Welcome Message

Dear Colleagues/Friends,

We warmly welcome you to Naples, Florida, to present, exhibit, and participate in the 6th IEEE International Symposium on Inertial Sensors and Systems (INERTIAL'19).

This year's event continues our recently 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.

The IEEE INERTIAL is sponsored by the IEEE Sensors Council and is the only IEEE event exclusively dedicated to the Inertial Sensors and Systems technology. The adoption and application of this technology is growing fast, with the MEMS Inertial Sensors market alone projected to exceed $5.5B by 2020.

The symposium offers a rare opportunity to meet and network with leaders in the field of Inertial Sensors and Systems in an informal atmosphere of a focused international technical gathering. We hope the atmosphere, breadth and depth of research topics combined with the quality of invited and contributed technical presentations will make the INERTIAL a 'must attend' event for you every year.

The INERTIAL has an ambition 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 the world experts 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.

The technical program covers three and a half days of technical presentations. By design, this is a single track symposium with high quality oral and poster presentations. 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 four distinct invited speakers will open our morning sessions. The contributed papers will be presented in oral (33 papers) and poster (22 papers) formats, with poster sessions preceded by brief oral sessions introducing the posters. Following the success of previous years, we expanded our program by a day and increased the number of tutorials. On Monday, there will be four tutorials offered, this year in the area of (i) inertial system aiding, (ii) sensor and system metrology, (iii) navigation in nature, and (iv) atomic clocks and time scales. The tutorials are organized and chaired by Doug Meyer and Jenna Chan.

The Digest of Technical Papers for the 2019 IEEE Inertial Sensors contains four-page versions of regular oral and poster presentations and 2-pagers of "late news" presentations, all provided to attendees in an electronic form. Most (but not all) presented papers will be available in the IEEE Xplore after the symposium. We will also continue our tradition, which is very specific for this conference, – the "Lightning Round" by Exhibitors as well as Posters and Open Posters by Participants. Right at the beginning, on Tuesday morning, our exhibitors will be invited to briefly introduce their companies, products, and services, stimulating interactions with attendees throughout the meeting. The primary poster presentation will take place on Wednesday afternoon before the banquet in the evening. The "Open Posters" session on Tuesday night will offer an opportunity for all attendees to discuss informally the latest and greats from the labs. The Tuesday night session will also include a number of developmental hardware demonstrations.

The Technical Program Committee will select two Best Student Papers, one from the oral track and another from the poster track (as well as first and second runner up papers). Ryan Lu and Kari Moran will be chairing the Award Committee this year, with awards being announced on Wednesday evening at the symposium banquet. Good luck to all presenting students!

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 submissions.

We thank the IEEE Sensors Council for sponsoring the 2019 IEEE Inertial Sensors as well as our Patrons and Exhibitors. Our special thanks to Rachel Brockhoff, and the entire staff at Conference Catalysts, LLC for administrative support.

Finally, we thank all speakers, presenters, and attendees for making the 2019 IEEE Inertial Sensors such a unique event. We hope that you find the INERTIAL'19 Symposium professionally stimulating and enjoyable, and of course, we are looking forward to seeing you back next year for the INERTIAL'20.

Michael Larsen
Symposium Chair
Northrop Grumman, USA

IEEE Inertial Sensors & Systems Symposium 2019 Organizers

Symposium Chair:
Mike Larsen, Northrop Grumman, United States

Oversight Committee:
Andrei Shkel, University of California, Irvine, United States
Giacomo Langfelder, Politecnico di Milano, Italy

Treasurer:
Igor Prikhodko, Analog Devices Inc., United States

Tutorials Chairs:
Doug Meyer, Northrop Grumman, USA
Jenna Chan, General Technical Services, LLC, USA

Technical Program Committee:
Mohammad Jalal Ahamed, University of Windsor, Canada
Ryuta Araki, Sumitomo Precision Products Co., LTD, Japan
Julien Auger, Safran Electronics and Defense, France
Danielle Braje, MIT Lincoln Lab, USA
Justin Brown, Physical Sciences, Inc., USA
Michael Bulatowicz, Northrop Grumman, USA
Jenna Chan, General Technical Services, LLC, USA
Johannes Classen, Robert Bosch GmbH, Germany
Stefano Facchinetti, ST Microelectronics, Italy
Paul Griffin, University of Strathclyde, UK
Joan Giner, GLOBALFOUNDRIES, Singapore
Eric Imhof, Northrop Grumman, USA
Olivier Le Traon, ONERA, France
Ryan Lu, Navy, SSC Pacific, USA
Robert Lutwak, Air Force Research Laboratory, USA
Doug Meyer, Northrop Grumman, USA
Kari Moran, Navy, SSC Pacific, USA
Sachin Nadig, Panasonic Device Solutions Laboratory Massachusetts Of Panasonic R&D Company of America, USA
Tommi Piirainen , Murata Electronics Oy, Finland
Andrea Pizzarulli, Civitanavi Systems srl, Italy
Ronald Polcawich, Defense Advanced Research Projects Agency, USA
Igor Prikhodko, Analog Devices, Inc., USA
Jennifer Strabley, Honeywell., USA
Alexander Trusov, Northrop Grumman, USA
Takahiro Tsukamoto, Tohoku University, Japan

