Susanna Kaiser, Institute of Communications and Navigation, German Aerospace Center (DLR)

Alternate Presentations

1. **Performance Evaluation of Kinematic Doppler Positioning with LEO Satellites in Urban Environments,** Yoji Takayama, Furuno Electric Co., Ltd.; Takateru Urakubo, Kobe University

2. **Indoor Localization Based on PDR and Signals of Opportunity from Ambient Generic BLE Devices,** Masakatsu Kourogi, Akihiro Sato, Ryosuke Ichikari, Satoki Ogiso, Takashi Okuma, National Institute of Advanced Industrial Science and Technology

Awards Luncheon • 12:15 p.m. - 1:30 p.m. • Lunch served until 12:30 p.m.; late arrivals will not be served.

E5: PANEL: Algorithms and Methods for GNSS Cyber Physical Security
Date: Friday, September 20, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 6

Session Chairs		Track Chair
Dr. Joe J. Rushanan	**Dr. Sherman Lo**	**Byungwoon Park**
The MITRE Corporation	*Stanford University*	*Sejong University*

Networked or cooperative applications of GNSS have become pervasive in low-cost devices such as smart-phones, wearables, and geolocated Internet of Things (IoT) devices, and similar uses are rapidly being adopted in aerial and automotive settings. There are security opportunities that can come with the use of PNT with networked connectivity and centralized large-network processing; in the development of cyber-physical institutions for sensor certification, fraud prevention, and cooperative use of network resources. It also can come with risks such as when used with heterogeneous and potentially untrustworthy sources of data for inference. What new security benefits and challenges will arise in networked deployments of PNT technology for IoT, aerial, and vehicular applications? And what are the right strategies or methods to ensure cyber physical security?

Panel Members:

In-Person Presentations
In-Person presentations will be presented live at the conference. Presenters will provide a pre-recorded presentation for on-demand viewing by registered attendees.

1. **Dr. Steven Lewis,** The Aerospace Corporation
2. **Dr. Andrew Hansen,** Department of Transportation
3. **Mr. Magnus Danielson,** Net Insight AB
4. **Eric Lam,** Air Force Research Laboratory

Awards Luncheon • 12:15 p.m. - 1:30 p.m. • Lunch served until 12:30 p.m.; late arrivals will not be served.

F5: Remote Sensing, Timing, Space and Scientific Applications
Date: Friday, September 20, 2024
Time: 8:30 a.m. - 12:15 p.m.
Room: Holiday Ballroom 3

Session Chairs

Track Chair

Dr. Andria Bilich
National Geodetic Survey/NOS/NOAA

Fiona Luhrmann
Oregon State University

Dr. Attila Komjathy
Jet Propulsion Laboratory

8:35. ISCO: Algorithms for Space GNSS Guaranteed Positioning: Integrity for Space Corridor, Danilo Forte, Ramin Moradi, Jack Daniel McHugh, Ginés Moreno López, Jaime Fernández Sánchez, Diego Ramirez Rodriguez, Jorge Eduardo Martínez Esmeral, Arkadiusz Groth, Marc Fernández Usón, Jiachen Yin, GMV; Filipe De Oliveira Salgueiro, European Space Agency

8:57. A System Concept Study for GNSS/LEO-PNT-Reflectometry in Low Earth Orbit, Juan M. Parro-Jimenez, Raul Orus-Perez, Maria Paola Clarizia, Nicolas Floury, European Space Agency

9:20. Mapping the Mean Surface Gradient of Lake Ladoga with Spire CubeSats GNSS-R Measurement, Yang Wang, Smead Department of Aerospace Engineering Sciences, University of Colorado Boulder, J. Toby Minear, Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder

9:43. First (Reflected) Light: GNSS Reflectometry at the McMurdo Ice Shelf, Seebany Datta-Barua, Illinois Institute of Technology; Alison F. Banwell, University of Colorado Boulder; Arthur Baverel, Christian Allen, Roohollah Parvizi, Alec Weedman, Logan Garcia, Illinois Institute of Technology; and Kristine Larson, University of Colorado Boulder

10:05-10:35, Break. Refreshments served outside of session rooms

10:40. Modeling Variations in GNSS Precise Frequency Transfer: Focus on Troposphere Effects, Ahmed Elmaghraby, Steffen Schön, Leibniz University Hannover, Institute für Erdmessung

11:03. Method Research on PWV Prediction Model and Threshold-Based Precipitation Forecasting Based on Long and Short-Term Memory Neural Networks, Li Li, Li Kai, School of Geographical Science and Geomatics Engineering, Suzhou University of Science and Technology, Research Center of BeiDou Navigation and Environmental Remote Sensing, Suzhou University of Science and Technology

11:26. Multi-Frequency Kalman Filter Carrier Phase Tracking for Ionospheric Scintillation Mitigation and Monitoring, Rodrigo de Lima Florindo and Felix Dieter Antreich, Aeronautics Institute of Technology (ITA)

11:48. Accuracy Analysis of Error Compensation of BDS Broadcast Ionospheric Model Based on ABC-BP Neural Network, Xing Su, College of Geodesy and Geomatics, Shandong University of Science and Technology; Qiang Li, GNSS Research Center, Wuhan University; Zhimin Liu, College of Geodesy and Geomatics, Shandong University of Science and Technology

Alternate Presentations

1. **Evaluating Interchannel Biases of Spire Grazing Angle GNSS Reflectometry Cubesats for Altimetry Applications,** Jiahua Zhang, Jan-Peter Weiss, John Braun, UCAR

2. **Preliminary Design and Validation of the Navigation Framework for Albedo's VLEO Constellation,** Ryan Watson and Kevin Kloster, Albedo Space

On-Demand Presentations

1. **Lightweight Remote Sensing Image Small Object Detection Based on REM-YOLO,** Xin Yan, Dong Zhou, Dan Tian, Wenshaui Zhang, University of Electronic Science and Technology of China

2. **The Galileo Timing Receiver: Definition of Requirements and Related Test Procedures in Support of Standardization,** Matteo Sgammini, Javier Tegedor, Ciro Giogia, Joint Research Center – European Commission; Juan Pablo Boyero, European Commission

Awards Luncheon • 12:15 p.m. - 1:30 p.m. • Lunch served until 12:30 p.m.; late arrivals will not be served.

