January 21–24, 2020
Hyatt Regency Mission Bay
San Diego, CA

INTERNATIONAL TECHNICAL MEETING
PRECISE TIME AND TIME INTERVAL SYSTEMS AND APPLICATIONS MEETING

ONSITE PROGRAM
Free Conference Wi-Fi
Network: @Hyatt_Meetings
Access Code: ion2020

ion.org
Pre-Conference Tutorials: Tuesday, January 21

**PTTI Tutorial Sessions (Bayview Ballroom 3)**
- 9:00 a.m.–12:00 p.m.: Tutorials
- 12:00 p.m.–1:30 p.m.: Lunch on Your Own
- 1:30 p.m.–5:45 p.m.: Tutorials

Must add tutorials on ITM/PTTI Registration Form. Additional Fee.

### ITM/PTTI Technical Sessions

<table>
<thead>
<tr>
<th>Time</th>
<th>ITM Track A</th>
<th>ITM Track B</th>
<th>PTTI Track</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bayview Ballroom 1</td>
<td>Bayview Ballroom 2</td>
<td>Bayview Ballroom 3</td>
</tr>
<tr>
<td><strong>Wednesday, January 22</strong></td>
<td>1:45 p.m. - 5:30 p.m.</td>
<td>1:45 p.m. - 5:30 p.m.</td>
<td>1:45 p.m. - 5:10 p.m.</td>
</tr>
<tr>
<td></td>
<td>A1: DRMC Airborne Error Models</td>
<td>B1: Advanced Signal Processing for GNSS Receivers</td>
<td>P1a: Laboratory Reports and Activities</td>
</tr>
<tr>
<td></td>
<td><strong>8:30 a.m. - 12:15 p.m.</strong></td>
<td><strong>8:30 a.m. - 12:15 p.m.</strong></td>
<td><strong>8:30 a.m. - 12:15 p.m.</strong></td>
</tr>
<tr>
<td></td>
<td>A2: GNSS for Aviation: Integrity and Augmentation</td>
<td>B2: Precise GNSS Positioning</td>
<td>P2: Time and Frequency Transfer Beyond GNSS</td>
</tr>
<tr>
<td></td>
<td><strong>12:15 p.m. - 1:45 p.m.</strong></td>
<td><strong>12:15 p.m. - 1:45 p.m.</strong></td>
<td><strong>12:15 p.m. - 1:45 p.m.</strong></td>
</tr>
<tr>
<td></td>
<td>Lunch in Exhibit Hall (Regatta Pavilion)</td>
<td><strong>1:45 p.m. - 3:25 p.m.</strong></td>
<td><strong>1:45 p.m. - 3:25 p.m.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>1:45 p.m. - 5:30 p.m.</strong></td>
<td><strong>1:45 p.m. - 5:30 p.m.</strong></td>
<td><strong>1:45 p.m. - 5:30 p.m.</strong></td>
</tr>
<tr>
<td></td>
<td>A3: Challenges for Unmanned Aerial Vehicles and Autonomous Systems</td>
<td>B3a: Pedestrian and Indoor Localization</td>
<td>P3a: Advances in Next Generation Clocks</td>
</tr>
<tr>
<td></td>
<td><strong>3:55 p.m. - 5:30 p.m.</strong></td>
<td><strong>3:55 p.m. - 5:30 p.m.</strong></td>
<td><strong>3:55 p.m. - 5:30 p.m.</strong></td>
</tr>
<tr>
<td></td>
<td>B3b: High-Performance GNSS Receivers</td>
<td><strong>3:55 p.m. - 5:30 p.m.</strong></td>
<td><strong>3:55 p.m. - 5:30 p.m.</strong></td>
</tr>
<tr>
<td><strong>Thursday, January 23</strong></td>
<td><strong>8:30 a.m. - 10:05 a.m.</strong></td>
<td><strong>8:30 a.m. - 10:05 a.m.</strong></td>
<td><strong>8:30 a.m. - 10:05 a.m.</strong></td>
</tr>
<tr>
<td></td>
<td>A4a: Challenges in Terrestrial and Urban Environments</td>
<td>B4: Atmospheric and Space Weather</td>
<td>P4a: Time and Frequency Transfer Using GNSS and RNSS</td>
</tr>
<tr>
<td></td>
<td><strong>10:15 a.m. - 12:15 p.m.</strong></td>
<td><strong>10:15 a.m. - 12:15 p.m.</strong></td>
<td><strong>10:15 a.m. - 12:15 p.m.</strong></td>
</tr>
<tr>
<td></td>
<td>A4b: Alternatives, Backups and Complements to GNSS</td>
<td><strong>B5a: Timing for PNT Resilience</strong></td>
<td><strong>P4b: PTTI Applications and Techniques</strong></td>
</tr>
<tr>
<td></td>
<td><strong>2:00 p.m. - 3:35 p.m.</strong></td>
<td><strong>2:00 p.m. - 3:35 p.m.</strong></td>
<td><strong>2:00 p.m. - 3:35 p.m.</strong></td>
</tr>
<tr>
<td></td>
<td>A5: GNSS and Security: Jamming and Spoofing</td>
<td>B5a: Timing for PNT Resilience</td>
<td>P5a: Timescales and Algorithms</td>
</tr>
<tr>
<td></td>
<td><strong>3:35 p.m. - 5:10 p.m.</strong></td>
<td><strong>3:35 p.m. - 5:10 p.m.</strong></td>
<td><strong>3:35 p.m. - 4:45 p.m.</strong></td>
</tr>
<tr>
<td></td>
<td>B5b: Integrated Navigation Systems</td>
<td><strong>P5b: Exceptional Timing Infrastructure for GNSS Providers</strong> (Joint PTTI/ITM Session)</td>
<td></td>
</tr>
<tr>
<td><strong>Friday, January 24</strong></td>
<td><strong>12:15 p.m. - 1:45 p.m.</strong> Awards Luncheon (Regatta Pavilion) - Late Arrivals will not be served after 12:30 p.m.</td>
<td><strong>2:00 p.m. - 3:10 p.m.</strong></td>
<td><strong>2:00 p.m. - 3:35 p.m.</strong></td>
</tr>
<tr>
<td></td>
<td>2:00 p.m. - 5:10 p.m.</td>
<td>B5a: Timing for PNT Resilience</td>
<td>P5a: Timescales and Algorithms</td>
</tr>
<tr>
<td></td>
<td>A5: GNSS and Security: Jamming and Spoofing</td>
<td><strong>3:35 p.m. - 5:10 p.m.</strong></td>
<td><strong>3:35 p.m. - 4:45 p.m.</strong></td>
</tr>
<tr>
<td></td>
<td><strong>3:35 p.m. - 5:10 p.m.</strong></td>
<td>B5b: Integrated Navigation Systems</td>
<td><strong>P5b: Exceptional Timing Infrastructure for GNSS Providers</strong> (Joint PTTI/ITM Session)</td>
</tr>
</tbody>
</table>

### HYATT CAMPUS MAP

**MEETING SPACE**

**Regatta Pavilion** (Exhibit Hall)

**CAMPUS OVERVIEW**

ITM/PTTI 2020
January 21 - 24, 2020 • San Diego, California
ion.org
Special Events at ITM/PTTI 2020
The following events are included in all full-conference and student registrations. Single day registrations include events taking place on the day the attendee is registered. Retired registrations include all meal functions located within the exhibit hall; a ticket is required for Friday’s Awards Luncheon.