Symposium Management:
Conference Catalysts, LLC, United States

Technical Reviewers

Eihab Abdel-Rahman
Christoph Affolderbach
Chae Hyuck Ahn
Erkan Aktakka
dana Anderson
Serhan Ardanuc
Mohammad Asadian
Sina Askari
Julien Auger
Farrokh Ayazi
Behraad Bahreyni
Ralf Bauer
Ridha Ben Mrad
Marco Bestetti
Dennis Bevan
Gianluigi Biancucci
Clint Blankenship
Kai Bongs
Mike Braasch
Danielle Braje
Justin Brown
Etienne Brunstein
Alexander Buhmann
Michael Bulatowicz
John Burke
Jim Campanile
Jenna Chan
Jae Yoong Cho
Johannes Classen
John Close
Frédéric Davi
Stefano Dellea
Michel Diggonet
Sam Dimashkie
Andrea Donadel
Hideyuki Doyama
Dan Endean
Charles Fancher
Sebastien Ferrand
Glen Fitzpatrick
Takayuki Fujita
Ryunosuke Gando
Marco Garbarino
Wolfram Geiger
Federico Giacci
Joan Giner De Haro
Farid Golnaraghi
Jeffrey Gregory
Daniele Grifi
Jean Guerard
Jacques Haesler
Siyuan He
Ryan Hennesy
Joel Hensley
Jonathan Hoffman
Tracy Hudson
Chae Hyuck Ahn
Tamio Ikehashi
Eric Imhof
Stuart Ingleby
Raphael Jarraud
Alain Jeanroy
Yaesuk Jeong
Burgess Johnson
Brian Kasch
Steven Kim
Pawel Knapkiewicz
Ryan Knight
Ole Kock
Burkhard Kuhlmann
Vinaya Kumar
Jean-Baptiste Lacambre
Juha Lahdenperä
Amit Lal
Giacomo Langfelder
Michael Larsen
Olivier Le Traon
Raphael Levy
Timo Liewald
Matti Liukku
Daniel Lopez
Ryan Lu
Robert Lutwak
Daisuke Maeda
Cristiano Marra
Doug Meyer
Paolo Minotti
Ben Mohr
Greg Moore
Kari Moran
Takafumi Moriguchi
Isaac Nacita
Sachin Nadig
Khalil Najafi
Frank Narducci
Karl Nelson
Reinhard Neul
Matt Nicholson
Naoki Okimoto
Kazuo Ono
Mikko Partanen
Mike Perlmutter
Tommi Piirainen
Stefano Polesel
Igor Prikhodko
Vincent Ragot
Payman Rajai
John Reinke
Marcus Rinkiö
Emmanuel Robert
Christophe Roper
Andrew Sabater
Frank Schmid
Adam Schofield
Doruk Senkal
Diego Serrano
Peng Shao
Andrei Shkel
Logan Sorenson
Matt Squired
Jennifer Strabley
Ryan Supino
Michael Suster
Siddharth Tallur
Dan Thrasher
Alexander Trusov
See-Ho Tsang
Toshiyuki Tsuchiya
Takshiro Tsukamoto
Ryohei Uchino
Philippe Ullah
Daryosh Vatanparvar
Thomas Wagner
Jong-Kwan Woo
George Xereas
Daisuke Yamane
Yushi Yang
Donguk Yang
Naoto Yarie
Sergei Zotov

Gold Patrons

Silver Patrons

Student Travel Grant Award Patron

NORTHROP GRUMMAN

Best Student Paper Award Patron

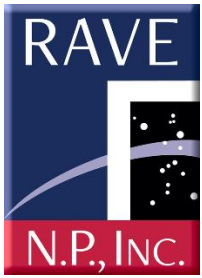
NORTHROP GRUMMAN

Lanyard Patron

lyncée tec

MEMS Analyzer & Dynamic 3D Characterization

Exhibitors



Exhibits will be in the Solarium North
Exhibits open at 08:00, Tuesday, April 2nd and closing at 16:00, Thursday, April 4th

Exhibitors

Exhibits will be in the Solarium North
Exhibits open at 08:00, Tuesday, April 2nd and closing at 16:00, Thursday, April 4th

Tutorials

Monday, April 1st

08:00 - 10:00
Inertial Navigation: Free and Aided
Room: River of Grass DEF
Instructor: Professor Michael Braasch, *Ohio University*

Abstract: Navigation-grade inertial systems are characterized by so-called “free inertial” position error drift rates on the order of one nautical mile-per-hour of operation. Such performance implies a certain class of gyros and accelerometers and thus certain specifications on biases, scale factor errors and noise. The first part of this tutorial will cover the basics of free-inertial processing (e.g., determination of position/velocity/attitude) and will consider the major error analyses that dominate system performance. Attention will then be turned to the subject of aiding. For more than five decades, the Kalman filter has been the primary tool used to reduce inertial drift through the integration of various sensors. Specifically, the aiding sources (e.g., stellar, Doppler, GPS, etc) are used by the filter to estimate the errors in the free inertial processing. Thus, the heart of any aided-inertial Kalman filter is the inertial error model including, specifically, sensor errors. The tutorial will discuss these models and will proceed to explain how aiding source observations are then used by the filter, in conjunction with the models, to estimate the inertial errors. For example, a given aiding source may provide an independent measurement of position, yet somehow the filter is able to use this in order to estimate gyro biases in the inertial system. Join us as we unravel these mysteries.

Tutorials Continued

10:20 – 12:20
Metrology and Methods for Inertial Instruments and Systems
Room: River of Grass DEF
Instructors: Adam Schofield*, U.S. Army CERDEC*
Brian Grantham*, U.S. Army* AMRDEC

Abstract: Bias stability vs. instability? Stability vs. repeatability? Alignment vs. misalignment? These terms are sometimes used interchangeably even though they have distinct meanings when it comes to gyroscope, accelerometer, and inertial system characterization. This tutorial will re-introduce standard inertial terminology for inertial navigation errors according to IEEE Standards. Additionally, this tutorial will delve into recommended practices for test and data acquisition equipment, instrumentation, test facilities, and data analysis techniques used in inertial sensor and system metrology. This tutorial will also discuss how the sensor-level errors propagate into system-level navigation errors and provide insight into how to determine which of these errors may be most significant to a given system.

13:40 – 15:40
Navigation, Guidance and Control in Natural Systems
Room: River of Grass DEF
Instructor: Jennifer Talley, *U.S. Air Force Research Laboratory*

Abstract: The bumblebee paradox: engineers said that bumblebee flight was impossible, and yet they flew. That may be inspirational, teaching us to reach for goals despite the doubts and criticisms of other people, but it could not be more wrong. Insects were the first organisms on Earth to develop flight and yet when humans successfully took to the skies, they used fixed wing aircraft more like birds and pterodactyls rather than flapping flight. The explanation of how insects are able to fly came not from applying fixed wing aerodynamics, which gave rise to the bumblebee paradox, but instead counted on completely new ideas published in the 1984 Ellington papers reporting on years of research into flapping wing flight aerodynamics. This discovery was made possible by combining the tools of engineering and the measurements of biologists; neither discipline alone could have resolved the bumblebee paradox. More than 30 years before the mathematics of flapping flight had been worked out, the modified hind wings of dipteran flies had been established as gyroscopic sensors optimized to detect Coriolis forces, enabling stabilization of the unsteady fly in roll, pitch, and yaw. This leaves out the bumblebee, however, since it still retains all four of its wings. Attention has now turned into how other body parts could serve as inertial sensors for stabilizing unsteady insect bodies in flight. Beyond inertia, there are at least a dozen modes of sensing and half a dozen modes of transduction that all contribute to the guidance, navigation, and control of natural systems. Studying these integrated sensing and actuation systems may substantially aid the future development of cheap, fast, agile, autonomous flight.