A6a: Augmentation Services, Integrity, and Authentication 2
Date: Friday, September 20, 2024
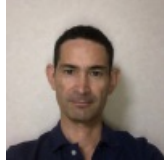**Time:** 1:45 p.m. - 3:20 p.m.
Room: Holiday Ballroom 1

Session Chairs

Dr. Thomas Pany
University of the Bundeswehr, Munich

Dr. Rui Hirokawa
Mitsubishi Electric Corporation

Track Chair

Steffen Thoelert
German Aerospace Center (DLR)

1:50. SBAS Authentication Standards, Jed Dennis, Tetra Tech Inc; Todd Walter, Jason Anderson, Stanford University; Ignacio Fernandez-Hernandez, European Commission; Ettore Canestri, Mikael Mabilleau, EUSPA; Eric Châtre, European Commission

2:12. GNSS Augmentation Satellite System (GAUSS), Thomas Zechel, Omar Garcia-Crespillo, Grzergorz Michalak, Matthias Simon, Tobias D. Schmidt, Gabriele Giorgi, German Aerospace Center – Institute of Communications and Navigation; Michael Meurer, DRL & RWTH Aachen University, Chair of Navigation; Jean-Jacques Wasbauer, Clément Gazzino, Francois Dufour, Alexandre Ramos, Centre National d'Etudes Spatiales

2:35. TESLA Chimera Discrete Event Simulation for GPS Authentication, James Gillis, Rachel Allen, The Aerospace Corporation

2:58. User Level Demonstrations of the UKSBAS Testbed, Javier González Merino, Michael Pattinson, Madeleine Easom, María Romero Llapa, Sangeetha Priya Ilamparithi, GMV; David Hill, George Newton, Viasat

Alternate Presentations

1. **Application of u-blox SPARTN Corrections in RTKLib,** Sandesh Mishra, Jiahuan Hu, Sunil Bisnath, York University; Rodrigo Leandro, Michael Albright, u-blox
2. **Stochastic Uncertainty Modeling of Network RTK Correction Residuals for Network External Users,** Yebin Lee, Yunho Cha, Yongrae Jo, Junesol Song, Byungwoon Park, Sejong University

On-Demand Presentations

1. **Seamless Reference Time Switching Based on Dual-Frequency Multi-Constellation GNSS for Time Steering in SBAS Ground Stations,** Sergi Locubiche-Serra, Marc Solé-Gaset, Indra Espacio

A6b: Marine Applications and Search and Rescue
Date: Friday, September 20, 2024
Time: 3:20 p.m. - 4:50 p.m.
Room: Holiday Ballroom 1

Session Chairs   ### Track Chair

Dr. Richard J. Hartnett   **Dr. Pyo-Woong Son**   **Steffen Thoelert**
U.S. Coast Guard Academy *Chungbuk National University* *German Aerospace Center (DLR)*

3:20. Initial Test of the Proposed Medium Frequency R-Mode Navigation Message in the Baltic, Stefan Gewies, Filippo Giacomo Rizzi, Lars Grundhöfer, Niklas Hehenkamp, German Aerospace Center (DLR); Michael Hoppe, Michael Schütteler, German Federal Waterways and Shipping Administration

3:42. VDES R-Mode Advanced User Technologies for Alternative PNT (VAUTAP) final Developments, Martin Bransby, Tim Whitworth, Pekka Peltola, Telespazio UK; Anders Bjørnevik, Kongsberg

4:04. VDES R-Mode Test Bed in Long Island Sound, Gregory Johnson, Kenneth Dykstra, Serco, Inc.; Ryan Cassidy, James Spilsbury, USCG Research and Development Center

4:26. Locating Simultaneous VHF Distress Calls Using a Single LEO Satellite – An Idea for Augmenting Rescue 21 in Alaska, Dahnyoung McGarry, Richard J. Hartnett, U.S. Coast Guard Academy; Peter F. Swaszek, University of Rhode Island; Myles G. DeCoste, Andrew W. Ferderer, Charles T. Leventhal, and Ryan N. Mitchell, U.S. Coast Guard Academy

Alternate Presentations

1. **GNSS Attack Detection through Situational Awareness,** Harsimrat Bhundar, Zighra Inc.; Anil Somayaji, Carleton University; Deepak Dutt, Zighra Inc.

2. **MF R-Mode Receiver Advancements,** Gregory Johnson, Kenneth Dykstra, Serco, Inc.; Jean Delisle, Frédérick Hudon, Canadian Coast Guard

3. **AI-Augmented System for Reducing Multipath Positioning Error,** Robert I. Miron, Stefan S. Mihai, Ileana Mihu, Antonia Ivan, Alexandru C. Pandele, Bianca C. Ionescu, Romanian InSpace Engineering

B6: GNSS Applications in Space
Date: Friday, September 20, 2024
Time: 1:45 p.m. - 4:50 p.m.
Room: Holiday Ballroom 5

Session Chairs

Track Chair

Dr. Sampad Kumar Panda
KL University

Florian Kunzi
German Aerospace Center (DLR)

Dr. Sudha Vana
Rx Networks

1:50. Integrity for Satellite Space Corridor, Ginés Moreno López, Ramin Moradi, Danilo Forte, Jaime Fernández Sánchez, Jack Daniel McHugh, Diego Ramirez Rodriguez, Jorge Eduardo Martínez Esmeral, Arkadiusz Groth, Marc Fernández Usón, Jiachen Yin, GMV; Filipe De Oliveira Salgueiro, European Space Agency (ESA)