Exhibitor Hosted Breakfast
Wednesday, 8:30 a.m. - 9:30 a.m.
Exhibit Hall, Regatta Pavilion

Informal Luncheon
Wednesday, 12:45 p.m. - 1:45 p.m.
Exhibit Hall, Regatta Pavilion

Informal Luncheon
Thursday, 12:15 p.m. - 1:45 p.m.
Exhibit Hall, Regatta Pavilion

Annual Awards Luncheon
Friday, 12:15 p.m. - 1:45 p.m.
Late arrivals will not be served after 12:30 p.m.
Regatta Pavilion

Special Events for Speakers/Session Chairs
All session chairs and the presenting author of primary and alternate presentations should attend the Speakers’ Meeting (Wednesday) or the Speakers’ Breakfast (Thursday-Friday), taking place in Mission Ballroom 3 on the day of their presentation. Names will be checked at the door. Attend the Speakers’ Meeting/Breakfast only on the morning of your presentation. If you have not uploaded your bio in AMP, please bring a printed copy for your session chair.

Access to Technical Papers and Presentations
Qualified attendees may download copies of conference presentations and papers online for FREE by logging on at ion.org/itm or ion.org/ptti. Only presentations and papers provided to the ION by the presenting author will be available. Presentations will only be made available once the full technical paper is submitted. If a desired document is not available, we recommend you contact the author directly. Official conference proceedings will be distributed electronically in March to all eligible conference participants.

Mobile Conference Site
Access the technical program, exhibitor list and other conference information from your mobile device. Visit m.ion.org.

Complimentary Internet
Free wireless internet is available to attendees in all technical session rooms and meeting room lobbies.
Network ID: @Hyatt_Meetings
Password: ion2020

Photography Policy
Your presence at ITM/PTTI constitutes your agreement to be photographed, filmed, videotaped or otherwise recorded by conference management, or its agents, and your agreement that your image or voice may be distributed in print or electronic communications media without any compensation being paid to you. Video recording by participants is not allowed without written 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 any images labeled as proprietary. Flash photography, or any form of photography, that disturbs those around you, is prohibited.

Special Events at ITM/PTTI 2020
The following events are included in all full-conference and student registrations. Single day registrations include events taking place on the day the attendee is registered. Retired registrations include all meal functions located within the exhibit hall; a ticket is required for Friday’s Awards Luncheon.

Exhibitor Hosted Breakfast
Wednesday, 8:30 a.m. - 9:30 a.m.
Exhibit Hall, Regatta Pavilion

Informal Luncheon
Wednesday, 12:45 p.m. - 1:45 p.m.
Exhibit Hall, Regatta Pavilion

Informal Luncheon
Thursday, 12:15 p.m. - 1:45 p.m.
Exhibit Hall, Regatta Pavilion

Annual Awards Luncheon
Friday, 12:15 p.m. - 1:45 p.m.
Late arrivals will not be served after 12:30 p.m.
Regatta Pavilion

Special Events for Speakers/Session Chairs
All session chairs and the presenting author of primary and alternate presentations should attend the Speakers’ Meeting (Wednesday) or the Speakers’ Breakfast (Thursday-Friday), taking place in Mission Ballroom 3 on the day of their presentation. Names will be checked at the door. Attend the Speakers’ Meeting/Breakfast only on the morning of your presentation. If you have not uploaded your bio in AMP, please bring a printed copy for your session chair.

Access to Technical Papers and Presentations
Qualified attendees may download copies of conference presentations and papers online for FREE by logging on at ion.org/itm or ion.org/ptti. Only presentations and papers provided to the ION by the presenting author will be available. Presentations will only be made available once the full technical paper is submitted. If a desired document is not available, we recommend you contact the author directly. Official conference proceedings will be distributed electronically in March to all eligible conference participants.

Mobile Conference Site
Access the technical program, exhibitor list and other conference information from your mobile device. Visit m.ion.org.

Complimentary Internet
Free wireless internet is available to attendees in all technical session rooms and meeting room lobbies.
Network ID: @Hyatt_Meetings
Password: ion2020

Photography Policy
Your presence at ITM/PTTI constitutes your agreement to be photographed, filmed, videotaped or otherwise recorded by conference management, or its agents, and your agreement that your image or voice may be distributed in print or electronic communications media without any compensation being paid to you. Video recording by participants is not allowed without written 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 any images labeled as proprietary. Flash photography, or any form of photography, that disturbs those around you, is prohibited.

Premium Professional Membership
“Upgrading to Premium Professional Membership has given me additional support for my research. With downloads of up to 25 papers per month from the ION database, I have direct access to highly-specialized technical papers from ION’s conferences and peer-reviewed articles related to PNT.”

Allison Kealy, ION Member
**TUTORIAL DESCRIPTIONS**

**Introduction to Optical Clocks**

In the first part of this tutorial the fundamental principles that led to the development of modern optical clocks will be presented. Optical clocks based on trapped neutral atoms in optical lattices or single ions in rf traps currently realize the most accurate frequency standards. Their performances are such that a re-definition of the SI second using an optical clock is expected to happen within the next decade. They outperform the accuracy of cesium fountain clocks that currently define the SI second by two orders of magnitude. An overview of these optical clocks and a comparison of their respective performances will be given.

The primary focus of the second part will be on single-ion optical clocks. The optical clock developed at NRC, based on a trapped and laser-cooled single ion of 88Sr+, will be presented in more detail to provide a concrete example of the steps involved in achieving very low uncertainties. Many important topics will be covered, from the basic operation of our standard to a discussion of key systematic shifts that must be well-understood and controlled to achieve high accuracy. At present, the 88Sr+ ion clock at NRC has an evaluated fractional uncertainty of 10^{-17}. Methods for reducing it to the 10^{-18} level will be discussed briefly. The tutorial will conclude with examples of optical clock applications in fundamental physics and relativistic geodesy.

