



IEEE

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ISPCS 2025

International IEEE Symposium on Precision Clock Synchronization
for Measurement, Control, & Communication

INTERNATIONAL IEEE SYMPOSIUM ON PRECISION CLOCK SYNCHRONIZATION
FOR MEASUREMENT, CONTROL, & COMMUNICATION

SYMPOSIUM PROGRAM

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Message from the General Co-Chairs

Welcome to the 2025 International IEEE Symposium on Precision Clock Synchronization (ISPCS) for Measurement, Control, and Communication. This year, we are gathering in Ottawa, Canada, a hub for research and innovation in communications, networking, and computing. Our symposium will take place at the Holiday Inn & Suites Ottawa Kanata, followed by a visit to Defence Research and Development Canada (DRDC), where participants will see firsthand some of Canada's leading contributions to precision timing and synchronization.

As in previous years, ISPCS continues to serve as the premier forum for exchanging ideas on precision clock synchronization. We will address the latest research and development results from academia, industry, and government.

The IEEE Instrumentation and Measurement Society (IMS) has sponsored ISPCS annually under the leadership of the Technical Committee on Sensor Technology (TC-9) since 2007. This year, we are thrilled to have the IMS President, Dr. Shervin Shirmohammadi, of the University of Ottawa, welcome and address the ISPCS participants.

Also, we are honored to announce our keynote speaker for ISPCS 2025: Dr. Boris Braverman. Optical atomic clocks have transformed precision timekeeping, offering superior stability and accuracy compared to their microwave-based counterparts. A key challenge in achieving this performance is mitigating Doppler shifts caused by the thermal motion of atoms, which limits spectroscopic resolution. Traditionally, this challenge is addressed by tightly confining atoms, as in optical lattices and ion clocks. An emerging alternative is Doppler-free excitation via multi-photon processes, where Doppler shifts of the individual laser beams cancel out. In his keynote, Dr. Braverman will explore the advantages and limitations of Doppler-free approaches, highlighting recent developments in two- and three-photon optical clocks. These systems promise to rival and even surpass microwave clocks in performance, while offering simplicity and robustness.

ISPCS consists of a Plugfest and a symposium. It provides an excellent opportunity for attendees to discover the latest developments in precise clock synchronization and distributed time-based research, as well as learn about the state-of-the-art advancements in these areas. The Plugfest remains a cornerstone of ISPCS, providing implementers of the IEEE 1588 Precision Time Protocol (PTP) standard with the opportunity to test their equipment for interoperability. These annual events ensure that PTP-based systems are robust and interoperable, strengthening the industry ecosystem. Following the success of last year's contest-style Plugfest with Time Stick, we are excited to continue this enhanced format. Once again, we would like to challenge participants with a defined objective, and with results benchmarked and compared across different perspectives. This format has proven to foster innovation, collaboration, and spirited technical exchange and challenge.

We sincerely thank our supporters and sponsors whose contributions are essential in making ISPCS possible and successful year after year. Your commitment to advancing precision timing and synchronization helps ensure the symposium's continued success.

We are also grateful to the ISPCS Organizing, Plugfest, and Program Committees for their tireless dedication. Finally, we extend our thanks to the staff at the Holiday Inn & Suites Ottawa Kanata, Defence Research and Development Canada (DRDC), and Conference Catalysts for their efforts in bringing this year's event to life.

We look forward to meeting you at ISPCS 2025 in Ottawa!

Ahmad Byagowi and Kang B. Lee
ISPCS 2025 General Co-Chairs

Message from the Program Co-Chairs

On behalf of the Program Committee, we are honored to welcome all speakers and attendees to Ottawa for ISPCS 2025, the eighteenth IEEE Symposium on Precision Clock Synchronization for Measurement, Control, and Communication.

We are especially pleased that the conference will open with an introduction from Dr. Shervin Shirmohammadi, Professor at the University of Ottawa and President of the IEEE Instrumentation and Measurement Society. Additionally, the symposium will feature four keynote presentations this year, with speakers from the University of Toronto, the Canadian National Research Council, Xanadu Quantum Computing Company, and QA Labs.

This year's Call for Papers attracted a high number of high-quality submissions from across the globe. Reflecting the diversity of these submissions, the Program Committee itself is composed of members from various regions, representing both academia and industry. After a thorough review process, the committee selected 30 submissions to be presented at the symposium, including 14 full papers that will be published in the ISPCS 2025 proceedings.