2:12. Design and Testing of NewSpace Galileo Receiver for LEO Precise Onboard Orbit Determination in the Horizon 2020 IOV/IOD Mission, F. Menzione, A. Piccolo, M. Paonni, J. Pablo Boyero, European Commission & JRC/EC; S. Casotto, M. Bardella, University of Padua; R. Prata, F. J. Belmonte-Calero, M. Perez, B. Moreno, D. Sanchez, A. Cardenosa, J. Lozano, J.M. Arias, B. Cardeira, C. Cardoso, F. Carvalho, J. Silva, Deimos Space & Deimos Engenharia; A. Amézaga, M. Badia, MWSE (former Balamis)

2:35. In-orbit Real-Time Precise Point Positioning using the Galileo High Accuracy Service, Radu I. Olteanu, Stefan S. Mihai, Alexandru C. Pandele, Antonia Ivan, Romanian InSpace Engineering

2:58. Orbit and Clock Determination for Navigation Message of Korean Regional Navigation Satellite System, Jaeuk Park, Bu-Gyeom Kim, and Changdon Kee, Department of Aerospace Engineering and SNU-IAMD, Seoul National University

3:20. The Impact of Ionospheric delay on GEO GNSS Receivers and a New Perspective for TEC Estimation, N. Estrada, A. Zin, S. Zago, Thales Alenia Space Italia; P. Bidart, D. Martella, Thales Alenia Space France

3:42. Science Objectives and Investigations for the Lunar GNSS Receiver Experiment (LuGRE), Lauren Konitzer, Joel J.K. Parker, Benjamin Ashman, Nathan Esantsi, NASA Goddard Space Flight Center; Frank Bauer, FBauer Aerospace Consulting Service; Claudia Facchinetti, Luigi Ansalone, Gabriele Impresario, Italian Space Agency; Fabio Dovis, Alex Minetto, Andrea Nardin, Politecnico di Torino

4:04. Taking PNT to the Moon: Ensuring Lunar PNT Mission Success through Simulation, Ricardo Verdeguer Moreno, Spirent Communications PLC

4:26. Conceptual Development of Ground Based Augmentation System on the Moon using a Swarm of Lunar Rovers, Euiho Kim, Danim Jung, and Dongwook Kim, Hongik University

Alternate Presentations

1. **A Novel Navigation Message for LEO Satellites,** Filipe De Oliveira Salgueiro, Miguel Cordero Limon, Pietro Giordano, European Space Agency (ESA/ESTEC)

2. **Methods for Accurate Ephemeris Modeling of the Lunar Near Rectilinear Halo Orbit,** Garvin Saner and Kirsten Strandjord, University of Minnesota

On-Demand Presentations

1. **Modelling the Earth-Moon Link Budget for the Next Lunar Missions,** Matilde Boschiero, Matteo Pulliero, Simone Tedesco, Samuele Fantinato, Efer Miotti, Oscar Pozzobon, Qascom S.r.l.; Claudia Facchinetti, Mario Musmeci, Italian Space Agency (ASI); Benjamin Ashman, Lauren Konitzer, Siddartha Sanathanamurthy, NASA Goddard Space Flight Center (GSFC); James J. Miller, NASA Headquarters; Lisa Valencia, Overlook Systems; Fabio Dovis, Politecnico di Torino

C6: Harsh Urban and Indoor GNSS
Date: Friday, September 20, 2024
Time: 1:45 p.m. - 4:50 p.m.
Room: Holiday Ballroom 6
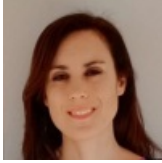
Session Chairs

Track Chair

Dr. Terry Moore
University of Nottingham

Dr. Ilaria Martini
u-blox

Dr. Melania Susi
Topcon Positioning System

1:50. Feature Map Aided Robust High Precision GNSS Positioning in Harsh Urban Environments, Fabian Ruwisch and Steffen Schön, Institut für Erdmessung, Leibniz Universität Hannover

2:12. Factor Graph Optimization-Based RTK-GNSS for Urban Positioning, Taro Suzuki, Chiba Institute of Technology

2:35. Accurate Pedestrian Positioning through Sidewalk Matching in Urban Canyons, Duojie Weng, Wu Chen, Xiaolong Mi, and Simin Liu The Hong Kong Polytechnic University

2:58. Robust GNSS Multipath Error Modeling based on Deep Quantile Regression with Gaussian Overbounding, Florian Roessl, Omar Garcia Crespillo, German Aerospace Center (DLR)

3:20. Reliable and Accurate Velocity: RAIM and Multi-GNSS for TDCP, Antonio Angrisano, Messina University; Salvatore Gaglione, Parthenope University; Ciro Gioia, Independent Researcher

3:42. Factor Graph-Based Spatial-Temporal-Enhanced Attention Network-Assisted Optimal Time Difference TDCP Positioning, Ziyao Li, Jiaqi Zhu, Shouyi Lu, Guirong Zhuo, Lu Xiong, Tongji University

4:04. Neural Network-Based GNSS Multipath Mitigation using Time-Frequency Analysis for Deep Urban Area, Min-Ji Kim, Yongjun Lee, Byungwoon Park, O-Jong Kim, Department of Aerospace Engineering, Sejong University

4:26. Radio SLAM Navigation with Terrestrial Signals of Opportunity in a GPS-Jammed Environment, Zak (Zaher) M. Kassas and Artun Sel, The Ohio State University; Chiawei Lee, US Air Force

Alternate Presentations

1. **Comparison of GNSS Multipath/NLoS Characterization Between Geodetic Receivers and Smartphones Across GPS L1 C/A and L5 Signals,** Yihan Guo, Simone Zocca, Fabio Dovis, Department of Electronics and Telecommunications, Politecnico di Torino; Paolo Dabove, Department of Environment, Land and Infrastructure Engineering, Politecnico di Torino