Dr. Pierre Dubé received his Ph.D. in physics from the University of Toronto. He went on to be a postdoctoral fellow at JILA in Boulder, Colorado, with John Hall, and a postdoctoral fellow at TRIUMF, in Vancouver, Canada, with Otto Haüsser. Since 2000, he has been working at the National Research Council of Canada, primarily on high-accuracy single-ion optical clocks.

**Optical Frequency Combs: from Principles of Operation to Metrological Applications**

Femtosecond optical frequency combs are highly versatile tools for precision measurements. Providing phase coherent frequency references across the entire optical spectrum, they offer users a unique combination of broad spectral coverage, high spectral resolution and a calibrated frequency scale. As a result, they have found numerous applications in frequency metrology and beyond. This tutorial will explain how femtosecond optical frequency combs work, covering both the fundamental principles and some practical details. The construction and major components of several of the most common types of frequency comb technology will be described. Differentiating factors that may influence the choice of technology for a particular application will be discussed. Finally, case studies will illustrate how optical frequency combs are applied in precision frequency metrology.

Dr. Helen Margolis is an NPL Fellow in Optical Frequency Standards and Metrology. She leads NPL's research activities in optical frequency metrology using femtosecond combs, which are part of the research programme to develop a new generation of high accuracy optical atomic clocks based on laser-cooled trapped ions and atoms.
Realization of a UTC(k) Time Scale

Many different approaches can be found in literature for the realization of a time scale. Most of them consider the realization of an autonomous time scale without considering the specific needs of a UTC(k). This tutorial suggests an unconventional approach, oriented to the practical implementation of a physically available robust UTC(k) time scale. This tutorial is based on the assumption that an UTC(k) is a physical representation of UTC with the best availability and the lowest possible departure from UTC, taking into account the fact that the number and the quality of the available clock is limited by external constraint. The first part will be devoted to a description of UTC and of the expected characteristics of an UTC(k) time scale. The second part will describe the steering of an UTC(k) to UTC, with examples provided. The analysis of performances of some UTC(k) will be discussed.

Dr. Daniele Rovera has been a researcher at LNE-SYRTE Observatoire de Paris, (formerly LPTF) since 1989 where his current interests include atomic clocks, optical frequency measurements, time comparisons and time scales.

Global Navigation Satellite System (GNSS) Overview with a Focus on Precise Time Disseminations and Standards

GPS has provided an operational Position Navigation and Timing (PNT) services for more 25 years. The vast majority of PNT applications use GPS as its fundamental source for PNT data. GPS operates using very precise synchronized ranging signals, where in general every nanosecond of synchronization error can lead to one foot of navigation error. Because of this exquisite timing synchronization, GPS provides a precise timing service used to support many important user communities ranging from power grid, telecommunication networks, science and the banking industry. Today GPS is no longer the only GNSS system, there are now several other GNSS systems in either operations and/or system development. This tutorial will provide an overview of how GPS operates, discuss the other GNSS systems and the reference standard that underlay each system.

Ed Powers received his BS and MS degrees in Electronic Engineering and Instrumental Science from the University of Arkansas. Previously, he has worked at NRL on GPS clock development and at the USNO as the GPS Operations Division Chief. Ed joined the Aerospace Corp in October 2018 as Senior Project Engineer, GNSS Engineering & Technology.

Optical Fiber and its Use for Time and Frequency Transfer

The need to know the time in present and future society is increasing, whether it is in a time stamp of a financial transaction, or the data handover between two base stations in a 5G network. In many occasions it is satisfied with time through radio transmission, but with synchronization needs related to national security or international regulations, the security of an optical fibers is essential. The comparison of frequency from an optical clock is also fundamental for enhanced accuracy in measurements. While techniques for fiber optic communication are in constant development, with data rates exceeding 400 Gbit/s, the evolution of techniques for time or frequency transfer over fiber must follow a different path. While the necessary bandwidth is low, the requirements for stability and symmetry are huge, and not easily handled. The difference in transfer of frequency in comparison to time is also fundamental, since it relates either to the momentary change in phase or delay, or the accumulated changes. This tutorial will demonstrate the background of fiber optics, from the physics of light confinement in glass fibers to the limitations that must be overcome, including attenuation, dispersion, polarization and environmental variations. It will conclude with the presentation of the latest state-of-the-art time and frequency transfer results, which have been experimentally demonstrated around the globe.

Dr. Sven-Christian Ebenhag received his PhD from Chalmers University of Technology in Sweden. Since 2002 has he worked at the SP Technical Research Institute of Sweden, where he is one of the senior scientists in the implementations of time and frequency transfer over a national fiber communication network.
ITM/PTTI PLENARY KEYNOTES

Atomic Timekeeping as a Hobby
9:40 a.m. - 10:20 a.m.
Tom Van Baak
Leapsecond.com

Ancient Chinese Time Service and Navigation Technology
10:20 a.m. - 11:00 a.m.
Dr. Xiaochun Lu
Chinese Academy of Sciences, China

Galileo System Status and Challenges Ahead
11:00 a.m. - 11:40 a.m.
Marco Falcone
European Space Agency, The Netherlands

INTRODUCTION
9:30 a.m. - 9:40 a.m.

KEYNOTE PRESENTATIONS
9:40 a.m. - 11:40 a.m.

EXHIBITOR PRESENTATIONS
11:40 a.m. - 12:40 p.m.

LUNCH IN THE EXHIBIT HALL
12:45 p.m. - 1:45 p.m.
Session A1: DFMC Airborne Error Models
Room: Bayview Ballroom 1
1:45 p.m. – 5:30 p.m.

