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Welcome Message

Dear Colleagues, dear Friends,

After two years of successful virtual Symposia, it is time to turn our dreams into reality! We warmly welcome you to the 9th in person IEEE International Symposium on Inertial Sensors and Systems, INERTIAL’22, which will be held in the city of Avignon, France, Palais des Papes, an outstanding place with over 7 centuries of history.

This year’s event continues our established tradition, started in 2014 in Laguna Beach, CA, USA of informal international meetings discussing the latest developments in the area of modern inertial sensors and emerging applications enabled by inertial sensors.

IEEE INERTIAL is sponsored by the IEEE Sensors Council and is the only IEEE event exclusively dedicated to Inertial Sensors and Systems technology.

This symposium offers a rare opportunity to meet and network with leaders in the field of inertial sensors and systems through the informal atmosphere of a focused international technical gathering. After two years of virtual conferences, the time has come to meet again; to rediscover the remarkable atmosphere of our symposium: conviviality and high-quality exchanges. We hope the atmosphere, breadth and depth of research topics, combined with the quality of invited and contributed technical presentations, will continue to make INERTIAL a ‘must attend’ event for you every year.

IEEE INERTIAL aspires to establish itself as the premier forum for reporting the latest research, development, and commercialization results in modern inertial sensors technology. You will hear from world experts about the latest in materials and micro-fabrication processes, innovative designs, new physical principles, increased performance, and a growing number of new applications and business opportunities.
This year, our program will begin on **Sunday, May 8th**, with three **tutorials** offered in the areas of i: fiber optic gyroscopes, ii: quantum sensors, iii: inertial MEMS, given respectively by Dr. Enrico Quatraro, Dr. Malo Cadoret and Dr. Dusan Radovic.

The **technical program** covers three days of technical presentations, **May 9th to 11th**. By design, this is a single-track symposium with high quality oral presentations and exhibitions. Each presentation was carefully reviewed and selected by our Technical Program Committee, after a careful evaluation by at least three independent reviewers – the technical experts in the field.

Our **three keynote speakers**, Dr. Valérie Renaudin, Dr. Udo-Martin Gomez and Dr. Manuel Rodrigues will open each day with stimulating topics, including innovative solutions for pedestrian indoor navigation, an overview of Inertial MEMS technologies and market, and, finally, the success story of Microscope mission, the first satellite to test the equivalence principle in space.

Our **two invited speakers**, Dr. Philippe Bouyer and Dr. Carlo Valzasina will open the corresponding sessions throughout the meeting with focused talks on quantum sensors, and new dual-mode applications of 6-axis low-power IMUs.

The contributed papers will be presented in oral and poster formats, with poster sessions preceded by a brief oral session introducing the posters.

**Several exhibitors** will bring their latest industrial products and achievements, available for interaction during the coffee breaks and lunches from May 9th on, introduced by a lightning round session on the first exhibition day.

The Digest of Technical Papers for the 2022 IEEE Inertial Sensors contains four-page versions of both the “regular technical papers” and “late news” presentations”, all provided to attendees in an electronic form. Most presented papers will be available through IEEE Xplore after the symposium.

Continuing the long-standing IEEE Inertial tradition, the Technical Program Committee will select one Best Student Paper, as well as first and second runner up papers. The Awards will be announced Thursday during the Gala Dinner.

We would like to express our special thanks to the Oversight Committee, the Technical Program Committee, and many experts who contributed their time to evaluate over 90 paper submissions representing 17 countries.
We thank the IEEE Sensors Council for sponsoring the 2022 IEEE Inertial Sensors Symposium as well as our Patrons and Exhibitors. Our special thanks to Caroline Foster, at the beginning of this story..., now Caroline Kravec; Brianna Orr, and the entire staff at Conference Catalysts, LLC for administrative support.

Finally, we thank all speakers, presenters, and attendees for making the 2022 IEEE Inertial Sensors Symposium such a unique event. We hope that you find the INERTIAL’22 Symposium professionally stimulating and enjoyable, and of course, we are looking forward to seeing you back next year for the INERTIAL’23.

In this so particular time, we are convinced that we will live an exceptional event, together in Avignon, Palais des Papes, France!

Olivier Le Traon
IEEE INERTIAL 2022 General Chair

Giacomo Langfelder
IEEE INERTIAL 2022 Technical Program Committee Chair
General Chair:
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ONERA, France

TPC Chair:
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Politecnico di Milano, Italy

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Mike Larsen
Northrop Grumman, USA

Paola Carulli
ST Microelectronics, Italy

Paolo Minotti
Bosch Sensortec, Germany

Philippe Bouyer
CNRS- Institut d’Optique Graduate School, France

Raphaël Levy
Onera, France

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U.S. Army Research Laboratory, USA

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Sumitomo Precision Products Co., LTD, Japan

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Tohoku University, Japan

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Tel Aviv University, Israel

Takshiro Tsukamoto
Tohoku University, Japan

Tommi Piirainen
Murata Electronics Oy, Finland
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Jim Adleman
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Fabio Alves
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Edoardo Belloni
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Rosana Dias
Andrea Donadel
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Marco Gadola
Leonardo Gaffuri
Pagani
Ryunosuke Gando
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Matteo Gianollo
Joan Giner

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Jonathan Hoffman
Tamio Ikehashi
Eric Imhof
Steven Jefferts
Yaesuk Jeong
Burgess Johnson
Jerome Juillard
Shiori Kaji
Christophe Kergueris
Imran Khan
Mario Kiuchi
Ryan Knight
Akira Konno
Naftaly Krakover
Vinaya Kumar
Juha Lahdenperä
Giacomo Langfelder
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Robert Lutwak
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Kevin Meier
Douglas Meyer
Damiano Milani
Paolo Minotti
Radwan Mohammednoor
Kari Moran
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Dr Saeed Mozaffari

Tal Nagourney
Frank Narducci
Christian Padovani
Mikko Partanen
Ujjval N. Patel
Ullah Philippe
Tommi Piirainen
Ronald Polcawich
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Payman Rajai
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Andrew Stewart
Matthew Straeten
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Yusheng Wang
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Contact:
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09:00 – 10:45
FIBER OPTIC GYROSCOPES – LIGHTING UP THE NAVIGATION
Room: Chambre du Trésorier
Instructor: Enrico Quatraro, Civitanavi Systems

Abstract: With his first experiments, in 1913, Georges Sagnac laid the groundwork for a new category of inertial sensors, capable of measuring rotation rates by means of light.