2. **Expanding High Accuracy Positioning Through the Mitigation of Influence Factors in Highly Urbanized Areas,** A. Chamorro, J.C. Lopez, J. Mate, E. Carbonell, A. Gonzalez, D. Calle, GMV

3. **Open-Source GNSS Direct Position Estimation Plug-in Module for Two-Step Positioning SDRs,** Sergio Vicenzo, HaoSheng Xu, Bing Xu, and Li-Ta Hsu, Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University

On-Demand Presentations

1. **Low-Cost Pseudolites: A Loop-Back Time Synchronization Scheme for Pseudolites Using Real-Time Clock Offset Calibration for Reliable PNT,** Muhammad Subhan Hameed, Mathias Phillip Blum, Thomas Pany, University of the Bundeswehr Munich; Daniel Sanroma, Sowmyashree Lakshmaiah, WORK Microwave GmbH
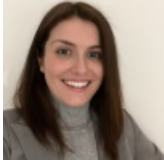
D6: Navigation Using Environmental Features
Date: Friday, September 20, 2024
Time: 1:45 p.m. - 4:50 p.m.
Room: Holiday Ballroom 4

Session Chairs

Track Chair

Dr. Sabrina Ugazio
Ohio University

Dr. Shahram Moafipoor
AEVEX Aerospace

Dr. Safoora Zaminpardaz
RMIT University

1:50. Validating a Star Tracker Algorithm and Measuring its Accuracy Through Suburban Night Sky Observations, Wen-Chiao Chen, National Cheng Kung University

2:12. Deep Space PNT Instrument (DESPINA) Sensor Design, Mel Nightingale, Dorcas Oseni, Kyle J. Houser, William Setterberg, Ragini Suttar, Lindsay Glesener, Demoz Gebre-Egziabher, University of Minnesota, Twin Cities

2:35. Measuring Gravitational Acceleration Using X-Ray Pulsars for Deep Space Navigation Algorithm Initialization, Kyle J. Houser and Demoz Gebre-Egziabher, University of Minnesota

2:58. Navigation Augmentation for Landing on Vertipads Utilizing Optical Detection of Standard ICAO Circular Markings, Finn Hübner, Robert Haupt, Ulf Bestmann, Peter Hecker, TU Braunschweig

3:20. Magnetic Anomaly Navigation Using a Multi-vehicle Batch Processing Algorithm of Variable Map Fidelity, Shawn Whitney, Aaron Nielsen, Frank van Graas, Air Force Institute of Technology

3:42. Accuracy of Magnetic Field-based Train Localization and the Impact of Unknown Calibration Parameters, Benjamin Siebler, Stephan Sand, German Aerospace Center (DLR); Uwe D. Hanebeck, Karlsruhe Institute of Technology

4:04. Map Outage Recovery: ICP Tolerance to Initialization Errors for Automotive Radar, Emma Dawson, Paulo Ricardo Marques de Araujo, Queen's University; Mohamed Elhabiby, Micro Engineering Tech Inc.; Aboelmagd Noureldin, Royal Military College of Canada and Queen's University

4:26. Neural City Maps for GNSS Shadow Matching, Daniel Neamati, Mira Partha, Shubh Gupta, and Grace Gao, Stanford University

Alternate Presentations

1. **Robust 3D Map-Matching With Visual Environment Features for Neural City Maps,** Mira Partha, Daniel Neamati, Shubh Gupta, and Grace Gao, Stanford University

2. **Tightly-Coupled Integration of PPP-RTK/INS/Vision via Factor Graph Optimization Aided by Visual Virtual Satellite in Dense Urban Areas,** Baoshan Song, Weisong Wen, Li-Ta Hsu, Department of Aeronautical and Aviation Engineering, the Hong Kong Polytechnic University

3. **Extended LTE Based Fingerprinting Positioning for Emergency Applications by utilizing Seq2seq Model with Beam-Search Inference,** Sun Sim Chun, Jung Ho Lee, Ju-Il Jeon, Jin Ah Kang, Young-Su Cho, Electronics and Telecommunications Research Institute

On-Demand Presentations

1. **GMRC-Aided Lidar-GNSS/INS: Ground Map Registration Constrained Lidar/GNSS/INS System for Precise Positioning in Urban Canyons,** Mengchi Ai, Dept. of Geomatics Engineering, University of Calgary; Mohamed Elhabiby, Micro Engineering Tech Inc.; Mehad Haggag, Ilyar Asl Sabbaghian Hokmabad, Dept. of Geomatics Engineering, University of Calgary; Mohamed Moussa, Micro Engineering Tech Inc.; Hongzhou Yang, Naser El-Sheimy, Dept. of Geomatics Engineering, University of Calgary

E6: Sensor Network and Cooperative Navigation
Date: Friday, September 20, 2024
Time: 1:45 p.m. - 4:50 p.m.
Room: Holiday Ballroom 3

Session Chairs

Track Chair

Dr. Ramsey Faragher
Focal Point Positioning

Dr. Gregor Möller
TU Wien

Byungwoon Park
Sejong University

1:50. UAV Navigation with Multi-Constellation LEO Satellite Signals of Opportunity, Will Barrett, Sharbel Kozhaya, and Zak (Zaher) M. Kassas, The Ohio State University

2:12. A Superimposed Signal Separation Algorithm for Satellite Navigation Receivers in Complex Environments Based on Capsule Networks, Jiangyan Chen, University of Electronic Science and Technology of China; Sicun Han, Rensselaer Polytechnic Institute; Chengjun Guo, Long Jin, Yunhao Liu, University of Electronic Science and Technology of China

2:35. Deeply Integrated GNSS-INS with CRPA to Constrain Attitude Biases for Robust Navigators, Daniel F. Sturdivant, Scott M. Martin, Auburn University

2:58. Robust Beampattern Synthesis for UAV-Swarm-Based Distributed Beamforming, W. Jeremy Morrison, Dao A. Ton-Nu, Todd E. Humphreys, Department of Aerospace Engineering and Engineering Mechanics, The University of Texas at Austin

