In St. Louis, Missouri, with its futuristic gateway arch, the in-person attendees of ION GNSS+ 2021 met to discuss how Positioning, Navigation and Timing (PNT) might both benefit from, and support, emerging technology sectors like artificial intelligence, low-orbiting satellites, autonomous vehicles, and human space travel.

The keynote talks, about NASA's Artemis program and cutting-edge products from Hexagon, set a decidedly forward-looking tone. Unlike the Apollo missions, the Artemis plan is to go to the Moon to stay. With the help of international and commercial partners NASA will develop the lunar-orbiting Gateway station, a surface base station and a rover that will support sustained exploration.

One advancement that could make lunar operations easier is PNT capability in cis-lunar space. Two presentations during the Civil GPS Service Interface Committee (CG-SIC) meeting, held before the main ION GNSS+ program, discussed work by NASA Goddard and SpacePNT of Switzerland that could help make that possible.

One of the first GNSS+ panels featured updates on the different GNSS constellations. With the launch of GPS III SV5 in June the American constellation had 24 satellites equipped with both M-code and the L2C signal out of its total of 30 healthy satellites, said Michael Dunn, the PNT capability area integrator for the Space Force’s Space System Command. Work continues, he said, on the Next Generation Operational Navigation (NGN) constellation.

The Institute of Navigation’s peer-reviewed and indexed quarterly journal, NAVIGATION: Journal of the Institute of Navigation, will transition to Open Access (OA). This change in the publishing and circulation format allows for research to be published free of user costs or other access barriers; and for the prioritization of NAVIGATION papers in electronic search engines (i.e., Google Scholar). It is anticipated circulation will expand, citations will increase, and additional quality submissions will result. The ION Council approved this recommendation at its July 16, 2021 meeting.

“Moving NAVIGATION to an Open Access domain is critical to supporting ION’s mission of advancing Positioning, Navigation and Timing,” said Dunn.
I am pleased to report the Military Division kicked off the ION’s return to in-person meetings in August with the ION’s Joint Navigation Conference. We had over 700 people attending. For many, this U.S. DOD/DHS event was the first opportunity in nearly two years to meet face-to-face and see recent advancements in defense PNT exhibited in a robustly busy exhibit hall.

Three weeks later, the Satellite Division convened in St. Louis, Missouri, for ION GNSS+ 2021, with both in-person and virtual attendees. In-person attendees certainly felt the absence of international colleagues, most of whom were unable to travel because of border restrictions. But there was more than a critical mass of people in the hallways and exhibit hall for the usual serendipitous meetings and conversations that make these events so valuable.

The ION was pleased to host CGSIC (the Civil GPS Service Interface Committee), ION panel discussions, and the ION plenary session; all live-streamed for virtual attendees. The plenary session featured two keynotes: Towards a Smart Digital Reality by Dr. Burkhard Boeckem (see: https://youtu.be/hfS42V_5dBU) and Artemis—Return to the Moon by Mr. Steven Clarke, NASA (see: https://youtu.be/z8kOc0KCrCM). ION has made these talks free through ion.org and ION’s YouTube channel; please enjoy and share.

ION GNSS+ was pleased to host Google’s Smartphone Decimeter Challenge where teams competed to obtain the best location accuracy with GNSS datasets provided from phones. We had 810 teams compete, from 63 different countries, with the following winners: third place, Ilya Elenik, mdo.ru, Russia; second place, Wojciech Rosa, Lublin University of Technology, Poland; and first place, Dr. Taro Suzuki, Chiba Institute of Technology, Japan. It was fascinating to see how different teams solved this problem, with machine learning playing a central role for many.

Thank you to Dr. Michael Fu and Dr. Mohammed Khider of Google for organizing the competition and to Google for sponsoring the prize money.

We hope that by January 2022 our international members will once again be able to join us in person. We are planning a full International Technical Meeting, co-located with the Precise Time and Time Interval (PTTI) Systems and Applications Meeting, to be held in Long Beach, California, January 25-27, 2022. Additionally, ION plans to present the ION annual awards and name ION fellows during this meeting.

Dr. Frank van Diggelen at ION GNSS+ hosted a function for co-authors of the recent textbook, “Position, Navigation, and Timing Technologies in the 21st Century,” he co-edited with Drs Y. Jade Morton, Brad Parkinson, Jim Spilker, Grace Gao, and Sherman Lo.

Back Row: Dr. Jim Farrell, Dr. Sabrina Ugazio, Dr. Ben Ashman, Dr. Bradford Parkinson, Dr. John Betz, Dr. Mark Psiaki, Dr. John Raquet, Dr. Todd Humphreys, Dr. Charles Toth and Dr. Zak Kassas. Seated on Couch: Dr. Boris Pervan, Dr. Mathieu Joerger, Dr. Todd Walter, and Dr. Frank van Diggelen.