We extend our warmest welcome to ISPCS 2025 and express our gratitude for your participation and valuable contributions.

Radim Bartos and Lee Cosart
ISPCS 2025 Program Committee Co-Chairs

ISPCS 2025: Symposium Committee

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Kang B. Lee, IEEE IMS TC-9

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For specifics on testing of PTP performance using ITU-T and O-RAN specifications, please see <https://www.keysight.com/zz/en/products/network-test/network-test-hardware/time-sync-analyzer.html>

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Albedo Telecom develops precision test, timing, and measurement solutions for telecom, power, and communications industries. Albedo's product suite supports network deployment, protocol verification, synchronization, and performance validation across technologies such as PTP, SyncE, IEC-61850, GOOSE, and packet-level diagnostics. Their tools enable customers to confirm that mission-critical infrastructure — and the applications built on it — meet rigorous reliability and timing standards.

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Microchip is a leading provider of smart, connected and secure embedded control and GNSS synchronization solutions. Its comprehensive portfolio enables customers to create optimal designs which reduce risk while lowering system cost and time to market. The company's solutions serve more than 120,000 customers in industrial, automotive, consumer, aerospace and defense, communications and computing markets. Microchip offers outstanding technical support along with dependable delivery and quality.



White Rabbit technology provides sub-nanosecond accuracy of synchronisation between devices on Ethernet networks. It is the most accurate implementation of the IEEE1588 standard and has now been adopted as the High Accuracy Default Profile of IEEE1588. CERN launched the White Rabbit Collaboration in 2024 to foster the uptake of the technology by industry. By pooling resources, the collaboration will ensure the IEEE1588 High Accuracy Profile is implemented through an open source core that is maintained and upgraded to the highest level of performance and support.

ISPCS 2025: Promotional Partners

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The National Institute of Information and Communications Technology (NICT) is a Japanese national research and development agency that promotes ICT R&D across a wide spectrum, from foundational research to practical implementation. NICT collaborates with universities, industry, local governments, and both domestic and international research institutions, aiming to drive innovation by contributing the results of its R&D to society.

NICT advances research in various fields of ICT, including space-time standards technology, focusing on Japan Standard Time and synchronization techniques. Additionally, in line with government strategy, NICT actively promotes R&D in the field of Beyond 5G, which is critical for next-generation ICT infrastructure and the early realization of Society 5.0.



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For more information, please visit www.decisivegroup.com

Plugfest: October 6, 2025 – October 7, 2025

Plugfest Chair: Douglas Arnold (Meinberg USA, USA)

Room: 2nd floor Kanata Ballroom

Monday, October 6, 2025

08:00 Registration Open
08:30 Room Open
09:00 Attendee set-up and default profile testing
10:00 Testing
12:00 Lunch
13:00 Power and telecom profile testing
17:00 Free Testing
19:00 End of sessions and Room Closed

Tuesday, October 7, 2025

08:00 Registration Open
08:30 Room Open
09:00 New profiles/technology testing
11:45 Lunch
13:00 New Profiles/Technology Testing
16:30 Tear Down and Pack Up
17:30 End of Session and Room Closed

Tutorial October 7, 2025

13:00 – 16:00

High-Dimensional (Tensor) Signal Processing

Session Chair: *Kang Lee (IEEE IMS TC-9, USA)*

Speaker: *Sherif S. Sherif, (University of Manitoba, Winnipeg, Canada)*

Algonquin Salon (2F)

Symposium: Wednesday, October 8, 2025

08:00 – 17:50
Registration Open

08:30 – 17:50
Exhibit Booths Open

08:30 – 08:40
Opening Session

Conference General Co-Chair Remarks

Ahmad Byagowi (Open Compute Project, Canada) and Kang Lee (IEEE IMS TC-9, USA)

Technical Program Committee Co-Chair Remarks

Lee Cosart (Microchip, USA) and Radim Bartos (University of New Hampshire, USA)

08:40 – 08:55
ISPCS 2025 Introduction
Session Chair: *Kang Lee (IEEE IMS TC-9, USA)*
Speaker: *Dr. Shervin Shirmohammadi, (President of the IEEE Instrumentation and Measurement Society)*