3:20. Low-Cost Collaborative Positioning for Autonomous Agents Using DGNSS, Eva Buchmayer, Christoph Schmied, Fabian Theurl, Institute of Geodesy, Graz University of Technology

3:42. Multi-Agent Multi-Sensor Collaboration for Improved Positioning in Urban Environment, Anat Schaper and Steffen Schön, Institut für Erdmessung, Leibniz Universität Hannover

4:04. Addressing Stochastic Consistency for Fusing Absolute and Relative Orbit Determination for Satellite Swarms, Marvin B. Stucke, Paula Peitschat, Kevin Gutsche, and Thomas Hobiger, Institute of Navigation, University of Stuttgart; Stefan Winkler, Airbus Defence and Space

4:26. Autonomous Constellation Fault Monitoring with Inter-Satellite Links: A Rigidity-Based Approach, Keidai Iiyama, Daniel Neamati, and Grace Gao, Stanford University

Alternate Presentations

1. **STAN: Spatial-Temporal Attention Based Inertial Navigation Transformer,** Zhengyang Fan, Peng Cheng, Hua-mei Chen, Yajie Bao, Intelligent Fusion Technology, Inc.; Khanh Pham, Erik Blasch, Air Force Research Laboratory (AFRL); Hao Xu, University of Nevada; Reno Genshe Chen, Intelligent Fusion Technology, Inc.

2. **Proximity-Based Location with Robustness to Byzantine Failures,** Guillermo Hernandez, Shuo Tang, and Pau Closas, Electrical and Computer Engineering Dept., Northeastern University

F6: GNSS Robustness to Vulnerabilities 2
Date: Friday, September 20, 2024
Time: 1:45 p.m. - 4:50 p.m.
Room: Holiday Ballroom 2

Session Chairs

Track Chair

Dr. Sophie Damy
European Commission JRC

Dr. Stefan Söderholm
Septentrio

Dr. Attila Komjathy
Jet Propulsion Laboratory

1:50. Classification of Spoofed and Non-Spoofed Cross-Ambiguity Function Image by Deep Learning Approach, Ellarizza Fredeluces, Tokyo University of Marine Science and Technology Nobuaki Kubo, Tokyo University of Marine Science and Technology

2:12. Jamming Mitigation Based on Improved GNSS/UWB Tightly-Coupled Integration, Zhuojian Cao, Iman Ebrahimi Mehr, Jiang Liu, Yihan Guo, Fabio Dovis, Wei Jiang, Bai-gen Cai, Beijing Jiaotong University

2:35. GNSS RFI Localization through Fusion of PDOA, TDOA, and AoA Measurements, Fred Taylor, Dennis Akos, and Evan Gattis, University of Colorado Boulder

2:58. Optimizing Covariance Estimation Model for Collaborative Integrity Monitoring in Heterogeneous Receiver Satellite Environments, Victor Vince; Thales SIX, Telecom SudParis, Institut Polytechnique de Paris; Dominique Heurguier, Thales SIX; Alexandre Vervisch-Picois, Telecom SudParis, Institut Polytechnique de Paris; Jose Manuel Rubio Hernan, Telecom SudParis, Institut Polytechnique de Paris

3:20. Assessment of Direct Position Estimation Performance in Multipath Channels, Shuo Tang, Dept. of Electrical and Computer Engineering, Northeastern University; Haoqing Li, Department of Geomatics Engineering, University of Calgary; Pau Closas, Dept. of Electrical and Computer Engineering, Northeastern University

3:42. Real-World Jammer Localization Using a Low-Cost Array-Based Software-Defined Radio, Lasse Lehmann, Søren R. Larsen, Daniel H. Olesen, Technical University of Denmark