In this tutorial, we will go beyond inertia. We will put inertial sensing in the context of how insects use all of their senses to navigate the world. Insects can detect acoustic waves, airflow, chemicals, gravity, magnetic fields, electromagnetic radiation, pressure, heat, ultrasonics, strain, and infrared. Precision in these noisy sensory signals is increased through range fractionation meaning the natural systems divide up the sensory space for representation rather than covering the entire spectrum like engineered sensors. We will explore not just the sensory systems, but how these signals are actually perceived mechanically and organically and transformed into neural signals. Natural systems do not operate in a vacuum, but instead are tightly integrated and understanding their inertial sense requires that we study it in context. Sensing and transduction and neural codes are a symbiosis that is the key to how noisy, low resolution low energy systems can still outperform engineered platforms.

Tutorials Continued

16:00 – 18:00
From Atomic Clocks to Time Scales
Room: River of Grass DEF
Instructors: Stefania Romisch, *NIST*
Steven Jefferts, *NIST*

Abstract: This tutorial will guide you through all the systems and tools involved in the generation and dissemination of time, including primary frequency standards, commercial atomic clocks, time scales, and the techniques and challenges associated with the distribution of accurate and assured time to its users.

We will cover the physics of traditional, commonly available, commercial atomic clocks, as well as a description of laboratory standards and nascent commercial laser-cooled atomic clocks, all based upon hyperfine splitting in Alkali systems. We then will delve into the analytic tools used in the characterization of these clocks (Allan Variance and its many progeny), to allow discussing the relative quality of these different clocks, in terms of their Size, Weight and Performance (SWaP).

Atomic clocks are used to generate time, the SI quantity that requires the highest degree of coordination and monitoring: time standards are not physical objects that require only occasional calibration, but fleeting pulses in time that occur once and then are gone. An overview of the systems involved in the generation of time will be provided, briefly describing how Universal Coordinated Time (UTC) is created and maintained.

Finally, an ever more interconnected world where precision timing is both a powerful enabler and a great vulnerability is adding a new dimension to the topic of time dissemination. The almost complete reliance on GNSS for the distribution of time to its large and very disparate number of users has brought to the fore the intrinsic vulnerabilities of a timing infrastructure based on a single technology. As a conclusion to this tutorial, we will provide an overview of the efforts under way in the community to address the need of a diverse and robust timing infrastructure at the (inter)continental level.

Invited Speakers

Tuesday, April 2nd
08:40 – 09:25
I1: Invited Talk
Room: River of Grass DEF

"Miniature Navigation Grade Inertial Sensors – Status and Outlook"
Dr. Ronald Polcawich*, DARPA*

Abstract:
The DARPA Precise Robust Inertial Guidance for Munitions (PRIGM) program has been running for over 3 years with a focus on developing inertial sensor technologies to enable positioning, navigation, and timing (PNT) in GPS-denied environments. This presentation will provide an overview of the program, the current status, and a glimpse at the outlook for miniature inertial sensors. Overall, PRIGM comprises two focus areas: development of a navigation-grade inertial measurement unit (NGIMU) based on micro-electromechanical systems (MEMS) platforms and basic research of advanced inertial micro sensor (AIMS) technologies for future gun-hard, high-bandwidth, high-dynamic-range, GPS-free navigation. The PRIGM:NGIMU focus area is developing a MEMS-based, navigation-grade inertial measurement unit (IMU) that has a mechanical/electronic interface compatible with drop-in replacement for existing tactical-grade IMUs on legacy DoD platforms. PRIGM:AIMS is a basic research program exploring alternative technologies and modalities for inertial sensing, including photonic and MEMS-photonic integration, as well as novel architectures and materials systems. The principal objective of PRIGM:AIMS is to identify promising candidate technologies for further development as high-performance inertial sensors for long-duration missions and deployment in extreme environments. The bulk of the presentation will focus on the new technology developments within the AIMS effort as a way of providing insight into the future possibility of navigation-grade-plus performance for miniature inertial sensors.

Wednesday, April 3rd
08:40 – 09:25
I2: Invited Talk
Room: River of Grass DEF

"A hybrid classical - quantum accelerometer"
Dr. Joseph Cotter, *Imperial College London, UK*

Abstract:
Cold atom inertial sensors have been developed in laboratory settings by several groups around the world. Because of their stable scale factor and low bias drift they have the potential to achieve significantly improved performance, compared with classical sensors, when applied to problems such as inertial navigation and the measurement of gravity. These benefits can be further enhanced by hybridising classical and quantum systems to provide both high-bandwidth and excellent long-term stability. In this talk I will give an introduction to the physics that underpins quantum inertial sensing and offer a review of the current state of the art. I will then present the hybrid accelerometer we have developed recently, along with our efforts to make this device field deployable. I will then describe some of the improvements we are making to achieve higher sensitivities and increased technology readiness, along with the potential applications of these and similar sensors.

.

Invited Speakers Continued

Thursday, April 4th
8:40 – 9:25
I3: Invited Talk
Room: River of Grass DEF

"The Importance of INS Accuracy for Map-Matching Navigation"
Aaron Canciani, *Air Force Institute of Technology*

Abstract:
Map-matching navigation is a common GPS-alternative navigation technique in which measurements from a sensor are matched to a map to provide navigation information. With repeatable measurements, almost any map may be used to navigate. Common maps used for navigation include terrain height, gravity, magnetic fields, WIFI RSS, and many more. The inertial navigation system often plays a critical role in the accuracy of these map-matching navigation methods. This presentation seeks to provide insight into how increased INS accuracy plays a synergistic role in an overall map-matching navigation system. The presentation will first give an overview of map matching navigation. It will then cover two state of the art examples of emerging map-matching navigation techniques. Finally, a detailed look at what makes the INS such a powerful aiding sensor will be given, with a focus on the non-obvious benefits of increasing INS accuracy.