1:50 Standardization of New Airborne Multipath Models: Michael Felux, Mihaela-Simona Circiu, Stefano Caizzone, Markus Rippel, German Aerospace Center (DLR), Germany; Pierre Durel, GSA; Matteo Sgammini, EC, Italy

2:12 Multipath Suppression Capability and Indicators for Airborne Dual Frequency GNSS Antennas: S. Caizzone, M.-S. Circiu, W. Elmarissi, C. Enneking, A. Winterstein, German Aerospace Center (DLR), Germany

2:35 Airborne Multipath Models for Dual-constellation Dual-frequency Aviation Applications: Mihaela-Simona Circiu, Michael Felux, Stefano Caizzone, Christoph Enneking, Friederike Fohlemister, Markus Rippel, German Aerospace Center (DLR), Germany; Ioana Gulei, David Rüegg, Airbus Defence and Space GmbH, Germany; Joseph Griggs, Collins Aerospace; Rémy Lazzerini, Florent Hagemann, Francois Tranchet, Airbus Operation SAS; Pierre Bouniol, Thales Avionics; Matteo Sgammini, Joint Research Centre, Italy

2:58 Effects of Preliminary DFMC Multipath Models on ARAIM Performance: Joseph Griggs, Collins Aerospace; Markus Rippel, Mihaela-Simona Circiu, Stefano Caizzone, German Aerospace Centre (DLR), Germany

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

4:00 GMP-Overbound Parameter Determination for Measurement Error Time Correlation Modelling: Sandeep Jada and Mathieu Joerger, Virginia Tech

4:23 Impact of DME/TACAN on GNSS L5/ESa Receiver: Axel Javier Garcia Pena, Christophe Macabiau, ENAC, France; Mikael Mabilleau, Pierre Durel, GSA, France

4:46 Impact of Satellite Biases on the Position in Differential MFMC Applications: Steffen Thoelt, Mihaela-Simona Circiu, Michael Meurer, German Aerospace Center (DLR) and RWTH Aachen University, Germany

Session B1: Advanced Signal Processing for GNSS Receivers
Room: Bayview Ballroom 2
1:45 p.m. – 5:30 p.m.

1:50 GPS L1CA/BDS B1I NLOS Signal Measurements and Modeling in Dense Urban Area: Xin Chen, Shanghai Jiao Tong University, China; Y. Jade Morton, University of Colorado Boulder; Di He, Shanghai Jiao Tong University, China

2:12 Intermediate Frequency Level GPS Multipath Simulator based on Vector Tracking and Ray-tracing: Bing Xu and Li-Ta Hsu, The Hong Kong Polytechnic University, Hong Kong; Taro Suzuki, Chiba Institute of Technology, Japan

2:35 Extended Short Multipath Insensitive Code Loop: Xu Weng, Yanhong Kou, Beihang University, China

2:58 Robust Interference Mitigation: a Measurement and Position Domain Assessment: D. Bori, C. Gioia, European Commission, Joint Research Centre, Ispra, Italy

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

4:00 Hybrid Carrier Tracking and Position Determination using the Low Elevation Satellite Signals: Rong Yang, Xingqun Zhan, Shanghai Jiao Tong University, China; Yang Wang, Y. Jade Morton, University of Colorado, Boulder; Jennifer S. Haase, University of California-San Diego

4:23 Implementation and Analysis of a GPS Differential Vector Delay/Frequency Lock Loop (DVFDLL): Tanner M. Watts, Scott M. Martin, David M. Bevly, Auburn University

4:46 Measurements of GNSS Pseudorange Biases Induced by SIS Distributions: Yanhong Kou, Yanshu Zhang, Huiwen Wu, Beihang University, China

5:08 GNSS Interconstellation Time-Offset Estimates from LEO CubeSat and Performance Improvement Analysis on High Altitude SSV in Terms of GDOP: Sabrina Ugaizzly, Brian C. Peters, Kevin Croissant, Gregory Jenkins, Ryan McKnight, and Frank van Graas, Ohio University

Alternates
2. Experimental Validation of IMM Algorithm for Carrier Phase Tracking Through Interference: Wengxiang Zhao and Boris Pervan, Illinois Institute of Technology
4. Interference Detection based on Fractional Fourier Transform for GNSS Receivers: Kewen Sun, Hefei University of Technology, China

Session P1a: Laboratory Reports and Activities
Room: Bayview Foyer
1:45 p.m. – 5:10 p.m.

1:50 PTB’s Time and Frequency Services 2018 – 2019: Dirk Piester, Andreas Bauch, Jürgen Becker, Martin Gutbrod, Tobias Klein, Thomas Polewka, Dieter Sibold, Egle Staliuniene, Kristof Teichel, Wilfried Vajen, Physikalisch-Technische Bundesanstalt (PTB), Germany

2:12 Update on Time and Frequency Activities at NIST: Elizabeth Donley, National Institute of Standards and Technology

2:35 Time and Frequency Activities at the JHU Applied Physics Laboratory: Mihran Miranian, Jeffrey F. Garstecki, Olukayode K. Okusaga, Richard A. Dragonette, Gregory L. Weaver, JHU/Applied Physics Laboratory


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

4:00 Time and Frequency Laboratory Activities at RISE: Carsten Rieck, Kenneth Jaldehag and Sven-Christian Ebenhag, Measurement Science and Technology, RISE, Sweden

4:23 Homogeneous UTC: Timing Problems in Russia: I. Blinova, S. Donchenko, A. Karaush, N. Kosheliaevskii, and A. Naumov, VNIITF, Russia

4:46 Report on UTC Lab Activities at ESA/ESTEC: P. Waller, A. Sampiri, R. Valceschini, ESA/ESTEC, Netherlands

Session P1b: Poster Session
Room: Bayview Foyer
5:10 p.m. – 5:45 p.m.

1. The Portable Cesium Clock Time Transfer at the Nano Second Level: Shinn Yan Lin, Wen-Hung Tseng, Telecommunications Laboratories, Taiwan

2. Alternative Spectral Windows for Precise Time Fibre Based Transport: Josef Vojtech, Ondrej Havlis, Martin Slapak, Sarbojeet Bhowmick, Jan Radil, Petr Munster, Tomas Horvath, Radek Velec, Jan Kundrat, Lada Altmannova, Vladimir Smetlach, Rudolf Vohnout, Martin Michal, Pavel Skoda, Michal Hazlinsky, Vaclav Kurnabrt, CESNE a.s., Czech Republic; Jan Hrabina, Martin Cizek, Lenka Pravdova, Simon Rerucha, Ondrej Cip, ISI CAS, Czech Republic
8:35  GNSS Spoofing Detection and Identification Based on Clock Drift Monitoring Using Only One Signal: Shunshun Shang, Hong Li, Yimin Wei, Mingquan Lu, Tsinghua University, China

8:57  A Research on Modeling and Monitoring of New BDS B1C Signal Distortions in the Context of Beidou Satellite-Based Augmentation System: Kefan Wei, Xiaowei Gu, Mingquan Lu, Tsinghua University, China

9:20  EWF Monitoring in SBAS Applied to Galileo E1c and E5a Signals Using SQM2b and Code-Carrier Incoherence Monitor: Ikhal Selmi, Paul Thevenon, Christophe Macabiau, ENAC, France; Michael Mabileulle, Pierre Durel GSA, France