Over one century of experiments and development attempts, pushed by the increasing interest of the Inertial Navigation community in a reliable and completely strap-down class of sensors, the optical gyros gained a dominant position in a wide range of applications and grades, from tactical to high end navigation.

The first uses of Sagnac effect sensors, that subsequently gained wide usage was represented by the Ring Laser Gyro, RLG;

Later on, by taking advantage of the advancements in optical fiber technology, pushed by the fast growth of the Telecom market, the efforts in the development of Fiber Optic Gyrosopes, FOGs; led these highly versatile and easily scalable sensors to overcome the RLG. Thus, FOGs have recently dominated most of the rotation rate sensor technologies, especially in high performance navigation grade applications.

This result by the FOG was achieved thanks primarily to its flexibility and highly advantageous, difficult to compete with, size to performance ratio.

The purpose of this tutorial is to provide a basic overview of FOG technology, from the working principles to the most common implementation techniques, going through the description of the building blocks of the sensor and addressing the main design challenges and the physical effects behind them.

Finally, we will discuss some of the advantages of FOGs compared to other gyro technologies.
PRECISION INERTIAL MEASUREMENTS USING COLD-ATOM INTERFEROMETRY

Room: Chambre du Trésorier
Instructors: Malo Cadoret, French Aerospace Lab, ONERA;

Abstract: Atom interferometry exploits the fact that matter, like light, exhibits wave-like properties. In optical interferometry, light waves are recombined after propagating along different paths. Depending on the difference in the waves’ phase accumulated along the two paths, the light may interfere constructively and appear bright or it may interfere destructively and appear dark.

Similar to an optical interferometer, an atom interferometer splits matter waves into different paths and recombines them in a coherent manner [1]. Cold-atom interferometry use atoms that are laser-cooled to millionths of a degree above absolute zero. The atom interferometer is then realized thanks to sequences of laser pulses used to split, deflect and recombine matter waves along different trajectories, acting as beam splitters and mirrors. Through measuring the resulting interference fringes, it is possible to extract the phase difference accumulated between the waves on the paths. Since these paths are influenced by inertial effects, inertial quantities that enter this phase difference can then be accurately determined, making atom interferometry a leading precision measurement technology with applications in both applied and basic science.

Atom interferometers today are the most sensitive instruments for measuring gravity or accelerations, and probing fundamental physical phenomena. Future applications of cold-atom interferometry include inertial navigation, satellite gravimetry and space-based experiments to test gravity. These applications require a new generation of cold-atom interferometers capable of highly precise and stable measurements within compact configurations, and able to operate in real-world field conditions which represent a significant challenge for the community.

This tutorial is designed to introduce those with a vague understanding of optical interferometers to cold-atom interferometry. We will outline the basic theory needed to calculate the observed phase shift, and indicate how this phase shift is experimentally determined. We illustrate the presentation with a description of some realizations of laboratory-based cold-atom sensors dedicated to fundamental tests of physics.

Additionally, in the scope of both field and mobile applications, we will make a review of the progress made towards the development of such instruments for measuring gravitational and inertial signals and the possible benefits that cold-atom quantum sensing may offer in navigation.

Abstract: Consumer inertial MEMS sensors or inertial measurement units, IMU; are tiny devices with typical package size of 2.5mm x 3mm which contain three axes accelerometer and gyroscope sensors. They can be found in many products we get in touch almost every day as smart phone, fitness tracker, smart watch, gaming controller, toy… Two of those high tech IMU devices named BMI160 are inside NASA helicopter Ingenuity which did fly many times on Mars surface in 2021.

The tutorial provides explanation what is inside tiny consumer inertial MEMS sensors and give each participant opportunity to put hands-on them by using hardware that will be provided. After looking what is inside, technology and application overview we continue with how to start using consumer inertial MEMS sensor by explaining basic electrical connections and communication protocols. Based on the datasheet information we show how to write simple scripts to obtain sensor data – motion information. Each participant will have opportunity to use its own hardware to configure sensor, read out data, do evaluation of parameters like accelerometer or gyroscope offset and noise. We conclude with some more experiments and proposals for further measurements with the provided hardware.
Monday, May 9th Keynote
Time Zone is CEST

09:05 – 09:45
THE GENERAL RELATIVITY TESTED IN SPACE BY THE MICROSCOPE SATELLITE
Room: Salle du Conclave
Instructor: Manuel Rodrigues, MICROSCOPE, Department of Physics, Instrumentation, Environment and Space

Abstract: MICROSCOPE is a French space mission aiming at testing the equivalence principle developed by CNES, the Observatory of Cote d’Azur and ONERA from 1999. At the foundation of the Einstein’s general relativity, the equivalence principle, EP; stipulates that all bodies are falling at the same rate in a uniform gravity field regardless of their mass or composition. Testing general relativity to its foundations is nothing more than finding the Grail of physics: the ultimate unification theory.

MICROSCOPE objective was to improve by two orders of magnitude the best current laboratory tests reaching barely 10-13. Launch in 2016, MICROSCOPE has delivered useful information for two and a half years. At the heart of the satellite, the scientific instrument developed by ONERA measured signals with a resolution better than 10-14m/s² at the particular frequency of the EP test. Apart from the scientific role, the instrument was also to feed the Drag-Free and Attitude Control System of the satellite to limit the environment accelerations to 10-13m/s² and the angular accelerations to 10-12rd/s². A first publication in 2017 confirmed at 10-14 the Einstein’s principle of equivalence with only 7% of the data available at that time. All the relevant data has been analysed and now provides the most accurate test of the equivalence principle: probably setting the test limit for the next decade.