4:04. Characterization of the Multipath Situation Under Meaconing Interference, Mathieu Hussong, Emile Ghizzo, Carl Milner, Axel Garcia-Pena, Fédération ENAC ISAE-Supaéro ONERA, Université de Toulouse
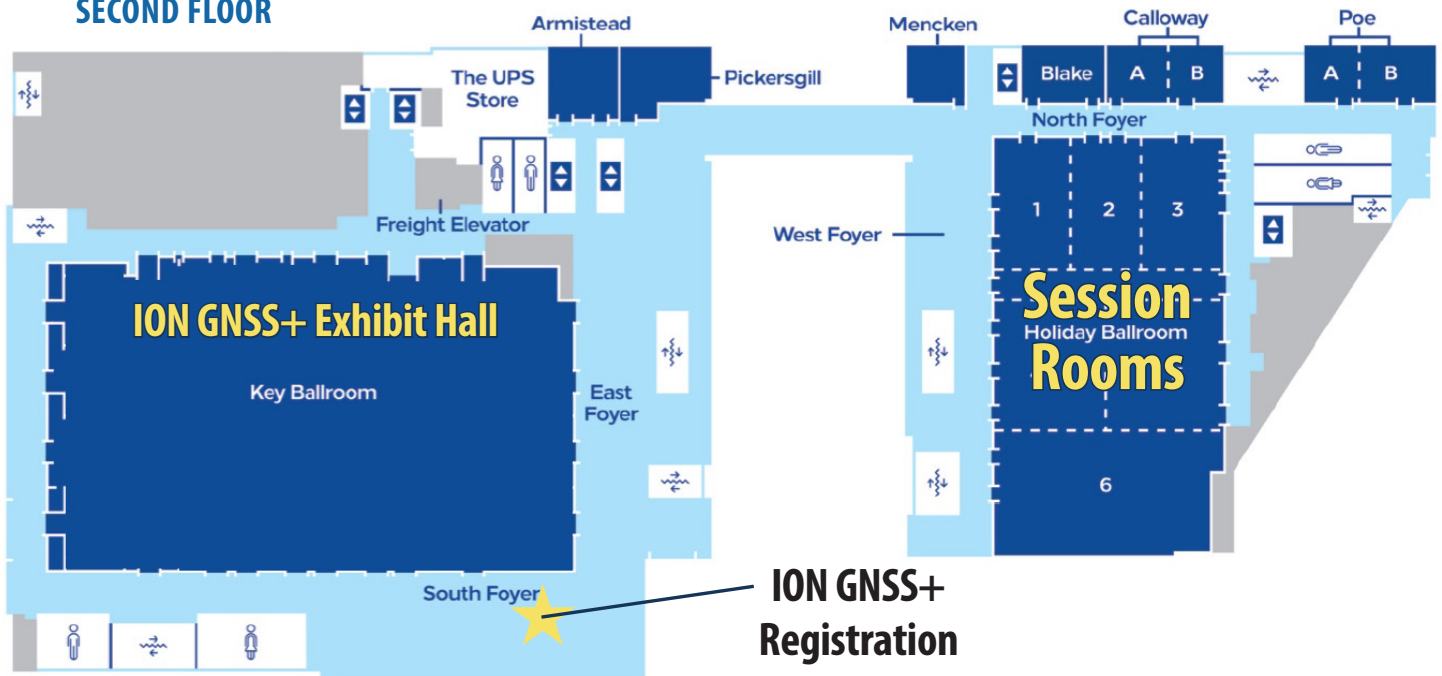
4:26. The Impact of GPS Signal Interference on Aircraft Navigation in the Contiguous USA, Wayne W. Cooper, The MITRE Corporation; Timothy S. Wallace, Federal Aviation Administration; Rick Niles, Jason Chou, Rich Baker, Joseph Minieri, Alex Tien, The MITRE Corporation
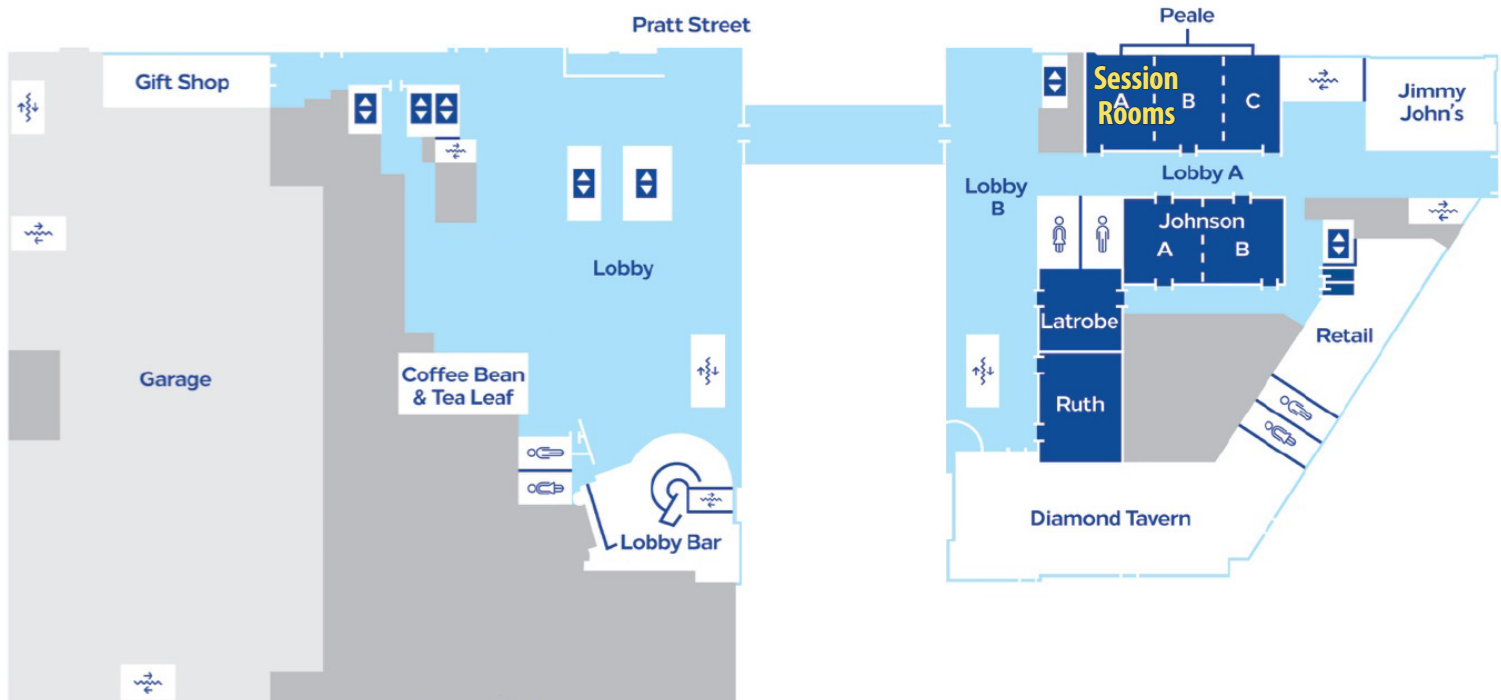
Alternate Presentations

1. **Neural Network-Based GNSS Code Measurement De-Weighting for Multipath Mitigation,** Haoqing Li and Kyle O'Keefe, Department of Geomatics Engineering, University of Calgary