9:43  GBAS Integrity Performance Evaluation Based on the Mixed g-and-h Distribution: Ludan Song, Kun Fang, Jisi Fang, Zhipeng Wang, Beihang University, China

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

10:40  Evaluating PPP Integrity for Aviation Using Flight Data: R. Eric Phelts, Kazuma Gunning, Juan Blanch, Todd Walter, Stanford University

11:03  Fault Detection and SIS Error Validation Method Tailored for an ARAIM ISM Generator Including Recommendations on the Ground Network: Matteo Sgammini, European Commission, Joint Research Centre (JRC), Italy; Ilaria Martin, European Commission, Belgium; Boris Pervan, Illinois Institute of Technology

11:26  ARAIM Continuity and Availability Assumptions, Assertions, and Evaluation Methods: Mathieu Joerger, Virginia Tech; Yawei Zhai, Daniel Medina, Ralf Ziebold, German Aerospace Center (DLR), Germany

11:48  Stress Testing Advanced RAIM Airborne Algorithms: Juan Blanch and Todd Walter, Stanford University

Alternate 1. The Post-broadcast Integrity System of Qianxun for SSR Service: Qilong Zhao, Hailin Guo, Shuai Jing, Jianhong Wu, Pumin Xin, Wenjia Mei, Jianping Wang, Yantong Feng, Xiaowei Hou, Yingming Jiang, Jie Chen, Shuai Li and Shaojun Feng, Qianxun Spatial Intelligence Inc., China

Alternate 2. Application of GNSS-Reflectometry for Vertical Datum Determination in Alaska: Su-Kyung Kim, Datum Determination in Alaska: Su-Kyung Kim, Datum Determination in Alaska; P. J. G. Teunissen, Curtin University of Technology, Australia; and Delft University of Technology, The Netherlands

11:48  State-space Positioning Corrections with Single-receiver GNSS Data: A. Khodabandeh and N. Nadarajah, University of Melbourne, Australia

Alternates 1. Best Integer Equivariant Estimation for Low-cost, Single- and Dual-frequency, Multi-GNSS RTK Positioning: R. Odolinski, University of Otago, New Zealand; P. J. G. Teunissen, Curtin University of Technology, Australia; and Delft University of Technology, The Netherlands

2. Application of GNSS-Reflectometry for Vertical Datum Determination in Alaska: Su-Kyung Kim, Datum Determination in Alaska; P. J. G. Teunissen, Curtin University of Technology, Australia; and Delft University of Technology, The Netherlands

3. Optimal GNSS Satellites Selection Using Second-Order Cone Programming: L. B. Rapoport, Topcon and Institute of Control Sciences; T. A. Tornagov, MIPT and Institute of Control Sciences, Russia

12:15 p.m. - 1:45 p.m. • Lunch in Exhibit Hall • Regatta Pavilion
Session A3: Challenges for Unmanned Aerial Vehicles and Autonomous Systems  
**Room:** Bayview Ballroom 1  
**Time:** 1:45 p.m. – 5:30 p.m.

1:50 Integrity Monitoring and Prediction Concept and Prototype for Fully Autonomous Vehicle Resilience and Safety: R. Tiwari and T. Stacey, Nottingham Scientific Ltd., UK; Felix Toran, European Space Agency (ESA), EGNOS Project Office, France

2:12 Error Bounds of the GNSS/INS Integrated System Against GNSS Fault for Integrity Monitoring: Wei Liu, Dan Song, Zhipei Wang, Yanbo Zhu, Qiang Li, Beihang University, China

2:35 GNSS/INS Tightly Coupled Scheme with Weighting and FDE for Rail Applications: Xin Han, BJTU/Ifsttar, France; Syed Ali Kazim, Ifsttar, France; Nourdine Altazirte, IRT Rallienium, France; Juliette Marais, Univ. Gustave Eiffel, France; Debiao Lu, BJTU, China

2:58 Observing User-segment Faults in the Residuals of a Consensus-based Multi-GNSS Solution: Zhen Zhu, East Carolina University; Eric Vinande, Jason Pontious, AFRL – Sensors Directorate

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

Session B3a: Pedestrian and Indoor Localization  
**Room:** Bayview Ballroom 2  
**Time:** 1:45 p.m. – 2:35 p.m.


2:12 TOA Estimation for Positioning with 5G NR Signals in Indoor Field Tests: Liang Chen, Xin Zhou, Feifei Chen and Ruizhi Chen, Wuhan University, China

2:35 Pedestrian Navigation in Urban Area Using GNSS Raw Data with Smartphones: Shinya Miyai, Yusuke Amano and Yukihiro Kubo, Ritsumeikan University, Japan

2:58 Pedestrian Navigation Fusing Artificial Neural Networks for Localization and Pedestrian Dead Reckoning with an Extended Kalman Filter: David J. Ellis, Joseph A. Curro, Clark Taylor, Air Force Institute of Technology

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

Session B3b: High-Performance GNSS Receivers  
**Room:** Bayview Ballroom 2  
**Time:** 3:55 p.m. – 5:30 p.m.

4:00 GNSS C/N0 Degradation Model in Presence of Continuous Wave and Pulsed Interference: Axel Javier Garcia Pena, Christophe Macabiau, ENAC, France; Mikael Mabilleau, Pierre Durel, GSA, France

4:23 Modeling Multipath Effects on Frequency Locked Loops: Liangchun Xu and Jason H. Rife, Tufts University

4:46 Combining and Integration Schemes for Acquisition of Weak GNSS Split-Spectrum Signals: Chuan Yang, Andrey Soloviev, QuNav; Jung C. Ha, AFRL/Ryan

5:08 A New Satellite Selection Method based on the Artificial Fish Swarm Optimization Algorithm: Ershen Wang, Sun Caimiao, Pingping Qu, Tao Pang, Chuanyun Wang, He He, Xu Song, Shenyang Aerospace University, China

5:30 A Molecular Clock Architecture for Deep Space Inter-SmallSat Radio Occultation: Lin Yi, Jet Propulsion Laboratory, California Institute of Technology; Mina Kim, Zhi Hu, Massachusetts Institute of Technology; Chi Ao, Eric Burt, Robert Tjoelker, Imran Mehdi, Jet Propulsion Laboratory, California Institute of Technology; Ruonan Han, Massachusetts Institute of Technology

2:12 Portable Cold Rubidium Atom Frequency Standard: Miao Zhu, Kisra Egodapitya, Brian Patton, Alan Bell, Thang Tran, Doug Harvey, Brenton Young, Gerald Wong, Frank Roller, Joshua Zirbel, Guillaume Plateau, Nathani Shou, Jamil Abo-Shaeeer, Martin Boyd, AOSense, Inc.