Pending final results, the presentation will focus on the outstanding preliminary results of the MICROSCOPE mission, the first test in space of EP and will present the implications of these results for physics.
Tuesday, May 10th Keynote
Time Zone is CEST

09:05 – 09:45 CEST
MEMS INERTIAL SENSORS – EVOLUTION OF MARKETS, SENSORS AND TECHNOLOGIES.
Room: Salle du Conclave
Instructor: Markus Ulm, Robert Bosch GmbH

Abstract: Since the first acceleration sensors in the mid-80s, the market and technology of MEMS-based inertial sensors have developed enormously in just a few decades. Starting from first applications for automotive airbag systems, MEMS and especially inertial sensors have become key components in almost all aspects of modern life.

Safety and comfort functions in our cars, modern user interfaces in our cell phones, intelligent power management in wireless headphones, independent recognition of gymnastic exercises in fitness trackers, or the various monitor functions in robots, smart homes, or industry – all functions that would be inconceivable without MEMS inertial sensors.

This progress has been made possible by an impressively high speed of innovation – even compared to Moore’s Law for semiconductors.

The combined figure of merit, cFOM; of MEMS inertial sensors has steadily improved by several orders of magnitude in just a few years, illustrating that performance of those sensors is increasing drastically despite power consumption and footprint being significantly reduced.

Cross-domain innovation is a key success factor here. New approaches in manufacturing, design or the integration of intelligent software / AI enable leaps in innovation and continually enabling completely new use-cases.

The presentation gives an overview of the development of MEMS inertial sensors from the beginning until today and explains the progress in their development with recent examples.
Wednesday, May 11th Keynote
Time Zone is CEST

09:05 – 09:45
FROM INERTIAL SIGNALS TO PRECISE PEDESTRIAN INDOOR POSITIONING: ASSESSING HUMAN GAIT
Room: Salle du Conclave
Instructor: Valérie Renaudin, Gustave Eiffel University

Abstract: Indoor positioning and navigation have become a prerequisite for many applications and services. Currently available solutions are mainly based on radio beacon networks deployed in the infrastructure or a-priori mapping of signal characteristics. The first approach is costly and requires numerous calibrations, and the second assumes that the signals are stable over time, which is rarely true.

Given these limitations, the use of inertial signals offers the promise of a solution that requires no infrastructure deployment, no knowledge of the map, is functional without mobile cellular networks coverage and therefore accessible to a larger population. It has become the backbone of pedestrian localization systems but must be fused with other measures to compensate for its measurement errors. The inertial sensors embedded in wearable devices are first of low quality and they require continuous calibration “tricks”. Second, they measure many human motions, which are not those we are trying to estimate to track the human gait. In this context, what accuracy is achieved by the recent inertial signals processing methods? Can we measure complex human movements even when the wearable device is worn by the pedestrian on different parts of the body? Is the hybridization of inertial signals with other data still needed to ensure high accuracy? What is the best strategy to label time series of inertial data for learning human gait features with artificial intelligence: physics or human interpretation?

I will talk about recent developments in indoor pedestrian localization with inertial measurements, including artificial intelligence approaches, whether for professional applications where a 6.8m after 2’500m 3D accuracy on 3 indoor levels, ANR/DGA MALIN competition; was recently achieved or for the general public with wearables where learning issues to gain robustness in everyday life will be presented.”
Monday, May 9th Invited Speaker (Time Zone is CEST)
14:00 – 14:30
Quantum Sensors for GPS-Denied Navigation
Room: Chambre du Trésorier
Instructor: Philippe Bouyer, CNRS– Institut d’Optique Graduate School, France

Abstract: Inertial sensors based on cold atoms and light-pulse interferometry exhibit state-of-the-art sensitivity and ultra-low measurement bias that could revolutionize a variety of fields including geophysics and seismology, gravitational wave detection and fundamental tests of gravity, and inertial navigation. We will present in this talk the progress towards a full, 3D, Quantum inertial Navigation System.

Wednesday, May 11th Invited Speaker
11:10 – 11:40
A Compact 6-Axis IMU Combining Low-Power Operation with High Stability and Low Noise
Room: Chambre du Trésorier
Instructor: Carlo Valzasina, STMicroelectronics

Abstract: Consumer-grade inertial measurement units (IMU) have traditionally fallen into either the low-power sensor category suitable for wearable and IoT applications or consumer high-end sensors for AR/VR applications with improved stability but higher power consumption. ST disrupts this compromise between power and performance with a low-current 6-axis MEMS IMU that demonstrates excellent stability and noise performance. Join me as we discover the architecture, design choices, and test results of this remarkable sensor.
ONERA, a central actor in aeronautics and space research, employs around 2,000 people. Under the supervision of the Ministry of the Armed Forces, it has a budget of 234 million euros, more than half of which comes from commercial contracts.

As a state expert, ONERA prepares tomorrow’s defense, responds to future aeronautical and space challenges, and contributes to the competitiveness of the aerospace industry. It has become an expert in all disciplines and technologies in the field. All of the major civil and military aerospace programs in France and Europe have some of ONERA’s DNA: Ariane, Airbus, Falcon, Rafale, missiles, helicopters, engines, radars, etc. Recognized internationally and often receiving awards, its researchers train many PhD students.

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Technical Program: Sunday, May 8th
Time Zone is CEST

08:00 – 09:00
Tutorial Registration
Room: Salle des Gardes

09:00 – 10:45
Tutorial: Fiber Optic Gyroscopes – Lighting Up the Navigation
Enrico Quatraro, Civitanavi Systems
Room: Chambre du Trésorier
Session Chair: Gabriele Gattere, ST Microelectronics

10:45 – 11:15
ColdQuanta Coffee Break
Room: Salle des Gardes

11:15 – 13:00
Tutorial: Precision Inertial Measurements Using Cold-Atom Interferometry
Malo Cadoret, French Aerospace Lab, ONERA;
Room: Chambre du Trésorier
Session Chair: Gabriele Gattere, ST Microelectronics

13:00 – 14:30
Lunch
Room: Espace Jeanne Laurent

14:30 – 17:00
Tutorial: Consumer Inertial MEMS – High Tech in Your Hands
Dušan Radović, Bosch Sensortec
Room: Chambre du Trésorier
Session Chair: Gabriele Gattere, ST Microelectronics

18:30 – 20:00
Tronics Microsystems Welcome Reception
Room: Espace Jeanne Laurent + Pont St Bénezet