2. **Analyzing Direction of Arrival Dynamics in GNSS Controlled-Reception Pattern Antennas Under Real Jamming Scenarios,** Aisha Elsayem, Department of Electrical and Computer Engineering, Queen's University; Mohamed Tamazin, GNSS Simulation Engineering, Research and Development, Safran Trusted 4D Canada; Haidy Elghamrawy, Department of Electrical and Computer Engineering, Royal Military College of Canada; Aboelmagd Noureldin, Department of Electrical and Computer Engineering, Royal Military College of Canada & Department of Electrical and Computer Engineering, Queen's University; and Pierre-Marie le Veel, Safran Trusted 4D France
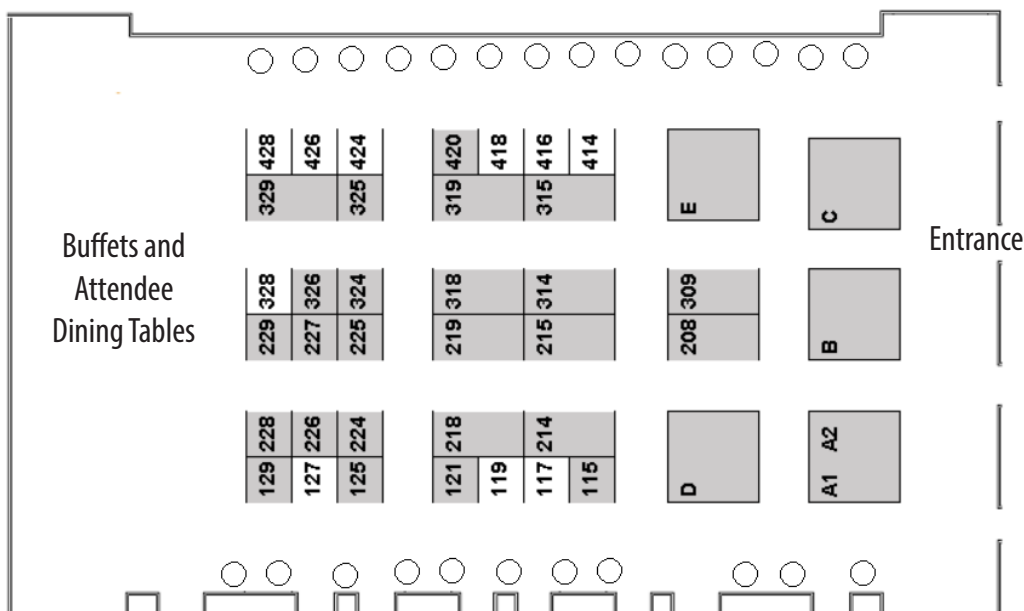
Hotel Floor Plan

SECOND FLOOR

Armistead

The UPS Store

Pickersgill

Mencken

Calloway

Blake · A · B

Poe · A · B

Freight Elevator

North Foyer

West Foyer

ION GNSS+ Exhibit Hall

Key Ballroom

East Foyer

1 · 2 · 3

Session Rooms

Holiday Ballroom

6

South Foyer

ION GNSS+ Registration

FIRST FLOOR

Pratt Street

Peale

Gift Shop

Session Rooms A · B · C

Jimmy John's

Lobby A

Lobby B

Lobby

Johnson A · B

Coffee Bean & Tea Leaf

Latrobe

Retail

Garage

Ruth

Lobby Bar

Diamond Tavern

EXHIBIT HALL FLOOR PLAN

Unshaded booths were available as of March 13

Buffets and Attendee Dining Tables

Entrance

| 428 | 426 | 424 | | 420 | 418 | 416 | 414 | | E | | C |
| 329 | | 325 | | 319 | | 315 | | | | |

| 328 | 326 | 324 | | 318 | | 314 | | | 309 | | | B |
| 229 | 227 | 225 | | 219 | | 215 | | | 208 |

| 228 | 226 | 224 | | 218 | | 214 | | | | A1 | A2 |
| 129 | 127 | 125 | | 121 | 119 | 117 | 115 | | D |

CURRENT EXHIBITORS

- Acutronic USA Inc.
- CAST Navigation, LLC
- Feyman Technology (USA) Inc.
- German Aerospace Center (DLR)
- GMV Aerospace and Defence S.A.U.
- GPS World
- Hemisphere GNSS
- IAI
- Ideal Aerosmith
- IEEE Journal of Indoor and Seamless Positioning and Navigation (J-ISPIN)
- IFEN GmbH
- Intelligent Fusion Technology, Inc.
- LabSat
- Lockheed Martin
- NAVPATH
- NavtechGPS
- NovAtel
- oneNav
- onocoy Association
- OxTS
- Qascom
- Rohde & Schwarz USA, Inc.
- Rx Networks, Inc.
- Safran – Electronics & Defense
- Satelles, Inc.
- Spirent Communications PLC
- Spirent Federal Systems
- Syntony GNSS
- Trimble Inc.
- Tualcom Elektronik A.S.
- UHU Technologies LLC

EXHIBIT HALL HOURS

Wednesday
10:00 a.m. – 7:00 p.m.   Hall Open
5:30 p.m. - 7:00 p.m.   Evening Exhibit Hours

Thursday
9:00 a.m. – 4:00 p.m.   Hall Open
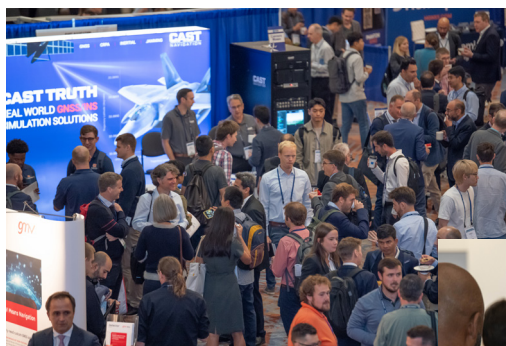
To reserve your booth, contact:
Megan Andrews
ION National Office
Phone: 1-703-366-2776
E-mail: mandrews@ion.org

Wednesday, September 18

Attendee Luncheon
12:15 p.m. – 1:15 p.m., Exhibit Hall
This event is included with all full conference, student, exhibit only and Wednesday registrations. See registration desk to purchase guest tickets.

Free Time in the Exhibit Hall
5:30 p.m. – 7:00 p.m., Exhibit Hall
This event is included with all registrations.

Visit this year's exhibitors to review developments in GNSS technology, talk shop, get the specifics directly from the vendors, and learn about what has been happening in the GNSS marketplace during the past year. This event is included with any type of registration.