Friday, April 5th
09:00 – 09:45
I4: Invited Talk
Room: River of Grass DEF

"High Performance Inertial Sensors at Analog Devices"
Dr. Mike Judy, *Analog Devices*

Abstract:
Analog Devices' (ADI) focus on high performance signal processing with world-class performance has successfully served a wide range of applications, customers and markets. When ADI decided to pursue MEMS in the late 1980's, this vision was applied to the development of MEMS inertial sensors with the goal of delivering sensor performance leadership. This presentation will look back at the challenges and successes of this pursuit with regards to ADI's iMEMS® (integrated Micro Electro Mechanical Systems) inertial sensor technology and manufacturing processes. The future will also be discussed as more advanced, higher performance MEMS accelerometers and gyroscopes are set to transform an incredibly diverse scope of new applications in an equally diverse list of markets. By combining ~30 years of MEMS experience with 50+ years of signal processing expertise, ADI is well positioned to lead the next wave of high performance MEMS sensor adoption.

Monday, April 1

07:00 - 16:00
Tutorial Registration ***Those not registered to attend tutorials may begin checking in after 8:30 AM.*
Room: The Orchid Atrium

08:00 – 10:00
Tutorial 1: Inertial Navigation: Free and Aided
Instructor: Professor Michael Braasch, *Ohio University*
Room: River of Grass DEF
Session Chairs: Doug Meyer, *Northrop Grumman, USA*
Jenna Chan, *General Technical Services, LLC, USA*

10:00 – 10:20
Coffee Break
Room: Solarium North

10:20 – 12:20
Tutorial 2: Metrology and Methods for Inertial Instruments and Systems
Instructor: Adam Schofield, *U.S. Army CERDEC* & Brian Grantham, *U.S. Army AMRDEC*
Room: River of Grass DEF
Session Chairs: Doug Meyer, *Northrop Grumman, USA*
Jenna Chan, *General Technical Services, LLC, USA*

12:20 – 13:40
Lunch
Room: River of Grass GHI

13:40 – 15:40
Tutorial 3: Navigation, Guidance and Control in Natural Systems
Instructor: Jennifer Talley, *U.S. Air Force Research Laboratory*
Room: River of Grass DEF
Session Chairs: Doug Meyer, *Northrop Grumman, USA*
Jenna Chan, *General Technical Services, LLC, USA*

15:40 – 16:00
Coffee Break
Room: Solarium North

16:00 – 18:00
Tutorial 4: From Atomic Clocks to Time Scales
Instructors: Stefania Romisch, *NIST &* Steven Jefferts, *NIST*
Room: River of Grass DEF
Session Chairs: Doug Meyer, *Northrop Grumman, USA*
Jenna Chan**,** *General Technical Services, LLC, USA*

18:00 – 20:00
Welcome Reception
Room: *Oceanfront Lawn*
***Weather Permitting, a new location will be announced if location is changed due to weather conditions outside.*

All attendees are invited to the Welcome Reception for drinks and light hors d'oeuvres.

Tuesday, April 2

08:00 - 18:00
Registration
Room: The Orchid Atrium

08:30 – 08:40
Opening Remarks
Michael Larsen, 2019 General Chair
Room: River of Grass DEF

08:40 – 09:25
I1: Invited Talk: Dr. Ronald Polcawich**,** *DARPA*
Room: River of Grass DEF
Session Chairs: Alexander Trusov, *Northrop Grumman, USA*
Kari Moran, *Navy, SSC Pacific, USA*

Miniature Navigation Grade Inertial Sensors – Status and Outlook
Dr. Ronald Polcawich, *DARPA*

09:25 – 10:15
T1: MEMS Gyroscopes I
Room: River of Grass DEF
Session Chairs: Alexander Trusov, *Northrop Grumman, USA*
Kari Moran, *Navy, SSC Pacific, USA*

Acousto-Optic Gyroscope with Improved Sensitivity and 100 Second Stability in a Small Form Factor
Ashraf Mahmoud, Lutong Cai, James Bain, Tamal Mukherjee, Gianluca Piazza
Carnegie Mellon University, United States

Fused Quartz Dual Shell Resonator
Mohammad Hossein Asadian, Andrei Shkel
University of California, Irvine, United States

10:15- 10:55
Exhibitors' and Patrons' Highlights
Room: River of Grass DEF
Session Chair: Rachel Brockhoff, *Conference Catalysts, LLC, USA*

10:55 – 11:20
Coffee Break
Room: Solarium North

10:55 – 11:20
Exhibits
Room: Solarium North

Tuesday, April 2

11:20 – 12:35
T2: MEMS Gyroscopes II
Room: River of Grass DEF
Session Chairs: Igor Prikhodko, *Analog Devices, Inc., USA*
Daniel Endean, *Honeywell International, USA*

Nonlinear Dynamical System Model for Drive Mode Amplitude Instabilities in MEMS Gyroscopes
Ulrike Nabholz{1}, Michael Curcic{1}, Jan Mehner{2}, Peter Degenfeld-Schonburg{1}
{1}Robert Bosch GmbH, Germany; {2}Technical University of Chemnitz, Germany

Analysis and Design of Super-Sensitive Stacked (S3) Resonators for Low-Noise Pitch/Roll Gyroscopes
Ali Darvishian, Khalil Najafi
University of Michigan, United States

Characterization of Scale Factor Nonlinearities in Coriolis Vibratory Gyroscopes
Daryosh Vatanparvar, Mohammad Hossein Asadian, Sina Askari, Andrei Shkel
University of California, Irvine, United States

12:35- 13:55
Lunch
Room: River of Grass GHI

13:55 – 15:15
T3: MEMS Gyroscopes III
Room: River of Grass DEF
Session Chairs: Johannes Classen, *Robert Bosch GmbH, Germany*
Takashiro Tsukamoto, *Tohoku University, Japan*

MEMS Rate Integrating Gyroscope with Temperature Corrected Virtual Rotation
Takashiro Tsukamoto, Shuji Tanaka
Tohoku University, Japan

Improving the Stability of 1.5 mm² Gyroscopes Down to 2°/hr at 1000 S with NEMS Based Sensing
Marco Gadola {1}, Marco Malvicini {1}, Giacomo Langfelder {1}, Mikael Colin {2}, Philippe Robert {2}
{1}Politecnico di Milano, Italy; {2}CEA-Leti, France

Amplitude Amplified Dual-Mass Gyroscope: Design Architecture and Noise Mitigation Strategies
Danmeng Wang, Alexandra Efimovskaya, Andrei Shkel
University of California, Irvine, United States

15:15 – 15:45
Lightning Round Presentations of the following Poster Session
Room: River of Grass DEF