08:55 – 09:20
Keynote Presentation I
Title: **Doppler-free optical clocks**
Keynote: *Boris Braverman, (University of Toronto, Canada)*
Session Chair: *Boniface Yogendran, (Defence Research and Development, Canada)*

09:20 – 09:45
Keynote Presentation II
Title: **Time and Frequency Metrology: Atomic Clocks and the SI Second - Now and the Future**
Keynote: *Kosuke Kato, (National Research Council, Canada)*
Session Chair: *Boniface Yogendran, (Defence Research and Development, Canada)*

09:45 – 10:35
Session I: Papers
Session Chair: *Kang Lee (IEEE IMS TC-9, USA)*

09:45 **Conformity Assessment of IEC/IEEE 60802 Clock Control Systems: An approach using parameter estimation**
Tim Lohrmeier and Alexander Biendarra (Fraunhofer IOSB-INA, Germany)

10:10 **First inter-comparison of optical to electrical time delay calibrated photodetectors and calibration setup validation**
Peter Jansweijer and Nayib A. D. Boukadida (Nikhef, The Netherlands); Kalle Hanhijärvi and Anders Wallin (VTT Mikes, Finland)

Symposium: Wednesday, October 8, 2025

10:35 – 11:15

Morning Break

Algonquin Salon and Foyer (2F)

11:15 – 12:05

Session II: Papers

Session Chair: Radim Bartos, (University of New Hampshire, USA)

11:15 Precision Delay Measurement in Optical and Electrical Transitions: Achieving Picosecond-Level Uncertainty

Mohammad Monjur and Robert Noseworthy (InterOperability Laboratory, USA, University of New Hampshire, USA)

11:40 Cracking the Microsecond: An Efficient and Precise Time Synchronization Scheme for Hybrid 5G-TSN Networks

Michael Gundall (German Research Center for Artificial Intelligence GmbH (DFKI), Germany); Hans D. Schotten (RPTU Kaiserslautern-Landau, Germany)

12:05 Simulating a communication middleware for one-sided and collective operations

Camille Coti (Ecole de Technologie Supérieure, Canada); Martin Quinson (ENS de Rennes, France)

12:30 – 13:40

Lunch

Algonquin Salon and Foyer (2F)

13:40 – 15:20

Session III: Papers

Session Chair: Nikolaus Kerö (Oregano Systems, Austria)

13:40 Assessing Packet Timestamping Robustness in LoRa Networks under Concurrent Transmission

Stefano Rinaldi (University of Brescia, Italy); Elia Mondini (Italy); Emiliano Sisinni, Paolo Ferrari, Alessandra Flammini and Salvatore Dello Iacono (University of Brescia, Italy)

14:05 Mitigating Imprecise Timing in Spiking Neural Networks through Offset-Aware Training

Taylor Kergan and Rui-Jie Zhu (University of California, Santa Cruz, USA); Ahmad Byagowi (University of Manitoba, Canada); Jason K. Eshraghian (University of California, Santa Cruz, USA)

14:30 Improved Low-Cost PTP Grandmaster Clock Utilizing the Beaglebone Line of Single Board Computers

Tamás Kovács házy and Tung Hoang Nguyen (Budapest University of Technology and Economics, Hungary)

14:55 – 15:45

Afternoon Break

Algonquin Salon and Foyer (2F)

Symposium: Wednesday, October 8, 2025

15:45 – 17:50

Session IV: Papers

Session Chair: *Denis Reilly, (Safran, USA)*

15:45 Leveraging Knowledge Graphs for Root-Cause Analysis in IEEE 802.1AS

Tobias Ferfers (Research - & Fraunhofer IOSB-INA, Germany)

16:10 On the Digital Signal Processing for Optical Aperture Synthesis with Photonic Integrated Circuits

Thushara Gunaratne (National Research Council Canada, Canada); Zoran Ljusic (National Research Council Canada, Canada & National Research Council of Canada (NRC), Canada); Brent R Carlson (National Research Council Canada, Canada); Glen Herriot, Alexis Hill and Ross Cheriton (National Research Council of Canada (NRC), Canada)

16:35 Comparative Analysis of High-Resolution Phase Measurement Principles for Picosecond Clock Synchronization

Nikolaus Kerö, Roland Höller and Sani Sarcevic (Oregano Systems, Austria)

17:00 Time Synchronization Performance of Single-Pair Ethernet (SPE) Solutions

Tamás Kovácsné and András Wiesner (Budapest University of Technology and Economics, Hungary)