Thursday, September 19

Attendee Luncheon
12:15 p.m. – 1:15 p.m., Exhibit Hall
This event is included with all full conference, student, exhibit only and Thursday registrations. See registration desk to purchase guest tickets.

Friday, September 20

Kepler and Parkinson Awards Luncheon
12:15 p.m. – 1:30 p.m.

The purpose of the Johannes Kepler Award is to honor an individual for sustained and significant contributions to the development of satellite navigation.

The Bradford Parkinson Award, which honors Dr. Parkinson for his leadership in establishing both the U.S. Global Positioning Systems and the Satellite Division of the Institute of Navigation, is given to an outstanding graduate student in the field of Global Navigation Satellite Systems.

The deadline for submitting nominations for both awards is June 30. See ion.org/awards for application requirements.

2023 Kepler Award Winner: Dr. Todd Humphreys

This event is included with a full, student, or Friday single day, conference registration. Tickets for exhibitors and/or guests may be purchased during registration or by visiting the ION GNSS+ registration desk onsite.

Travel and Business Information

Location and Parking
The conference will be held at the Hilton Baltimore Inner Harbor, 401 West Pratt Street, Baltimore, MD 21201. Self-parking is available at the daily parking rates of $36 (rate is subject to change).

Travel and Local Area Information
Please visit ion.org/gnss/travel.cfm for information on the local area, climate, airport transfers, getting around the Inner Harbor, and local attractions.

Session Papers Online
Registered attendees may download copies of conference presentations and papers online for free by logging in to the virtual meeting portal at ion.org/gnss. Only presentations and papers provided to the ION by the presenting author will be available. If a desired document is not available, we recommend you contact the author directly.

Proceedings
Official conference proceedings are scheduled for distribution in October to all eligible conference participants.

Customize Your Conference Schedule
Once you are registered for the conference, visit the ION website to build a customized schedule of presentations you wish to attend.

Other Services
A Business Center will be provided at the hotel to provide access to basic business services.

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

Video recording by participants is not allowed without permission of ION during any portion of the conference.

Photographs of copyrighted presentations are for personal use only and are not to be reproduced or distributed. Do not photograph images labeled as proprietary. Flash photography, or any photography, that disturbs those around you, is prohibited.

By registering for this event, you agree to abide by the ION Code of Ethics and Conference Code of Conduct available at ion.org.

Visa Waiver Countries
Travelers from ALL Visa Waiver Program countries must present either a machine-readable passport or a U.S. Visa. To learn more about the Visa Waiver Program and Machine Readable Passports see travel.state.gov/visas.

Non-Visa Waiver Countries
We recommend that you apply for your Visa at least three months in advance. Currently there is a mandatory security check period of 30 days for people whose passports are issued from several countries. U.S. consular offices now interview most applicants as part of the application process. Please ensure you arrive at the embassy with all required documentation at the time of your interview. Note that the Institute does not intervene in U.S. State Department's issuance of Visas.

**Attendees requesting a visa letter to attend ION GNSS+ must:**

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

Exemptions to this policy apply only to those authors whose papers have been accepted for presentation, company personnel working in the exhibit area, or trade associated press.
If the attendee is unable to secure a Visa, they will need to apply for a refund according to the printed refund rules of the event.
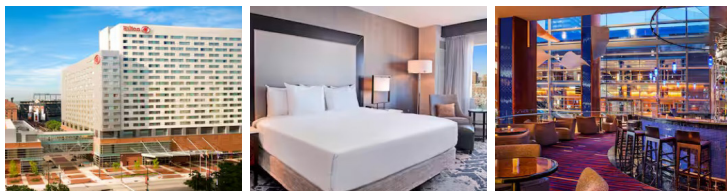
Headquarters Hotel/Conference Location
Hilton Baltimore Inner Harbor

401 West Pratt Street
Baltimore, MD 21201
Phone: 1-443-573-8700

Located next to Oriole Park at Camden Yards, the Inner Harbor's museums, the National Aquarium, and TopGolf Baltimore are all within a mile. The hotel is walking distance to downtown dining, and the Camden Station light rail is a three-minute walk.

All ION GNSS+ Sessions and Events are located at this hotel.

Rate: $234 single/double, limited government rate availability*
In-Room Internet: Free for guests in ION room block
Parking: Self-parking is available; the current rate is $36/day

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

Book your hotel with ION and save $300 in registration fees!

Save $300 on your conference registration fee by staying in the Hilton Baltimore Inner Harbor. To qualify for the discount, make your hotel reservation before you register for the conference. Enter your hotel confirmation number on the registration form to receive the discount.

How to Reserve Your Room

• Online: Go to ion.org/gnss/hotel.cfm
• Phone: +1-443-573-8700

Hotel Discount Deadline is August 16

August 11 is the last day that this rate will be available, but rooms at the discounted rates may fill up before then. Make your reservations now to avoid missing out on discounted room rates!

How to Register

1. **Make your hotel reservation** at the official conference hotel. Make your reservation at ion.org/gnss or by calling the hotel directly.

2. **Record your hotel confirmation number.** All attendees staying at the official conference hotel are eligible to receive $300 off their conference registration fees. Attendees must provide their valid hotel confirmation number at the start of the registration process to claim this discount; it cannot be applied retroactively.

3. **Register for ION GNSS+** at ion.org. Rates for attendees registering by August 16 and staying in the official conference hotel start at:
   • Full Technical Registration: $1,100.00
   • Single Day: $600.00
   • Student: $700.00
   • On-Demand Registration: $699
   • Tutorials (per course): $450

   In-person Registration includes all ION GNSS+ live technical sessions, access to the exhibit hall, meal functions and events, all on-demand conference content listed below, and conference proceedings.

   On-Demand Registration offers access to on-demand conference content and a recording of the plenary session. **There will be no live-streaming.**

4. **Complete the online registration process**. Be sure to input your hotel confirmation number during the registration process to claim your discount.

For more information, or to register, visit ion.org/gnss