All attendees are invited to the Welcome Reception for drinks and light hors d’oeuvres.
### Technical Program: Monday, May 9th

**Time Zone is CEST**

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<td><strong>Registration</strong></td>
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<td><strong>Real Time Q-Factor Mismatch Detection for Rate Integrating Gyroscope Using Amplitude Modulated Driving Signal</strong></td>
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<td>10:25 – 11:00</td>
<td><strong>Cielo Coffee Break/Exhibits</strong></td>
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Technical Program: Monday, May 9th  
Time Zone is CEST

11:00 – 11:30  
Exhibitors Lightning Round  
Room: Salle du Conclave

11:30 – 12:30  
Session – Emerging Applications  
Room: Salle du Conclave  
Session Chairs: Jenna Chan, U.S. Army Research Laboratory; Diego Serrano, Panasonic

11:30  
Cots MEMS Gyros for Space  
Guillaume Delavoipiere, CNES, France; Kateryna Kiryukhina, CNES, France; Francoise Bezerra, CNES, France; Djemel Lellouchi, ELEMCA, France; Olivier Gigan, TRONICS TDK, France; Yann David, TRONICS TDK, France; Antoine Filipe, TRONICS TDK, France; Guillaume Papin, TRONICS TDK, France

11:50  
Monitoring Cardiac Activity by Detecting Subtle Head Movements Using MEMS Technology  
Sarah Solbiati, Department of Electronics, Information and Bioengineering, Politecnico di Milano, Italy; Andrea Buffoli, Department of Electronics, Information and Bioengineering, Politecnico di Milano, Italy; Valentino Megale, Softcare Studios Srls, Italy; Gianfranco Damato, Softcare Studios Srls, Italy; Bruno Lenzi, Softcare Studios Srls, Italy; Giacomo Langfelder, Department of Electronics, Information and Bioengineering, Politecnico di Milano, Italy; Enrico Caiani, Department of Electronics, Information and Bioengineering, Politecnico di Milano, Italy

12:10  
A Neural Network Approach to Mitigate Thermal–Induced Errors in ZUPT–aided INS  
Chi–Shih Jao, University of California, Irvine, United States; Danmeng Wang, University of California, Irvine, United States; Austin Parrish, University of California, Irvine, United States; Andrei Shkel, University of California, Irvine, United State
Technical Program: Monday, May 9th
Time Zone is CEST

12:30 – 14:00
LITEF Lunch/Exhibits
Room: Grande Audience

14:00 – 15:30
Session – Quantum Inertial Sensors
Room: Salle du Conclave
Session Chairs: Kari Moran, Naval Information Warfare Center Pacific; Mike Larsen, Northrop Grumman

14:00
Invited Speaker: Quantum Sensors for GPS-Denied Navigation
Philippe Bouyer, CNRS- Institut d’Optique Graduate School, France

14:30
Marine and Airborne Gravimetry with an Absolute Cold Atom Sensor
Alexis Bonnin, ONERA, France; Yannick Bidel, ONERA, France; Cédric Blanchard, ONERA, France; Jeanne Bernard, ONERA, LCM-CNAM, France; Malo Cadoret, ONERA, LCM-CNAM, France; Nassim Zahzam, ONERA, France; Sylvain Schwartz, ONERA, France; Alexandre Bresson, ONERA, France

14:50
Diamond NMR Gyroscope
Andrey Jarmola, UC Berkeley, United States; Sean Lourette, UC Berkeley, United States; Victor Acosta, University of New Mexico, United States; Glen Birdwell, U.S. Army Research Laboratory, United States; Peter Blümler, Johannes Gutenberg-Universität Mainz, Germany; Dmitry Budker, Johannes Gutenberg-Universität Mainz, Germany; Tony Ivanov, U.S. Army Research Laboratory, United States; Vladimir Malinovsky, U.S. Army Research Laboratory, United States

15:10
Progress Towards the Development of a cold-Atom Inertial Measurement Unit for Onboard Applications
Jeanne Bernard, CNAM and ONERA, France; Malo Cadoret, CNAM and ONERA, France; Yannick Bidel, ONERA, France; Clément Salducci, ONERA, France; Nassim Zahzam, ONERA, France; Sylvain Schwartz, ONERA, France; Alexis Bonnin, ONERA, France; Cédric Blanchard, ONERA, France; Alexandre Bresson, ONERA, France
Technical Program: Monday, May 9th
Time Zone is CEST

15:30 – 16:00
Posters Lightning Round
Room: Salle du Conclave

16:00 – 16:30
Cielo Coffee Break/Exhibits
Room: Grande Audience

16:15 – 17:30
Poster Session/Coffee Break
Room: Grande Audience
Session Chairs: Slava Krylov, Tel Aviv University; Joan Giner, Bosch Sensortec

A Novel Modeling Method Based on 3D CT Images for Dynamics Analysis of the micro-Hemispherical Resonator Gyroscope, μ-HRG
Min Meng, Microsystem & Terahertz Research Center, China Academy of Engineering Physics, China; Kai Yang, Microsystem & Terahertz Research Center, China Academy of Engineering Physics, China; Wei Su, Institute of Electronic Engineering, China Academy of Engineering Physics, China; Shengwei Dong, Microsystem & Terahertz Research Center, China Academy of Engineering Physics, China; Hao Zhang, Microsystem & Terahertz Research Center, China Academy of Engineering Physics, China; Jie Zhang, Microsystem & Terahertz Research Center, China Academy of Engineering Physics, China; He Li, Microsystem & Terahertz Research Center, China Academy of Engineering Physics, China; Xi Wang, Microsystem & Terahertz Research Center, China Academy of Engineering Physics, China

Temperature Drift Self-Calibration for Honeycomb Like Disk Resonator Gyroscope
Tongqiao Miao, National University of Defense Technology, China; Yi Xu, National University of Defense Technology, China; Qingsong Li, National University of Defense Technology, China; Xiaoping Hu, National University of Defense Technology, China; Xuezhong Wu, National University of Defense Technology, China; Dingbang Xiao, National University of Defense Technology, China

Inertial Navigation Compensation with Machine Learning
Eric Bozeman, NIWC Pacific, United States; Minhdao Nguyen, NIWC Pacific, United States; Mohammad Alam, NIWC Pacific, United States; Jeffrey Onners, NIWC Pacific, United States
Technical Program: Monday, May 9th
Time Zone is CEST

Poster Session/Coffee Break (cont.)