Tuesday, April 2

15:45 – 16:00
Break **No Food & Beverage. Beverages and light hors d'oeuvres will be served during the Poster Session
Room: Solarium North

15:45 – 16:00
Exhibits
Room: Solarium North

16:00 – 18:00
Late News Posters, Open Posters, Hardware Demonstrations & IEEE International Sensors and Measurement Student Contest
Room: River of Grass GHI & Solarium North
Session Chair: Jenna Chan, *General Technical Services, LLC, USA*

This session will begin with "Lightning Round" Presentations in River of Grass DEF

Late News & Open Posters
Room: River of Grass GHI & Solarium North

LN-1 Quad Mass Gyroscope with 16 ppm Frequency Mismatch Trimmed by Focus Ion Beam
Jianlin Chen, Takashiro Tsukamoto, Shuji Tanaka
Tohoku University, Japan

LN-2 Annealing Experiments on the Quality Factor of Fused Silica Cylindrical Shell Resonator
Yiming Luo, Yao Pan, Guanqing Zhou, Tianliang Qu, Hui Luo, Bin Zhang
National University of Defense Technology, China

LN-3 Directional Ranging for Enhanced Performance of Aided Pedestrian Inertial Navigation
Yusheng Wang, Sina Askari, Chi-Shih Jao, Andrei Shkel
University of California, Irvine, United States

LN-4 A Laboratory Testbed for Self-Contained Navigation
Sina Askari, Chi-Shih Jao, Yusheng Wang, Andrei Shkel
University of California, Irvine, United States

LN-5 Integrated Temperature Sensor for Temperature Compensation of Inertial Sensors
Onurcan Kaya, Talha Köse, Kıvanç Azgın
Middle East Technical University, Turkey

LN-6 Sensor Fusion for Land Vehicle Localization Using Inertial MEMS and Odometry
Aleksandr Mikov{2}, Alexey Panyov{2}, Vasily Kosyanchuk{2}, Igor Prikhodko{1}
{1}Analog Devices, Inc., United States; {2}Navigine Corp., Germany

OP-1 MEMS BASED SENSOR FUSION ENABLING INERTIAL NAVIGATION WITHOUT GPS
Matthew Straeten, Nabeel Khan, Imran Khan and Mohammad Jalal Ahamed
MicroNano Mechatronics Lab, University of Windsor, Windsor, ON, Canada

OP-2 Tactical Grade Inertial Sensors & Systems
David Hoyh, Sergey Zotov
Systron Donner Inertial

Tuesday, April 2

OP-3 High-Q 3D Micro-Shell Resonator with High Shock Immunity and Low Frequency Mismatch for MEMS Gyroscopes
Sajal Singh, Ali Darvishian, Jae Yoong Cho, Behrouz Shiari and Khalil Najafi
Wireless Integrated MicroSensing and Systems (WIMS2), University of Michigan, Ann Arbor, MI, USA

OP-4 Next Generation, Low-Cost MEMS Gyroscopes: New Technology or New Working Principle
Marco Bestetti, Marco Gadola, Leonardo Gaffuri Pagani, Giacomo Langfelder
Dipartimento di Elettronica, Informazione e Bioingegneria, Politecnico di Milano, Italy

OP-5 A Low-Cost Navigation Grade ½U CubeSat IMU
A.D. Challoner, J.D. Popp, P.W. Bond
InertialWave, Inc.

OP-6 High Performance Quartz Vibrating Accelerometer
Rachid Taibi1, Thomas Kerrien1, Solene Guyomard1, Karl Aubry1, Sébastien Keller2, Gauthier Le Bihan1, Thomas Loret1
1 iXblue, Inertial Sensors Division, Saint Germain en Laye, France, 2 iXblue, Navigation Systems Division, Saint Germain en Laye, France

OP-7 Preliminary Investigation for the Inertial Sensor in Tianqin Mission
Hang Yin, Li Liu, Ding Yin Tan, Shao-Bo Qu and Shu-Chao Wu
Center for Gravitational Experiments, School of Physics, Huazhong Univ. of Science & Technology, Wuhan, China

OP-8 A Broadband Seismic Isolation Bench for Precision Accelerometer Testing
Li Liu , Shi-Xun Pei, Ding-Yin Tan, Hang Yin, Shao-Bo Qu and Shu-Chao Wu
Center for Gravitational Experiments, Huazhong University of Science and Technology, Wuhan, China

Live Demonstrations
Room: River of Grass GHI

Demonstration 1: Nuclear Magnetic Resonance Gyroscope Poster with Live demonstration
Michael Larsen
Northrop Grumman, USA

Demonstration 2: Demonstration of Self-Contained Personal Navigation System with Foot-Mounted Sensors
Yusheng Wang, Sina Askar
University of California, Irvine, United States

IEEE International Sensors and Measurement Student Contest
Room: River of Grass GHI

Smart Infant Monitoring System Capable of Detecting Apnea, Seizure and Other Activities
Omiya Hassan and Samira Shamsir
University of Missouri

Wednesday, April 3

08:00 - 18:00
Registration
Room: The Orchid Atrium

08:30 – 08:40
Opening Remarks, Day 2
Michael Larsen, 2019 General Chair
Room: River of Grass DEF

08:40 – 9:25
I2: Invited Speaker: Dr. Joseph Cotter, *Imperial College London, UK*
Room: River of Grass DEF
Session Chairs: Justin Brown, *Physical Sciences, Inc., USA*
Mohammad Jalal Ahamed, *University of Windsor, Canada*

Dr. Joseph Cotter, *Imperial College London, UK*

09:25 - 10:40
T4: Atomic Sensors I
Room: River of Grass DEF
Session Chairs: Justin Brown, *Physical Sciences, Inc., USA*
Mohammad Jalal Ahamed, *University of Windsor, Canada*

Cold Atom Gravity Gradiometry for Field Applications
Michael Holynski, Kai Bongs
University of Birmingham, United Kingdom

Demonstration of a Robust Hybrid Classical/Quantum Accelerometer
Pierrick Cheiney{2}, Brynle Barrett{2}, Simon Templier{1}, Olivier Jolly{2}, Baptiste Battelier{1}, Philippe Bouyer{1}, Henri Porte{2}, Fabien Napolitano{2}
{1}Institut d'optique Graduate School, France; {2}iXblue, France