2:35 Development of a High-Accuracy Transportable Single Ion Optical Clock at NRC: Pierre Dubé, John E. Bernard, Bin Jian, National Research Council Canada

2:58 Spectral Purity Transfer at the 1E-18 Level and Frequency Chain Assessment with Three Different Optical Frequency Combs: Héctor Álvarez-Martínez, Real Instituto y Observatorio de la Armada, Spain; Christian Barrentes, Yann Le Coq, and Rodolphe Le Target, LNE-SYRTE, Observatoire de Paris, Université PSL, CNRS, France

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

Session P3a: Advances in Next Generation Clocks  
**Room:** Bayview Ballroom 3  
**Time:** 1:45 p.m. – 3:25 p.m.

1:50 A Low-Cost High-Precision Vehicle Navigation System for Urban Environment using Time Differenced Carrier Phase Measurements: Jungbeom Kim and Changdon Kee, Seoul National University, South Korea

2:12 A Multi-Sensor Navigation System for Outdoor and Indoor Environments: Karsten Mueller, Jamal Atman, Institute of Systems Optimization (ITE), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany; Gert F. Trommer, IRE, KIT, Germany and ITMO University, Russia

2:35 Development of a Model and Estimation Method to Represent Team Search with Uncertain Detection: Audrey Balaska and Jason H. Rife, Tufts University

Alternate

1. Vulnerability Assessment of Integrated GNSS Receivers to Spoofing Attacks: Akmal Rustamov, Turin Polytechnic University, Italy; Alex Minetto, Fabio Dovis, Politecnico di Torino, Italy

2. Robust GNSS Estimation using Factor Graphs, Modified Gaussian Mixture Model and a Transformed Domain Method: Xin Zhang, Shanghai Jiao Tong University, China; Min Xu, Zhenjun Zhang, ComNav Technology, Co., Ltd., China


4:00 Resilient Timekeeping for Critical Infrastructure: John Fischer, Orolia

4:23 Industrial “5G” Telecom Infrastructure Time and Frequency Reference: Jean-Charles Fohlmeister, Université PSL, CNRS, France; Gert F. Trommer, IRE, KIT, Germany and ITMO University, Russia

4:46 Common Calendar Timestamp System: Brooks Harris, EdlMax LLC

5:08 A Molecular Clock Architecture for Deep Space Inter-SmallSat Radio Occultation: Lin Yi, Jet Propulsion Laboratory, California Institute of Technology; Mina Kim, Zhi Hu, Massachusetts Institute of Technology; Chi Ao, Eric Burt, Robert Tjoelker, Imran Mehdi, Jet Propulsion Laboratory, California Institute of Technology; Ruonan Han, Massachusetts Institute of Technology

2:12 Portable Cold Rubidium Atom Frequency Standard: Miao Zhu, Kisra Egodapitya, Brian Patton, Alan Bell, Thang Tran, Doug Harvey, Brenton Young, Gerald Wong, Frank Roller, Joshua Zirbel, Guillaume Plateau, Nathani Shou, Jamil Abo-Shaeeer, Martin Boyd, AOSense, Inc.

2:35 Development of a High-Accuracy Transportable Single Ion Optical Clock at NRC: Pierre Dubé, John E. Bernard, Bin Jian, National Research Council Canada

2:58 Spectral Purity Transfer at the 1E-18 Level and Frequency Chain Assessment with Three Different Optical Frequency Combs: Héctor Álvarez-Martínez, Real Instituto y Observatorio de la Armada, Spain; Christian Barrentes, Yann Le Coq, and Rodolphe Le Target, LNE-SYRTE, Observatoire de Paris, Université PSL, CNRS, France

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

Session P3b: Timekeeping in Commercial Applications  
**Room:** Bayview Ballroom 3  
**Time:** 3:55 p.m. – 5:30 p.m.

4:00 Resilient Timekeeping for Critical Infrastructure: John Fischer, Orolia

4:23 Industrial “5G” Telecom Infrastructure Time and Frequency Reference: Jean-Charles Fohlmeister, Université PSL, CNRS, France; Gert F. Trommer, IRE, KIT, Germany and ITMO University, Russia

4:46 Common Calendar Timestamp System: Brooks Harris, EdlMax LLC
Session A4a: Challenges in Terrestrial and Urban Environments  
Room: Bayview Ballroom 1  
8:30 a.m. – 10:05 a.m.

8:35 Robust Estimators in Multiconstellation GNSS Positioning for Urban Environments:  
Omar Garcia Crespiollo, Alice Andreotti, Anja Grosch, German Aerospace Center (DLR), Germany

8:57 Prediction of RTK-GNSS Performance in Urban Environments Using 3D Model and Continuous LoS Method:  
Rei Furukawa, Tokyo University of Marine Science and Technology / KOZO KEIKAKU ENGINEERING, Inc., Japan; Nobuaki Kubo, Tokyo University of Marine Science and Technology, Japan; Ahmed El-Mowafy, Curtin University, Australia

9:20 Improved Integration Method of Wide-area RTK/PPP with IMU and Odometer:  
Nobuaki Kubo, Daisuke Hatta, Kaito Kobayashi, Kyohei Aoki, TUMSAT, Japan

9:43 Improved Urban Navigation with Specular Matching and Direct Positioning:  
Kirsten L. Strandjord, Draper & University of Colorado Boulder; Penina Axelrad, University of Colorado Boulder; Shan Mohiuddin, Draper

10:05-10:35, Break. Refreshments in Foyer

Session A4b: Alternatives, Backups and Complements to GNSS  
Room: Bayview Ballroom 1  
10:35 a.m. – 12:15 p.m.

11:03 Pseudorange Measurements with LTE Physical Channels:  
Auryn Pink Soderini, Paul Thevenon, Christophe Macabiau, ENAC, France; Laurent Borgagni, John Fischer, Orolia

11:26 Description of VBOC2(1alpha1,1alpha2) GMGM Special Cases Waveforms:  
Theory, Computation, Simulations, and Animation:  
Ilir F. Progr, Gift inc.

11:48 Integrated THz Relative Positioning:  
Navigation Algorithm and Simulation:  
John Scott Parker, Tufts University & Draper; Jason Rife, Tufts University

Alternate

1. Sky-wave Error Mitigation Approaches for the Medium-frequency R-Mode Radio Navigation System:  
Niklas Hehenkamp, Lars Grundhoer, and Stefan Gewies, German Aerospace Center (DLR), Germany

Session B4: Atmospheric and Space Weather  
Room: Bayview Ballroom 2  
8:30 a.m. – 12:15 p.m.