SAR Imaging Challenges on UAV Trajectory Restitution / Study Case with SAR–Light Prototype at X-Band
Jean-Francois Nouvel, ONERA, France; Nicolas Castet, ONERA, France; Jerome Henrion, ONERA, France

A Transfer Model of HIGH-G Shock for MEMS in Real Working Conditions
Tianfang Peng, Tsinghua University, China; Zheng You, Tsinghua University, China

ULTRA-Fast Characterization of Detection Electrode Errors Under WHOLE-Angle Mode in 10 Seconds
Jiangkun Sun, National University of Defense Technology, China; Kui Liu, Xi’an Institute of Modern Control Technology, China; Sheng Yu, National University of Defense Technology, China; Xiang Xi, National University of Defense Technology, China; Xuezhong Wu, National University of Defense Technology, China; Yongmeng Zhang, National University of Defense Technology, China; Dingbang Xiao, National University of Defense Technology, China;

Effect of Geometry on Energy Losses in Fused Silica Dual–Shell Gyroscopes
Wei Guan, University of California, Irvine, United States; Danmeng Wang, University of California, Irvine, United States; Mohammad Asadian, University of California, Irvine, United States; Andrei Shkel, University of California, Irvine, United States

Q-Learning BASED-Noise Covariance Adaptation in Kalman Filter for MARG Sensors Attitude Estimation
Xiang Dai, University Grenoble Alpes, France; Vahid Nateghi, University Grenoble Alpes, France; Hassen Fourati, University Grenoble Alpes, France; Christophe Prieur, University Grenoble Alpes, France

Compact Cold Atom Accelerometer Payload for LOW-Earth Orbit Atmospheric Drag Measurement
Michael Trigatzis, Teledyne e2v, United Kingdom; Marton Kiss-Toth, Teledyne e2v, United Kingdom; Stephen Maddox, Teledyne e2v, United Kingdom; Isabelle Riou, Teledyne e2v, United Kingdom
Technical Program: Monday, May 9th
Time Zone is CEST

Poster Session/Coffee Break (cont.)

A Cooperation Positioning Algorithm Based on Time Delay Square Root Cubature Kalman Filter for AUVs

**Mingye Tong**, Harbin Institute of Technology, China; **Ya Zhang**, Harbin Institute of Technology, China; **Qingxin Wang**, Harbin Institute of Technology, China; **Jianbo Shao**, Harbin Institute of Technology, China

A Simulation Study of the Temperature Sensitivity and Impact of Fabrication Tolerances on the Performance of a Geometric Anti-Spring Based MEMS Gravimeter

**Vinod Belwanshi**, University of Glasgow, United Kingdom; **Abhinav Prasad**, University of Glasgow, United Kingdom; **Karl Toland**, University of Glasgow, United Kingdom; **Kristian Anastasiou**, University of Glasgow, United Kingdom; **Steven Bramsiepe**, University of Glasgow, United Kingdom; **Richard Middlemiss**, University of Glasgow, United Kingdom; **Douglas Paul**, University of Glasgow, United Kingdom; **Giles Hammond**, University of Glasgow, United Kingdom

An Analytical Model for Vibration Analysis of Disk Resonator Gyroscopes

**Mehran Hosseini Pishrobat**, Bilkent University, Turkey; **Baha Erim Uzunoglu**, Bilkent University, Turkey; **Derin Erkan**, Bilkent University, Turkey; **Erdinc Tatar**, Bilkent University, Turkey

UmiX Series – How to Miniaturize Fog Technology

**Sébastien Ferrand**, IXBLUE, France; **Maxime Rattier**, IXBLUE, France; **Cédric Moluçon**, IXBLUE, France; **Emmanuelle Peter**, IXBLUE, France; **Marco Mancini**, IXBLUE, Italy; **Kévin Gautier**, IXBLUE, France; **Pierrick Cheiney**, IXBLUE, France

17:30 – 17:45
Wrap Up
Room: **Grande Audience**

17:45 – 18:30
Sponsor Appreciation/Open Posters Social Event
Room: **Grande Audience**
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Technical Program: Tuesday, May 10th
Time Zone is CEST

08:00 – 09:00
Registration
Room: Salle des Gardes

09:00 – 09:05
Opening Remarks
Olivier Le Traon, 2022 General Chair
Room: Salle du Conclave

09:05 – 09:45
Keynote: MEMS Inertial Sensors – Evolution of Markets, Sensors and Technologies
Markus Ulm, Robert Bosch GmbH
Room: Salle du Conclave
Session Chair: Olivier Le Traon, ONERA

09:45 – 10:45
Session - Fiber Optic Gyroscopes
Room: Salle du Conclave
Session Chairs: Raphaël Levy, ONERA; Roberto Senatore, Civitanavi Systems

09:45
CMOS-Enabled Silicon Photonics Driver Chip for Interferometric Fiber Optics Gyroscope
Yen-Chieh Wang, National Sun Yat-sen University, Taiwan; Sin-Yun Lu, National Sun Yat-sen University, Taiwan; Min-Chi Chan, National Sun Yat-sen University, Taiwan; Yin-Hsuan Lee, National Sun Yat-sen University, Taiwan; Tzu-Hsiang Yen, National Sun Yat-sen University, Taiwan; Chia-Chien Wei, National Sun Yat-sen University, Taiwan; Yi-Jen Chiu, National Sun Yat-sen University, Taiwan; Ren-Young Liu, National Sun Yat-sen University, Taiwan; Yung-Jr Hung, National Sun Yat-sen University, Taiwan

10:05
Original Technique for Residual Amplitude Modulation Reduction in RFOG
Maxime Descampeaux, THALES AVS, THALES RESEARCH AND TECHNOLOGY, LUMIN CNRS ENS Paris-Saclay, France; Gilles Feugnet, THALES Research and Technology France, France; Fabien Bretenaker, LUMIN CNRS ENS Paris-Saclay, France
Session – Fiber Optic Gyroscopes (cont.)