Progress in Confined Cold Atom Sensing
Matthew Squires{1}, James Stickney{2}, Spencer Olson{1}, Brian Kasch{1}, Rudolph Kohn{2}
{1}Air Force Research Laboratory, United States; {2}Space Dynamics Laboratory, United States

10:40 – 11:05
Coffee Break
Room: Solarium North

10:40 – 11:05
Exhibits
Room: Solarium North

Wednesday, April 3

11:05 – 12:20
T5: Atomic Sensors II
Room: River of Grass DEF
Session Chairs: Jennifer Strabley, *Honeywell., USA*
Andrea Pizzarulli, *Civitanavi Systems srl, Italy*

Study on MEMS Glassblown Cells for NMR Sensors
Radwan Mohammed Noor, Nikita Kulachenkov, Mohammad Hossein Asadian, Andrei Shkel
University of California, Irvine, United States

Alkali-Metal Mixture for Synthetic Alkali Vapor Density Reduction
Justin Brown, Colin Hessel, Joel Hensley
Physical Sciences Inc., United States

A Chip-Scale Nanophotonic Optical Gyroscope
Parham P. Khial, Alexander D. White, Ali Hajimiri
California Institute of Technology, United States

12:20 – 13:50
Lunch
Room: River of Grass GHI

13:50 – 13:55
Introduction
Room: River of Grass DEF

13:55 – 15:10
T6: Accelerometers and Gyro Self-Calibration
Room: River of Grass DEF
Session Chair: Danielle Braje, *MIT Lincoln Lab, USA*

Frequency Staggered Accelerometer Array for Improved Ringdown Behavior
Metin Guney, Vincent P. J. Chung, Xiaoliang Li, Jeyanandh Paramesh, Tamal Mukherjee, Gary Fedder
Carnegie Mellon University, United States

Hourglass-Beam Nanogram-Proof-Mass Array: Toward a High Dynamic Range Accelerometer
Vincent P. J. Chung, Xiaoliang Li, Metin Guney, Jeyanandh Paramesh, Tamal Mukherjee, Gary Fedder
Carnegie Mellon University, United States

Retrospective Correction of Angular Gain by Virtual Carouseling in MEMS Gyroscopes
Sina Askari, Mohammad Hossein Asadian, Andrei Shkel
University of California, Irvine, United States

15:10 – 15:40
Lightning Round Presentations of the following Poster Session
Room: River of Grass DEF

The session will begin with 1 Minute "Lightning Round" Presentations in River of Grass DEF

Wednesday, April 3

15:40 – 16:00
Break- **No Food & Beverage. Beverages and light hors d'oeuvres will be served during the Poster Session
Room: Solarium North

15:40 – 16:00
Exhibits
Room: Solarium North

16:00 – 18:00
P2: Poster Session
Room: River of Grass GHI
Session Chairs: Ryan Lu, *Navy, SSC Pacific, USA*
Jenna Chan, *General Technical Services, LLC, USA*

***Session will include Poster Discussion, Exhibit Inspection and Food & Beverage*

P-1 Quaternion-Based Complementary Filter for Aiding in the Self-Alignment of the MEMS IMU
Haifeng Xing, Zhiyong Chen, Chengbin Wang, Meifeng Guo, Rong Zhang
Tsinghua University, China

P-2 Angle Random Walk Minimization for Frequency Modulated Gyroscopes
Andrew Sabater, Kari Moran
SPAWAR Systems Center Pacific, United States

P-3 Impacts of Inertial Sensor Errors on Both Data Fusion and Attitude-Based Bicycle Rider Assistance Systems in Order to Derive Sensor Requirements
Felix Dauer{1}, Daniel Görges{2}, Andreas Wienss{1}
{1}Robert Bosch GmbH, Germany; {2}University of Kaiserslautern, Germany

P-4 Micro Acceleration Measurement System Based on Highly-Sensitive Tunnel Magneto-Resistance Sensor
Lu Gao, Suiqiong Li, Yingfei Yao, Xiang Xu, Dacheng Xu
Soochow University, China

P-5 Impact of Parasitics on the Settling Time of a Readout Circuit for High Performance MEMS Accelerometers
Alice Lanniel{1}, Tobias Boeser{1}, Lena Aichholz{1}, Thomas Alpert{1}, Maurits Ortmanns{2}
{1}Robert Bosch GmbH, Germany; {2}Ulm University, Germany

P-6 The Study of a Novel Second-Order Stress Isolation for Silicon Resonator Applied on MEMS Sensor
Jing Zhang{2}, Yagang Wang{2}, Yudong Liu{2}, Chen Lin{2}, Zhichao Yao{2}, Yan Su{2}, Peiwen Xu{1}
{1}Nanjing SCIYON Automation Group Co.,Ltd, China; {2}Nanjing University of Science and Technology, China

P-7 An Improved Fabrication Process for Micro Hemispherical Resonator Gyroscope
Yan Shi, Xiang Xi, Wei Li, Wulie Wu, Xuezhong Wu, Kun Lu, Zhenjun Wang, Dingbang Xiao
National University of Defense Technology, China

P-8 Quality Factor Improvement Method of Honeycomb-Like Disk Resonator Gyroscope
Yi Xu, Qingsong Li, Jiangkun Sun, Kai Gao, Yongmeng Zhang, Zhanqiang Hou, Xuezhong Wu, Dingbang Xiao
National University of Defense Technology, China

Wednesday, April 3

P-9 A Novel Resonant Accelerometer Based on Quartz on Silicon (QoS)
Chao Han, Yulong Zhao, Cun Li
Xi'an Jiaotong University, China

P-10 Geometrical and Process Effects on MEMS Dimensional Loss: a Frequency Based Characterization
Gabriele Gattere, Francesco Rizzini, Lorenzo Corso, Anna Alessandri, Francesco Tripodi, Stefano Paleari
STMicroelectronics, Italy

P-11 Identification-Based Approach for Electrical Coupling Compensation in a MEMS Gyroscope
Kévin Colin{2}, Fabrício Saggin{2}, Christophe Le Blanc{1}, Xavier Bombois{2}, Anton Korniienko{2}, Gérard Scorletti{2}
{1}Asygn, France; {2}Laboratoire Ampère, Ecole Centrale de Lyon, Université de Lyon, France

P-12 Self-Induced Parametric Amplification in the Disk Resonant Gyroscope
Kari Moran, Kevin Stanzione, Andrew Sabater, Taneka Lewis, Veronica Badescu, Andrew Wang
SPAWAR Systems Center Pacific, United States