8:35 Unscented Kalman Filter based Carrier Tracking to Mitigate Ionospheric Scintillation Threat in High-latitude for Maritime PNT:  
R. Tiwari and J. Yin, Nottingham Scientific Ltd., UK; Stig Erik Christiansen, Kongsberg Seatex AS, Norway

8:57 One Year GNSS Ionospheric Scintillations Recording in the Arctic Area of Icebreaker ‘Polarstern’:  
Friederike Fohmleiter, Lothar Kurz, Simon Plass, Martin Kriegel, German Aerospace Center, (DLR), Germany

9:20 Performance Benefit from Dual-Frequency GNSS-based Atmospheric Disturbance Under Ionospheric Scintillation: A New Approach on Fading Process Modeling:  
Kiyoung Sun, Hyeyeon Chang, and Jiyun Lee, Korea Advanced Institute of Science and Technology, South Korea; Jiwon Seo, Yonsei University, South Korea; Y. Jade Morton, University of Colorado Boulder; Sam Pullen, Stanford University

9:43 Errors Analysis and Improvement on Estimating Low Latitude Ionospheric Delay Gradient Based on GPS/BDS Observations:  
Qiang Li, Yanbo Zhu, Beihang University & Aviation Data Communication Corporation, China; Zhipeng Wang, Wei Liu, Zhen Gao, Beihang University, China

10:05-10:35, Break. Refreshments in Foyer

10:40 BDS/AeroMACS Integrated Positioning Algorithm for Airport Surface Surveillance:  
Wang Zhipeng, Gao Zhen, Du Jingtian, Zhu Yanbo, Beihang University, China

11:03 Climatology of High and Low Latitude Scintillation in the Last Solar Cycle by Means of the Geodetic Detrending Technique:  
A. Rovira-Garcia, G. Gonzalez-Casado, J.M. Juan, J. Sanz, Universidad Polit&953;cnica de Catalunya (UPC), Spain; Raúl Orús-Pérez, European Space Agency (ESA)

11:26 Statistical Detection Threshold for TRNET Tracking to Mitigate Ionospheric Scintillation Threat in High-latitude:  
Dr. Bugyeom Kim, O-Jong Kim, Changdong Kee, Seoul National University, South Korea

11:48 Impact of Tropospheric Anomalies on GBAS Integrity:  
Yuanjuan Zhuang, Zhipeng Wang, Kun Fang, Yanbo Zhu, Beihang University, China

Session B4a: Time and Frequency Transfer Using GNSS and RNSS  
Room: Bayview Ballroom 3  
8:30 a.m. – 10:05 a.m.

8:35 Recent Results of Galileo Timing Services for Professional and Metrological Users:  
P. Waller, A. Samperi, R. Valceschini, ESA/ESTEC, The Netherlands

8:57 Using Broadcast Time Offsets for Multi-Constellation Users in Harsh Environments:  
Flore Meilman, Rafael Lucas Roque, Paola Crosta, Gaetano Galluzzo, Xunro Otero Villamile, Joerg Hahn, European Space Agency, The Netherlands

9:20 An Update on the use of GNSS Signals at PTB:  
Dirk Piester, Andreas Bauch, Thomas Polewka, Ege Staliuniene, Physikalisch-Technische Bundesanstalt (PTB), Germany

9:43 A New Approach to Improve Satellite Clock Estimates, Removing the Inter-day Jumps:  
J.M. Juan, J. Sanz, A. Rovira-Garcia, G. Gonzalez-Casado, Universidad Polit&953;cnica de Catalunya (UPC), Spain; J. Ventura-Traveset, L. Cacciapuoti, E. Schoenemann, European Space Agency (ESA), France

10:05-10:35, Break. Refreshments in Foyer

Session P4a: PTTI Applications and Techniques  
Room: Bayview Ballroom 3  
10:35 a.m. – 12:15 p.m.

10:40 Galileo Timing and Synchronisation Application Offering Architecture:  
Valeria Catalano, Reinhard Blas, European GNSS Agency – GSA, Czech Republic; Carla Filotico, SpaceTec Partners; Franco Gottifredi, GEA Space

11:03 Experimental Plans for the Navigation Timing Satellite (NTS-3) with Regards to the Time Keeping System:  
Kyle W. Martin, Applied Technology Associates; John Janis, L3Harris; Joanna Hinks, John Elgin, Gordon Lott, Air Force Research Laboratory Space Vehicles Directorate; Benjamin K. Stuhl, Space Dynamics Laboratory

11:26 A Master/Slave Ensembling Algorithm for CubeSat Missions:  
James Camparo, Travis Driskell, The Aerospace Corporation

11:48 Extensive Cosmic Showers Detection:  
Metrological Characterization and Optimization of the EEE Timing System:  
G. Cerretto, D. Calonico, E. Cantoni, F. Levi, A. Mura, M. Sellone, Istituto Nazionale di Ricerca Metrologica (INRIM), Italy; and the EEE Collaboration, Museo Storico della Fisica e Centro Studi e Ricerche Enrico Fermi, Italy

12:15 p.m. - 1:45 p.m. • Award Luncheon • Regatta Pavilion (Late arrivals will not be served after 12:30 p.m.)
**Session A5: GNSS and Security: Jamming and Spoofing**  
**Room: Bayview Ballroom 1**  
2:00 p.m. – 5:10 p.m.

- **2:05** Independent Time Synchronisation for Resilient GNSS Receivers: Ignacio Fernandez-Hernandez, European Commission, Belgium; Todd Walter, Andrew Neish, Stanford University
- **2:27** A Real-time OSNMA-ready Software Receiver: Beatrice Motella, Micaela Troglia Gamba, Mario Nicola, LINKS Foundation, Italy
- **2:49** A Flexible Replay Delay Control Method for GNSS Direct Meaoning Signal: Shunshun Shang, Hong Li, Yimin Wei, Mingquan Lu, Tsinghua University, China
- **3:40** Polyphase Decomposition based Space Frequency Adaptive Processing in Antenna Array GNSS Receivers: Xiangming Chang, Xiaowei Cui, Mingquan Lu, Tsinghua University, China
- **4:24** GNSS Anti-jam RF-to-RF On Board Unit for ERTMS Train Control: Cosimo Stallo, Pietro Salvatori, Andrea Coluccia, Radiolabs, Italy; Alessandro Neri, Massimo Massaro, University of Roma TRE, Italy; Francesco Rispoli, Hitachi Rail STS, Italy; Massimiliano Ciaffi, RFI, Italy
- **4:46** Receiver States for SBAS Data Authentication: Andrew Neish, Todd Walter, Stanford University; Ignacio Fernandez-Hernandez, European Commission, Belgium