17:25 Breaking Precision Time: OS Vulnerability Exploits Against IEEE 1588

Muhammad Abdullah Soomro (University of Massachusetts, Amherst, USA); Fatima Muhammad Anwar (University of Massachusetts Amherst, USA)

17:50 End of Wednesday Sessions

18:45 – 20:00

Welcome Reception

Foyer of ballroom and Kanata ballroom (2F)

Symposium: Thursday, October 9, 2025

08:00 – 17:50
Registration Open

08:30 – 17:50
Exhibit Booths Open

09:00 – 09:25
Keynote Presentation III
Title: Scaling and networking a modular photonic quantum computer
Keynote: *Dylan Mahler, (Xanadu, Canada)*
Session Chair: *Lee Cosart, (Microchip, USA)*

09:25 – 10:05
Session V: Presentations
Session Chair: Kang Lee (IEEE IMS TC-9, USA)

09:25 **PTP Security using Announce Message Authentication and Packet Filtering**
Douglas Arnold (Meinberg USA, USA)

09:45 **Using low-cost COTS digital devices and digital methods for high-performance ~100 fsec coherent clock distribution over aerial fiber, and spin-off applications**
Brent R Carlson, Zoran Ljusic, and Heng Zhang (National Research Council Canada, Canada)

10:05 – 10:45
Morning Break
Algonquin Salon and Foyer (2F)

10:45 – 11:45
Session V: Presentations (cont.)
Session Chair: *Radim Bartos, (University of New Hampshire, USA)*

10:45 **Implementing Secure Time: From Specification to Operation**
Karen F O'Donoghue (Meinberg USA, USA)

11:05 **Achieving Sub-Nanoseconds Time Comparison Accuracy for Wired Asynchronous Clock Devices**
Masahiro Kawano, Kenji Hyakutake and Atsushi Namie (Seiko Solutions Inc., Japan); Yuichiro Yano National Institute of Information and Communications Technology, Japan); Yosuke Kurata and Tetsuya Iwamoto (Seiko Solutions Inc., Japan)

11:45 – 13:00
Lunch
Algonquin Salon and Foyer (2F)

13:00 – 13:45
Promotional Partner Presentations
Session Chair: *Radim Bartos, (University of New Hampshire, USA)*

Symposium: Thursday, October 9, 2025

13:45 – 15:25

Session VI: Presentations

Session Chair: *Douglas Arnold, (Meinberg, USA)*

13:45 Real-Time Synchronization Holdover Prediction in Sync Networks using AI/ML Techniques

M Ramana Reddy (Altistar Networks, India); Raghunath Gopavaram (Rakuten, India)

14:05 TimeSync Distribution and Monitoring at scale

Med Belhadj (Feneck Inc, Canada)

14:25 Edge-Assisted Wireless Synchronization: Integrating PTP and SyncE Principles over Wi-Fi Networks

Chellappan Pillai Sreedevi Ullas Kumar (National University of Singapore, Singapore)

14:45 Highlights from SMPTE's 2nd Study Group Report on PTP Security

Leigh Whitcomb (Company & Meinberg USA, Canada)

15:05 Prototyping a Low-Cost CSAC-Based Time Card for Lunar CubeSat Missions

Philip J Linden (Open Lunar Foundation, USA & MoonDAO, Marshall Islands); Ashley Kosak (Open Lunar Foundation, USA); Eva Czukkermann, Tanner Smith, Ian Dolfi, Luke Schrom, Nsadhu Muyinda and Drew Schacke (Rochester Institute of Technology, USA)

15:25 – 15:50

Afternoon Break

Algonquin Salon and Foyer (2F)

15:50 – 16:50

Session VI: Presentations (cont.)

Session Chair: *Douglas Arnold, (Meinberg, USA)*

15:50 Comparison of Two-Way Satellite Time and Frequency Transfer (TWSTFT) and PTP over long Distances

Amir M Osman and Chris Cooper (Oak Ridge National Laboratory, USA)

16:10 Indoor Delivery of GNSS Reference clock via Wireless Precision Time Transfer (Wi-Wi)

Nobuyasu Shiga and Satoshi Yasuda (National Institute of Informations and Communications Technology, Japan); Ahmad Byagowi (Open Compute Project, USA)

16:30 Characterizing the Time Synchronization Capabilities of PTM and PTP Enabled Systems

Brandon Frech (Calnex Solutions, USA); Ahmad Byagowi (University of Manitoba, Canada); Daniel Herrera (Calnex Solutions, USA)

16:50 – 17:10

Plugfest Report

Symposium: Thursday, October 9, 2025

17:10 – 17:30
Closing Session

20:00 – 21:15
Conference Dinner
Foyer of ballroom and Kanata ballroom (2F)

Optional Tour: October 10, 2025

*Transportation and booking on attendees' own.