P-13 Study on Mounting Position of IMU for Better Accuracy of ZUPT-Aided Pedestrian Inertial Navigation
Yusheng Wang, Sina Askari, Andrei Shkel
University of California, Irvine, United States

P-14 Micro-Torr Vacuum Packaging of Gettered Ceramic Chip Carriers
Ryan Knight{2}, Don DeVoe{3}, Ronald Polcawich{1}, Jeffrey Pulskamp{2}, Brian Power{2}
{1}DARPA MTO, United States; {2}United States Army Research Laboratory, United States; {3}University of Maryland, United States

P-15 Improved Scale-Factor and Bias Stability of Ovenized Inertial Sensors in an Environmentally-Stabilized Inertial Measurement Unit (eIMU)
David Lemmerhirt{2}, Onnop Srivannavit{2}, Sam Chen{2}, Tom Litow{2}, Jay Mitchell{2}, Philip Cooksey{1}, Reese Sturdevant{1}, Jason Bingham{1}, Orlando Padilla{1}, M. Nayeli Trevino{1}
{1}746th Test Squadron, United States; {2}ePack, Inc., United States

P-15 Frequency Stabilization in a MEMS Oscillator with 1:2 Internal Resonance
Jun Yu{1}, Keivan Asadi{1}, Hatem Brahmi{1}, Hanna Cho{1}, Saman Nezmi{2}, Soobum Lee{2}
{1}Ohio State University, United States; {2}University of Maryland, Baltimore County, United States

P-16 Temperature Stabilized MEMS Capacitor for Inertial Sensing Application
Jonathan Puder{1}, Iain Kierzewski{1}, Victor Farm-Guoo Tseng{2}, Ryan Knight{3}, Jeffrey Pulskamp{3}
{1}General Technical Services, United States; {2}Oak Ridge Associated Universities, United States; {3}United States Army Research Laboratory, United States

P-17 Low-Power Frequency-to-Digital-Converter for a 6-Axis MEMS Frequency-Modulated Inertial Measurement Unit
Marco Bestetti{1}, Mauro Leoncini{1}, Paolo Minotti{1}, Cristiano Rocco Marra{1}, Giacomo Langfelder{1}, Alessandro Tocchio{2}, Stefano Facchinetti{2}
{1}Politecnico di Milano, Italy; {2}STMicroelectronics, Italy

Wednesday, April 3

P-18 Low Power High Bandwidth Acceleration Sensor for Industrial Applications
Roman Forke{3}, Karla Hiller{3}, Susann Hahn{1}, Sebastian Weidlich{1}, Stefan Konietzka{2}, Tim Motl{2}, Alexander Praedicow{2}, Thomas Otto{3}
{1}Chemnitz University of Technology, Germany; {2}EDC Electronic Design Chemnitz GmbH, Germany; {3}Fraunhofer-Institute for Electronic Nano Systems, Germany

P-19 Effect of Electrode Design on Frequency Tuning in Shell Resonators
Ali Darvishian, Christopher Boyd, Sajal Singh, Jae Yoong Cho, Jong-Kwan Woo, Guohong He, Khalil Najafi
University of Michigan, United States

P-20 Modeling of Nonlinear Oscillations of Doped Lamé-Mode MEMS Silicon Resonator
Payman Rajai, Nabeel Khan, Mohammed Jalal Ahamed
University of Windsor, Canada

P-21 Design Space Exploration of Hemi-Toroidal Fused Quartz Shell Resonators
Mohammad Hossein Asadian, Yusheng Wang, Radwan Mohammed Noor, Andrei Shkel
University of California, Irvine, United States

18:00 - 17:00
Banquet Dinner Entertainment
Room: Everglades Room

18:30 - 20:30
Banquet Dinner
Room: Everglades Room

Thursday, April 4

08:00 - 17:00
Registration
Room: The Orchid Atrium

08:30 – 08:40
Opening Remarks, Day 3
Michael Larsen, 2019 General Chair
Room: River of Grass DEF

08:40 – 9:25
I3: Invited Talk: Aaron Canciani, *Air Force Institute of Technology*
Room: River of Grass DEF
Session Chairs: Stefano Facchinetti, *ST Microelectronics, Italy*
Doug Meyer, *Northrop Grumman, USA*

"The Importance of INS Accuracy for Map-Matching Navigation"
Aaron Canciani, *Air Force Institute of Technology*

9:25 – 10:40
T7: Optical Gyroscopes
Room: River of Grass DEF
Session Chairs: Stefano Facchinetti, *ST Microelectronics, Italy*
Doug Meyer, *Northrop Grumman, USA*

Reducing Noise in a Ring-Laser Gyro Based on Stimulated Brillouin Scattering
Karl Nelson{1}, Matthew Puckett{1}, Jianfeng Wu{1}, Debapam Bose{2}, Sarat Gundavarapu{2}, Daniel Blumenthal{2}
{1}Honeywell Aerospace, United States; {2}UCSB, United States

Digital Closed-Loop Fiber Optic Gyroscopes - a Choice for Micro/Nano-Satellites Application
Jing Jin, Jiliang He, Kun Ma, Linghai Kong
Beihang University, China

Modulation Methods in Time Division Multiplexing Interferometric Fiber Optic Gyroscopes
Jiliang He{1}, Rui Gan{2}, Ningfang Song{1}
{1}Beihang University, China; {2}HuBei Sanjiang Space HongFeng Control Equipment CO,Ltd, China

10:40 – 11:05
Coffee Break
Room: River of Grass GHI

10:40 – 11:05
Exhibits
Room: Solarium North

11:05 – 12:20
T8: MEMS Sensors
Room: River of Grass DEF
Session Chair: Olivier Le Traon, *ONERA, France*

Pseudo-Extensional Mode MEMS Ring Gyroscope
Igor Prikhodko{1}, Jeffrey Gregory{1}, Daniel Shin{2}, Ryan Kwon{2}, Thomas Kenny{2}, Michael Judy{1}
{1}Analog Devices, Inc., United States; {2}Stanford University, United States

Near-Navigation Grade Tuning Fork MEMS Gyroscope
Daniel Endean, Kevin Christ, Patrick Duffy, Eugene Freeman, Max Glenn, Markus Gnerlich, Burgess Johnson, Jacob Weinmann
Honeywell International, United States