10:25
Impact of Photonic Bandgap HOLLOW-Core Fiber Loss Wavelength Dependence on the Performance of RFOG

Maxime Descampeaux, THALES AVIONICS, France; Gilles Feugnet, THALES RESEARCH AND TECHNOLOGY, France; Benoit Debord, GPPMM group, XLIM, CNRS, Université de Limoges, Limoges, France; Fetah Benabid, GPPMM group, XLIM, CNRS, Université de Limoges, Limoges, France; Fabien Bretenaker, LUMIN CNRS ENS Paris-Saclay, France; Foued Amrani, GPPMM group, XLIM, CNRS, Université de Limoges, Limoges, France; Frédéric Gérôme, GPPMM group, XLIM, CNRS, Université de Limoges, Limoges, France

10:45 – 11:15
Cielo Coffee Break/Exhibits
Room: Grande Audience

11:15 – 11:30
INERTIAL 2023 Presentation
Room: Salle du Conclave

11:30 – 12:50
Session – Solid-State Gyroscopes
Room: Salle du Conclave
Session Chairs: Paola Carulli, ST Microelectronics; Andrei Shkel, University of California, Irvine

11:30
Si–MEMS Gyro by Safran – Towards the Navigation Grade

Jean-Sebastien Mace, Safran Electronics and Defense, France; Christophe Kergueris, Safran Colibrys, Switzerland; Frederic Fretouly, Safran Electronics and Defense, France; Julien Auger, Safran Electronics and Defense, France; Yan Lenoir, Safran Electronics and Defense, France; Fabrice Delhaye, Safran Electronics and Defense, France; Jean-Daniel Emerard, Safran Electronics and Defense, France

11:50
GYTRIX, a Novel Axisymmetric Quartz Gyroscope for Navigation Purpose

Thomas Perrier, ONERA - The French Aerospace Lab, France; Olivier Le Traon, ONERA - The French Aerospace Lab, France; Raphaël Levy, ONERA - The French Aerospace Lab, France; Jean Guérard, ONERA - The French Aerospace Lab, France; Amandine Andrieus Ledier, ONERA - The French Aerospace Lab, France; Pierre Lavenus, ONERA - The French Aerospace Lab, France
Session – Solid-State Gyroscopes (cont.)

12:10
Effect of Metallization on Fused Silica Dual-Shell Gyroscopes
Danmeng Wang, UCI MicroSystems Laboratory, United States; Wei Guan, UCI MicroSystems Laboratory, United States; Mohammad Asadian, UCI MicroSystems Laboratory, United States; Andrei Shkel, UCI MicroSystems Laboratory, United States

12:30
Investigating the Effects of Silicon Etching Imperfections on the Quadrature Error in MEMS Gyroscopes
Alexandre Azier, THALES, France; Bertrand Leverrier, THALES, France; Najib Kacem, Univ. Bourgogne Franche-Comte, FEMTO-ST Institute, CNRS/UFC/ENSMM/UTBM, France; Bernard Chaumet, THALES, France; Noureddine Bouhaddi, Univ. Bourgogne Franche-Comte, FEMTO-ST Institute, CNRS/UFC/ENSMM/UTBM, France

12:50 – 14:10
Lunch/Exhibits
Room: Grande Audience

14:10 – 15:30
Session – Aiding Technologies and Navigation
Room: Salle du Conclave
Session Chairs: Cristiano Marra, TDK-InvenSense Italy srl; Ron Polkawich, U.S. Army Research Laboratory

14:10
Inertial and Imaging Sensor Fusion for an Autonomous Tomorrow
Igor Prikhodko, Analog Devices, United States

14:30
Gyroscope-Aided Odometry Navigation Using a Highly-Precise Automotive MEMS IMU Complemented by a Low-Cost Sensor Array
Lukas Blocher, Robert Bosch GmbH, Germany; Wolfram Mayer, Robert Bosch GmbH, Germany; Miloš Vujadinović, Robert Bosch GmbH, Germany; Jonas Haack, Robert Bosch GmbH, Germany; Johannes Hoefeke, Robert Bosch GmbH, Germany; Dušan Radović, Robert Bosch GmbH, Germany; Tobias Hiller, Robert Bosch GmbH, Germany; Joachim Gerlach, Albstadt-Sigmaringen University, Germany; Oliver Bringmann, University of Tuebingen, Germany

14:50
Magnetometer Based on a Quartz MEMS Resonator with Two DETFs and a Stack of Magnetic Materials
Charles Mauc, ONERA, France; Thomas Perrier, ONERA, France; Raphaël Levy, ONERA, France; Johan Moulin, C2N, France; Patrick Kayser, ONERA - The French Aerospace Lab, France
Technical Program: Tuesday, May 10th
Time Zone is CEST

Session – Aiding Technologies and Navigation (cont.)
15:10
Frequency Modulated MEMS Lorentz Force Magnetometer Using CW/CCW Modes
Linxin Zhang, Tohoku University, Japan; Takashiro Tsukamoto, Tohoku University, Japan; Shuji Tanaka, Tohoku University, Japan

15:30 – 16:00
Posters Lightning Round
Room: Salle du Conclave

16:00 – 16:30
Cielo Coffee Break/Exhibits
Room: Grande Audience

16:15 – 17:30
Poster Session/Coffee Break
Room: Grand Audience
Session Chairs: Julien Auger, Safran Electronics & Defense; Igor Prikhodko, Analog Devices

Rayleigh-OFDR Strain Distribution Measurement on a Self-Standing Fiber-Gyro Coil
Hugo Boiron, Laboratoire Hubert Curien, UJM-CNRS-IOGS / iXblue, France; Jérémie Pillon, Université Paris-Saclay, ENS Paris-Saclay, CNRS, LMT / iXblue, France; Emmanuelle Peter, iXblue, France; Emmanuel Marin, Laboratoire Hubert Curien, UJM-CNRS-IOGS, France; Matthieu Collignon, iXblue, France; Adriana Morana, Laboratoire Hubert Curien, UJM-CNRS-IOGS, France; Sylvain Girard, Laboratoire Hubert Curien, UJM-CNRS-IOGS, France; Hervé Lefèvre, Laboratoire Hubert Curien, UJM-CNRS-IOGS / iXblue, France