Experience Ottawa from both land and water with Lady Dive Tours! This scenic amphibious bus tour showcases some of the city's most iconic attractions, including the National Art Gallery (with its famous Maman spider sculpture), the Museum of Civilization, and more. The tour begins near the War Memorial and offers a unique perspective of Ottawa's landmarks.

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Keynote Speakers



Boris Braverman
(University of Toronto, Canada)

“Doppler-free optical clocks”

BIO

Dr. Boris Braverman is an Assistant Professor in the Department of Physics at the University of Toronto. Dr. Braverman’s work focuses on developing controlled quantum systems to perform cutting-edge quantum sensing and computation, building practical metrological instruments, and testing the validity of quantum theory in new parameter regimes. Currently, Dr. Braverman is developing new approaches for ultra-precise atomic clocks, and techniques for controlling and measuring optical fields using complex, multimode optical cavities. Dr. Braverman played a key role in the first demonstration of precision enhancement in an optical lattice clock with quantum entanglement, and in the deployment of the first cloud-accessible neutral-atom quantum processor.

ABSTRACT

Optical atomic clocks have transformed precision timekeeping, offering superior stability and accuracy compared to their microwave-based counterparts. A key challenge in achieving their exceptional performance is mitigating the Doppler shift caused by the thermal motion of atoms, which limits the achievable spectroscopic resolution. Conventionally, this shift is suppressed by tightly confining atoms, as in optical lattice and ion clocks. An emerging alternative is Doppler-free excitation via multi-photon processes, where the Doppler shifts of the individual laser beams cancel out. In this talk, I will explore the advantages and limitations of this Doppler-free approach and highlight recent developments in two- and three-photon optical clocks. These systems promise to rival or surpass microwave clocks in performance while maintaining their simplicity and robustness.

Keynote Speakers



Kosuke Kato

(National Research Council Canada (NRC))

“Time and Frequency Metrology: Atomic Clocks and the SI Second - Now and the Future”

BIO

Kosuke Kato received his Ph.D. in physics from York University in 2019. He then went on to become a postdoctoral fellow at the University of Toronto. He joined the National Research Council Canada (NRC) as a part of the NRC Postdoctoral Fellowship Program in 2020. His main research activities at the NRC include the development of a transportable high-accuracy single-ion optical clock and the study of systematic frequency shifts in single-ion systems.

ABSTRACT

In this presentation, I will briefly describe the work carried out by the Frequency and Time (FT) group, a subdivision of the Metrology Research Centre at the National Research Council of Canada (NRC). The first part of the presentation will introduce our team’s operations, including our calibration services, the realization and dissemination of UTC(NRC), and the operation and maintenance of our primary and secondary frequency standards that contribute to TAI. The second part will focus primarily on our recent developments in support of the international effort toward redefining the SI second based on optical atomic transitions.

Keynote Speakers



Dylan Mahler
(Xanadu)

“Scaling and networking a modular photonic quantum computer”

BIO

Dylan Mahler is a Senior Principal Scientist at Xanadu, developing the company's sources of optical qubits for use in fault tolerant quantum computation, as well as their processing and measurement. Dylan has been part of the Xanadu team since 2018, where he has had the opportunity to grow with the company during its expansion to over 220 employees.

ABSTRACT

Continuous variable quantum optics presents a promising avenue for the development of quantum technologies. Xanadu's recent prototype, Aurora, showcases the potential of scaling and networking within a modular architecture for the purposes of building a fault tolerant quantum computer. Aurora encompasses all the essential components and functionalities required for a photonic quantum computer, serving as a scale model of Xanadu's quantum architecture. It also constitutes a large quantum network, interconnecting multiple photonic integrated chips coherently. In this talk, I'll highlight some of the key experimental results and engineering milestones achieved with Aurora and discuss how the lessons learned from this demonstration inform our path to building a fault-tolerant quantum computer.