**Session B5a: Timing for PNT Resilience**  
**Room: Bayview Ballroom 2**  
2:00 p.m. – 3:10 p.m.

- **2:05** A Next-generation, Miniaturized Rub Atomic Clock Reference for Mobile, GNSS-denied Environments: William Krzewicz, Jamie Mitchell, John Bollettiero, Peter Cash, Kevin Wellwood, Igor Kosvin, Microchip Technology Inc.
- **2:27** Precise and Continuous Time and Frequency Transfer with Carrier Phase Compensation in Satellite Ground Link: H. J. Liang, S.C. Sun, Y. Bai, S.G. Wang, L.J. Wang, Tsinghua University, China
- **2:49** Moving Receiver PVT Solution Authentication Based on Monitoring the Combination of Clock Bias and Drift: Zhiyuan Chen, Hong Li, Shunshun Shang, Yimin Wei, Mingquan Lu, Tsinghua University, China

**Session B5b: Integrated Navigation Systems**  
**Room: Bayview Ballroom 2**  
3:35 p.m. – 5:10 p.m.

- **3:40** Integrity/Continuity Algorithm of a Tightly-coupledKF based GNSS/IMU Navigation System with Redundant IMUs: Jinsil Lee, Dongwoo Kim, Dongchan Min, Kihun Nam, and Jiyun Lee, Korea Advanced Institute of Science and Technology, South Korea
- **4:02** Mitigation of Odometry Drift with a Single Ranging Link in GNSS-limited Environments: Young-Hee Lee, Technical University of Munich (TUM), Germany; Chen Zhu, Gabriele Giorgetti, German Aerospace Center (DLR), Germany; Christoph Günther, TUM and DLR, Germany
- **4:24** Wheel-based Aiding of Low-cost IMU for Land Vehicle Navigation in GNSS Challenging Environment: M. Moussa, A. Moussa, University of Calgary, Canada; M. Elhabibiy, Ain Shams University, Egypt; N. Elsheimy, University of Calgary, Canada
- **4:46** Resilient Sensor Management for Dismounted Assured-PNT: Shahram Moafi spoiled, Lydia Bock, Jeffrey A. Fayman, Geodetics Inc.

**Alternates**

1. A New Navigation System for Unmanned Aerial Vehicles in Global Positioning System-Denied Environments Based on Image Registration with Mutual Information and Deep Learning: Cagla Sahin, TOBB University of Economics and Technology and Turkish Aerospace, Turkey; Imam Samil Yetik, TOBB University of Economics and Technology, Turkey

**Session P5a: Timescales and Algorithms**  
**Room: Bayview Ballroom 3**  
2:00 p.m. – 3:35 p.m.

- **2:05** Proportional-Integral-Derivative (PID) Controllers and “Real-world” Clocks: Demetrios Matsakis, Masterclock, Inc.
- **2:27** Analysis of the Long-term Stability of a Homogenous Cesium Standard Ensemble for Future System Time Generation: Ludwig Blümel, Tobias D. Schmidt, Christian Trinotti, German Aerospace Center (DLR), Germany; Johann Further, Galileo Competence Center, DLR, Germany
- **2:49** Reliable and Robust Real-time Time Scale Generation: Developments and Experimental Results at INRIM: V. Formichella, G. Signorile, T. T. Thai, A. Perucca, E. Cantoni, M. Sellone, A. Mura, Quantum Metrology and Nano Technologies Division, INRIM, Italy; M. Siccardi, SKK Electronics, Italy; G. D. Rovera, LNE-SYRTE, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, France; I. Sesia, L. Levi, Quantum Metrology and Nano Technologies Division, INRIM, Italy
- **3:11** Use of a Precise Ensemble Clock to Combine the Outputs of Frequency and Time Standards Getting an Even More Precise Output Signal: Werner Lange, Lange-Electronic GmbH, Germany

**Session P5b: Emergent Timing Infrastructure for GNSS Providers**  
**Joint PTTI/ITM Session**  
**Room: Bayview Ballroom 3**  
3:35 p.m. – 4:45 p.m.

- **3:40** Detection and Identification of Phase and Frequency Drifts in Clock Ensembles: Christian Tranotti and Gabriele Giorgetti, German Aerospace Center (DLR), Germany
- **4:24** The GIANO Project: Development of a Galileo-Based Timing Receiver for Increasing Critical Infrastructures Resilience: Livio Marradi, Gianluca Franzoni, Marco Puccitteri, Roberto Campagna, Thales Alenia Space, Italy; Valeria Catalano, European GNSS Agency; Roberto Muscinelli, Business Integration Partners, Italy; Pawel Nogas, PtkTime Systems, Poland; Jerzy Nawrocki, Edoardo Detoma, Space Research Center PAS, Poland; Ricardo Prata, Deimos, Portugal

Refreshments will be available in the Foyer at 3:30 p.m.
EXHIBIT HALL

Show Hours:

Wednesday, January 22
8:30 a.m. – 5:00 p.m. Exhibit Hall Open
8:30 a.m. – 9:30 a.m. Exhibitor Hosted Breakfast

Thursday, January 23
8:00 a.m. – 4:30 p.m. Exhibit Hall Open

Exhibitors:

- ALBEDO TELECOM, Inc. (Booth 13)
- Brandywine Communications (Booth 14)
- Cycle GmbH (Booth 10B)
- CAST Navigation (Booth 3)
- Frequency Electronics, Inc. (Booth 8)
- GuideTech (Booth 7)
- IFEN, Inc. (Booth 9)
- Jackson Labs Technologies, Inc. (Booth 10)
- Labsat By Racelogic (Booth 18)
- Masterclock Inc. (Booth 5)
- Microchip Technology Inc. (Booth 6)
- NEL Frequency Controls, Inc (Booth 16)
- Orolia Switzerland Inc. (Booth 2)
- Oscilloquartz SA (Booth 15)
- Pendulum Instruments Inc. (Booth 19)
- Spectradynamics Inc. (Booth 17)
- Spirent Federal Systems (Booth 11)
- Syntony GNSS (Booth 20)
- The Institute of Navigation (Booth 16B)
- TimeTech GmbH (Booth 4)
- Vescent Photonics (Booth 1)

Bold = ION Corporate Member
List current as of 1/3/20