Design Methodology and Model Order Reduction for Resonant Accelerometers
Omer Halevy, Tel Aviv University, Israel; Slava Krylov, Tel Aviv University, Israel

Towards Real-Time Frequency Modulated Accelerometer Bias Calibration
Andrew Sabater, Naval Information Warfare Center, NIWC; Pacific, United States; Eric Bozeman, Naval Information Warfare Center, NIWC; Pacific, United States; Stephen Hobbs, Naval Information Warfare Center, NIWC; Pacific, United States

Wobble Estimation of a Turntable Axis by Using an Inertial Measurement Unit
Mehdi Bussutil, iXblue, France; Bernard Vau, iXblue, France; Damien Ponceau, Scalian, France; Clément Pinzio, iXblue, France
Miniaturized Navigation Grade Quartz VBA Accelerometer for Space Applications
Olivier Jolly, Ixblue, France; Pierrick Cheiney, Ixblue, France; Thomas Kerrien, Ixblue, France; Stéphanie Michel, Ixblue, France; Steven Fosset, Ixblue, France; Alexandre Cadu, Isae Supaero, France

Modular Probecard-Measurement Equipment for Automated Wafer-Level Characterization of High Precision MEMS Gyroscopes
Sebastian Weidlich, Chemnitz University of Technology; Roman Forke, Fraunhofer ENAS, Germany; Karla Hiller, Fraunhofer ENAS, Germany; Daniel Bülz, Fraunhofer ENAS, Germany; Alexey Shaporin, Fraunhofer Institute for Electronic Nano Systems ENAS; Harald Kuhn, Fraunhofer ENAS, Germany

Characterization of Mass-Loaded Silicon Nitride On-Chip Resonators for Traceable Sensing of Low Amplitude Acceleration
Timothy Hodges, The University of Ottawa, Canada; Lixue Wu, National Research Council Canada, Canada; Gengyang Mu, The University of Ottawa, Canada; Nikaya Snell, The University of Ottawa, Canada; Alexandre Bouchard, The University of Ottawa, Canada; Michel Stephan, The University of Ottawa, Canada; Triantafillos Koukoulas, National Research Council Canada, Canada; Richard Green, National Research Council Canada, Canada; Raphael St-Gelais, The University of Ottawa, Canada

High Stability Two Axis cold-Atom Gyroscope
Mohamed Guessoum, SYRTE, France; Romain Gautier, SYRTE, France; Quentin Bouton, SYRTE, France; Leonid Sidorenkov, SYRTE, France; Arnaud Landragin, SYRTE, France; Remi Geiger, SYRTE, France

Noise Reduction by Data Fusion in a Multisensor System of Replicated MEMS Inclinometers
Alessandro Nastro, University of Brescia, Italy; Marco Ferrari, University of Brescia, Italy; Camilla-Irène Mura, STMicroelectronics, Italy; Andrea Labombarda, STMicroelectronics, Italy; Marco Viti, STMicroelectronics, Italy; Sandro Dalle-Feste, STMicroelectronics, Italy; Vittorio Ferrari, University of Brescia, Italy

A MEMS Gravimeter with multi-Axis Gravitational Sensitivity
Richard Middlemiss, University of Glasgow, United Kingdom; Paul Campsie, University of Strathclyde, United Kingdom; William Cunningham, University of Glasgow, United Kingdom; Rebecca Douglas, University of Glasgow, United Kingdom; Victoria McLvor, University of Glasgow, United Kingdom; Vinod Belwanshi, University of Glasgow, United Kingdom; James Hough, University of Glasgow, United Kingdom; Sheila Rowan, University of Glasgow, United Kingdom; Douglas Paul, University of Glasgow, United Kingdom; Abhinav Prasad, University of Glasgow, United Kingdom; Giles D. Hammond, University of Glasgow, United Kingdom
Technical Program: Tuesday, May 10th
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Poster Session/Coffee Break (cont.)
Indirectly-Coupled Optical Resonators for Anti-Parity-Time-Symmetric Gyroscopes

Martino De Carlo, Photonics Research Group, Department of Electrical and Information Engineering, Politecnico di Bari, Italy;
Francesco De Leonardis, Photonics Research Group, Department of Electrical and Information Engineering, Politecnico di Bari, Italy;
Francesco Dell’Olio, Department of Electrical and Information Engineering Politecnico di Bari, Italy; Pietro Peliti, Northrop Grumman Italia, Pomezia, Italy; Fabrizio Berton, Northrop Grumman Italia, Pomezia, Italy; Mario Lucchesini, Northrop Grumman Italia, Pomezia, Italy; Vittorio M. N. Passaro, Photonics Research Group, Department of Electrical and Information Engineering, Politecnico di Bari, Italy

Planar Foucault Pendulum Silicon Gyro

Lucas Hudeley, ONERA – The French Aerospace Lab, France; Alain Bosseboeuf, C2N, CNRS, University Paris-Saclay, France; Olivier Le Traon, ONERA – The French Aerospace Lab, France; Thomas Perrier, ONERA – The French Aerospace Lab, France; Raphaël Levy, ONERA – The French Aerospace Lab, France; Jean Guérard, ONERA – The French Aerospace Lab, France

17:30 – 17:45
Wrap Up
Room: Grande Audience

19:30 – 21:30
Gala Dinner and Awards Ceremony
Room: Grand Tinel
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Technical Program: Wednesday, May 11th
Time Zone is CEST

08:00 – 09:10
Registration
Room: Salle des Gardes

09:10 – 09:20
Opening Remarks
Olivier Le Traon, 2022 General Chair
Room: Salle du Conclave

09:20 – 10:00
Keynote: From Inertial Signals to Precise Pedestrian Indoor Positioning: Assessing Human Gait
Valérie Renaudin, Gustave Eiffel University
Room: Salle du Conclave
Session Chair: Olivier Le Traon, ONERA

10:00 – 10:45
Session - Late News
Room: Salle du Conclave
Session Chair: Giacomo Langfelder, Politecnico di Milano