Development of a High-G Shock Sensor Based on MEMS Technology for Mass-Market Applications
Jean Marie Darmanin, Alessandro Tocchio, Giovanni Carlo Tripoli, Paolo Pesenti, Andrea Donadel, Angelo Granata, Matteo Quartiroli, Paolo Rosingana, Stefano Facchinetti
STMicroelectronics, Italy

12:20 – 13:50
Lunch
Room: River of Grass GHI

13:50 – 13:55
Introduction
Room: River of Grass DEF

13:55 – 15:35
T9: Applications
Room: River of Grass DEF
Session Chair: Tommi Piirainen, *Murata Electronics Oy, Finland*

Evaluation Method for the Absolute Orientation from the Rotation Vector on Mobile Devices
Nils Büscher, Marcel Stieringer, Christian Haubelt
Univertity of Rostock, Germany

Laser Self-Mixing Interferometry for Precision Displacement Measurement in Resonant Gyroscopes
Guohong He, Robert Gordenker, Jong-Kwan Woo, John Nees, Behrouz Shiari, Tal Nagourney, Jae Yoong Cho, Khalil Najafi
University of Michigan, United States

Design and Performance of Wheel-Mounted MEMS IMU for Vehicular Navigation
Oleg Mezentsev{2}, Jussi Collin{1}
{1}JC Inertial Oy., Finland; {2}Pacific Inertial Systems Inc., Canada

Ice-Surface Profilometry with Millimeter Vertical Resolution Over 10's of Meters Using a MEMS Inclinometer
Marshall Bremer, Karl-Heinz Mertins
Appareo Systems, United States

15:35 – 16:00
Coffee Break
Room: Solarium North

15:35 – 16:00
Exhibits
Room: Solarium North

16:00 – 17:35
T10: Best Failed Ideas
Room: River of Grass DEF
Session Chair: Michael Larsen, *Northrop Grumman, USA*

Idea 1: Tackling SDM Feedback Coefficient Modulation in Area Optimized Frontend Readout Circuit for High Performance MEMS Accelerometers
Alice Lanniel{1}, Tobias Boeser{1}, Thomas Alpert{1}, Maurits Ortmanns{2}
{1}Robert Bosch GmbH, Germany; {2}Ulm University, Germany

Idea 2: Cross-Axis Rejection with the magic ratio
Michael Larsen
Northrop Grumman, USA

Idea 3: Metal-Alloy MEMS Sense Elements Are Not Good for Inertial Applications
John Cole
Founder and President of Silicon Designs, Inc.

Idea 4: Cold Ion Collision measurement system
Steven Jefferts
NIST

Idea 5: "TCXO for low cost and low power frequency reference in NMR gyroscopes"
Michael Bulatowicz
Northrop Grumman, USA

INERTIAL 2020

The 7th IEEE International Symposium on Inertial Sensors & Systems

Grand Prince Hotel Hiroshima | Hiroshima, Japan | March 23-26, 2020

SAVE THE DATE

This exclusive international Symposium on Inertial Sensors and Systems will be held in Hiroshima, Japan. The event continues our annual tradition of informal single-track international meetings discussing the latest developments in the area of modern inertial sensors and emerging applications. The INERTIAL 2020 will be a four-day event with one day of tutorials, and three days of technical sessions.

INERTIAL 2020 will be held at the Grand Prince Hotel Hiroshima. The hotel stands directly by the beautiful Seto Inland Sea, a 40 minute train ride from Hiroshima Station. Hiroshima Prefecture is located in the southwestern part of the Japanese islands. It is rich in the natural beauty of the Inland Sea and the Chugoku Mountains, with mountains, sea, rivers, valleys, plains, basins that characterize Japan's landscape.

TOPICS OF INTEREST

- Sensors Phenomena & Modeling
- Sensor Systems & Electronics
- Atomic/Quantum Sensors
- Low-cost Manufacturing
- Advanced Packaging
- Advanced Test & Evaluation
- Aiding Technology
- Emerging Applications
- Best Failed Ideas

Friday, April 5

08:00 - 17:00
Registration
Room: The Orchid Atrium

08:30 – 09:00
Opening Remarks, Day 4
Michael Larsen, 2019 General Chair
Room: River of Grass DEF

09:00 – 9:45
I4: Invited Talk: Dr. Mike Judy, *Analog Devices*
Room: River of Grass DEF
Session Chair: Giacomo Langfelder, Politecnico di Milano

"High Performance Inertial Sensors at Analog Devices"
Dr. Mike Judy, *Analog Devices*

9:45 – 10:35
T10: Late News I
Room: River of Grass DEF
Session Chair: Giacomo Langfelder, Politecnico di Milano

Characterization of Energy Dissipation Mechanisms in Dual Foucault Pendulum Gyroscopes
Mohammad Hossein Asadian, Sina Askari, Yusheng Wang, Andrei Shkel
University of California, Irvine, United States

Investigation of Scale Factor Versus Frequency for a Bulk Wave Diffraction Gyroscope
Visarute Pinrod, Benyamin Davaji, Amit Lal
Cornell University, United States

10:35 – 11:00
Coffee Break
Room: Solarium North

Friday, April 5

11:00 – 12:15
T11: Late News II
Room: River of Grass DEF
Session Chairs: Michael Bulatowicz, *Northrop Grumman, USA*
Julien Auger, *Safran Electronics and Defense, France*

Optimized Diamond Development for Quantum Vector Magnetometry
John Barry, Xingyu Zhang, Linh Pham, Alexandra Day, Charles Wuorio, Danielle Braje
Massachusetts Institute of Technology, United States

Prospects of Spin Gyroscopes Based on Nitrogen-Vacancy Centers in Diamond
Andrey Jarmola{3}, Dmitry Budker{1}, Sami Hawasli{2}, A. Glen Birdwell{2}, Tony Ivanov{2}, Vladimir S. Malinovsky{2}
{1}Helmholtz-Institut Mainz, Germany; {2}United States Army Research Laboratory, United States; {3}University of California, Berkeley, United States

Low-Cost, High-End Tactical-Grade Fiber Optic Gyroscope Based on Photonic Integrated Circuit
Liming Wang, Daniel Halstead, Thomas Monte, Jan Khan, Jeffrey Brunner, Martin Kits van Heyningen
KVH Industries, United States

12:15 – 12:30
Closing Remarks
Room: River of Grass DEF