10:00
Glass Molding for Microstructures
Bin Luo, Southeast University, China; Zhaoxi Su, Southeast University, China; Jintang Shang, Southeast University, China

10:15
Open Source Bio-Logger for Monitoring and Recording Inertial Movement
Stéphane Viollet, CNRS, France; Nicolas Huloux, Aflokkat, France; Julien Diperi, CNRS, France; Jean-Marc Ingargiola, Aix-Marseille University, France; Akiko Kato, CNRS, France; Yan Roppert-Coudert, CNRS, France

10:30
ULTRA-Low Resonance Frequency MEMS Gravimeter with Off-Resonance Closed-Loop Control
Chenzhi Yi, Waseda University, China; Jun Wu, Waseda University, China; Hideyuki Maekoba, Coventor, A Lam Research Company, Japan; Arnaud Parent, Coventor, A Lam Research Company, France; Tamio Ikehashi, Waseda University, Japan
10:45 – 11:10
Coffee Break/Exhibits
Room: Grande Audience

11:10 – 12:40
Session – Technologies for MEMS Inertial Sensors and IMUs
Room: Salle du Conclave
Session Chairs: Caroline Coutier, CEA Leti; Shuji Tanaka, Tohoku University

11:10
Invited Speaker: A Compact 6-Axis IMU Combining Low-Power Operation with High Stability and Low Noise
Carlo Valzasina, STMicroelectronics, Italy; Luca Giuseppe Falorni, STMicroelectronics, Italy; Francesco Rizzini, STMicroelectronics, Italy; Luca Guerinoni, STMicroelectronics, Italy; Marco Milani, STMicroelectronics, Italy; Marco Garbarino, STMicroelectronics, Italy; Stefano Polesel, STMicroelectronics, Italy; Matteo Quartiroli, STMicroelectronics, Italy; Alessandro Mecchia, STMicroelectronics, Italy; Alessandra Maria Rizzo Piazza Roncoroni, STMicroelectronics, Italy

11:40
0.25 deg/h Closed-Loop Bulk Acoustic Wave Gyroscope
Diego Emilio Serrano, Panasonic Device Solutions Laboratory of Massachusetts, USA; Amir Rahafrooz, Panasonic Device Solutions Laboratory of Massachusetts, USA; Ronald Lipka, Panasonic Device Solutions Laboratory of Massachusetts, USA; Duane Younkin, Panasonic Device Solutions Laboratory of Massachusetts, USA; Kieran Nunan, Panasonic Device Solutions Laboratory of Massachusetts, USA; John English, Panasonic Device Solutions Laboratory of Massachusetts, USA; Chihchuan Chen, Panasonic Device Solutions Laboratory of Massachusetts, USA; Ryan Hennessy, Panasonic Device Solutions Laboratory of Massachusetts, USA; Yaesuk Jeong, Panasonic Device Solutions Laboratory of Massachusetts, USA; Eugene Ivanov, Panasonic Device Solutions Laboratory of Massachusetts, USA; Dan Sullivan, Panasonic Device Solutions Laboratory of Massachusetts, USA; Ijaz Jafri, Panasonic Device Solutions Laboratory of Massachusetts, USA

12:00
The BDRIE-HS* Technology Approach for Tiny Motion Detection with Improved Sensitivity and Noise Performance
Roman Forke, Fraunhofer ENAS; Karla Hiller, Fraunhofer ENAS; Susann Hahn, TU Chemnitz; Alexey Shaporin, Fraunhofer ENAS; Sebastian Weidlich, TU Chemnitz; Daniel Buelz, Fraunhofer ENAS; Matthias Kuechler, Fraunhofer ENAS; Danny Reuter, Fraunhofer Institute for Electronic Nano Systems ENAS / Chemnitz University of Technology, Germany; Christian Helke, Chemnitz University of Technology, Germany; Dirk Wuensch, Fraunhofer ENAS; Knut Gottfried, Fraunhofer Institute for Electronic Nano Systems ENAS, Germany; Harald Kuhn, Fraunhofer ENAS
Technical Program: Wednesday, May 11th
Time Zone is CEST

Session – Technologies for MEMS Inertial Sensors and IMUs (cont)

12:20
High Performance MEMS IMU with ThELMA-Double Technology

Gabriele Gattere, STMicroelectronics, Italy; Francesco Rizzini, STMicroelectronics, Italy; Luca Guerinoni, STMicroelectronics, Italy; Luca Falorni, STMicroelectronics, Italy; Carlo Valzasina, STMicroelectronics, Italy; Federico Vercesi, STMicroelectronics, Italy; Giorgio Allegato, STMicroelectronics, Italy

12:40 – 14:10
Lunch/Exhibits
Room: Grande Audience

14:10 – 15:10
Session - MEMS Accelerometers
Room: Salle du Conclave
Session Chairs: Tommi Piirainen, Murata Electronics Oy; Philippe Robert, CEA-Leti for the session MEMS Accelerometers

14:10
Nanoresonator-Based Accelerometer with Large Bandwidth and Improved Bias Stability

Theo Miani, cea leti, France; Thierry Verdot, cea leti, France; Audrey Berthelot, cea leti, France; Federico Maspero, cnr, Italy; Alexandra Koumela, cea leti, France; Philippe Robert, cea leti, France; Giacomo Langfelder, deib politecnico, Italy; Julien Arcamone, cea leti, France; Marc Sansa, cea leti, France

14:30
A Low-Noise Mixed Signal ASIC for Navigation-Grade Resonant MEMS Accelerometer

Rémy Dejaeger, Thales, France; Olivier Lefort, Thales, France; Mathieu Jeanneteau, Thales, France; Jean-Michel Muguet, Thales, France

14:50
Active Shock/Vibes Rejection in FM MEMS Accelerometers

Leonardo Gaffuri Pagani, Politecnico di Milano, Italy; Paolo Frigerio, Politecnico di Milano, Italy; Dario Falato, Politecnico di Milano, Italy; Christian Padovani, Politecnico di Milano, Italy; Francesco Rizzini, STMicroelectronics, Italy; Giacomo Langfelder, Politecnico di Milano, Italy

15:10 – 15:40
Closing Remarks
Room: Salle du Conclave
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