Dr. Frank van Diggelen (at podium) presenting as part of the ION GNSS+ Multiband Satellite Panel. Also pictured: Dr. Sanjeev Gunawardena and Dr. Paul McBurney.
PACIFIC PNT 2022 to be Held Virtually … FREE for ALL ION Members!

In light of special travel restrictions in the Hawaiian Islands, the Executive Committee approved a proposal to defer an in-person Pacific PNT meeting until 2024. Instead, it was decided that ION would host a series of webinars over Pacific PNT’s original dates. Sessions will be held on BeiDou, COMSIC/FORMOSAT, and QZSS each day, April 12-14, 9:00 a.m. Japan Standard Time (JST), 5:00 p.m. Pacific Daylight Time (PDT) April 11-13. Please watch for additional program and registration information to follow.

Council Approves ION Journal to be Distributed Electronically Open Access (OA)

The ION Council approved a transition of NAVIGATION: Journal of the Institute of Navigation to open access (OA) beginning in January 2022. This means the journal will be published online, accessible by everyone.

The NAVIGATION Editorial Advisory Board’s recommendation to the ION Council to move to an OA model is in keeping with the growing trend to broaden the impact and availability of scholarly research. OA has been shown to increase citations, increase readership, improve the quality of paper submissions, improve search engine prioritization, and increase a journal’s impact factor.

Transitioning NAVIGATION to an electronic format will also impact the ION’s membership model. First, the ION will become more environmentally friendly with the discontinuation of printed paper volumes. Beginning with the Spring 2022 issue, ION members will receive a carbon-neutral link to download a compiled electronic copy of each issue. Second, ION members download benefits will be dramatically expanded. See the explanation of new membership benefits on page 12 in this issue. We are enthusiastically looking forward to the broader reach this will give to our authors and the Institute as we strive to make PNT research more readily available to the world.
After the Joint Navigation Conference (JNC) was rescheduled in 2020 only to be cancelled due to Covid-19 and then rescheduled twice in 2021, the ION’s Military Division finally convened in person August 24-27 in Covington, Kentucky. The conference hosted nearly 800 attendees with strong joint services and government participation. The energy and enthusiasm was palpable for Positioning, Navigation, and Timing (PNT) technologies as the foundation for the United States’ military ops and homeland security.

Pre-Conference Tutorials Strong Showing

This year’s tutorial track had notably high attendance as the majority of attendees arrived early this year to take full advantage of conference offerings. Our outstanding lecturers brought forward tutorials in areas that were largely new to JNC, though organizers made sure to schedule some of the tried-and-true subjects that are always a strong draw. At the helm was Dr. John Raquet, IS4S, providing GPS/GNSS 101—JNC’s primary and foundational tutorial. The conference also repeated the Introduction to SatNav SDRs using Python taught by Dr. Sanjeev Gunawardena and Mark Carroll. New tutorial offerings for 2021 included Resilient and Robust PNT taught by Terrance Nelson, Integrity/Assurance of Navigation Systems taught by Dr. Samer Khanafseh, and an Introduction to Cryptography with Attention to Navigation by Dr. Joe Rushanan.

Technical Program Highlights

The technical program hosted parallel sessions on a variety of topics including autonomous systems and positioning, navigation and timing (PNT) and a full day of complementary PNT focused sessions.

Popular topics included space navigation, reconfigurable SatNav and NTS-3; military GPS equipment and applications; PNT open systems architecture; NAVWAR; and the application of PNT technologies in homeland critical infrastructure. JNC added several new panel subjects to this year’s program about the threat to national critical infrastructure, Joint Urgent Operational Need (JUON), rapid agile development and manufacturing and the integration of military GPS user equipment (MGUE). Additionally, the popular warfighter panel was hosted during which warfighters with recent operational experience made suggestions to the community about how to better design and manage military PNT systems to meet operational in-field warfighter needs.
### Exhibitors, Sponsors and Media Partners

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**ION Joint Navigation Conference 2022**

**June 6-9, 2022**

Town and Country Hotel
San Diego, California

**ABSTRACTS DUE FEBRUARY 4, 2022**
continued from page 1

Control System (OCX) which is expected to transition to operations in the last three months of 2022. A contract was let in April 2021 to upgrade the system to support GPS IIIIF capabilities with operational acceptance expected in the 3rd quarter of calendar year 2027.

Paul Verhoef, director of navigation for the European Space Agency’s Navigation Directorate said there are 22 Galileo satellites in service for general navigation services. Twelve new satellites are being prepared with full operational capability for Galileo’s open service expected in 2022. Eric Chatre of the European Commission said they were now demonstrating the high accuracy service.

The Russians have 25 operational satellites in orbit with two more in testing in medium Earth orbit (MEO). Sergey Katurin, GLONASS’s designer general, told attendees there was also a new Interface Control Document poised for release in a few weeks.

Japan is expanding its regional QZSS system from four satellites to seven with completion expected in 2023. The program is currently offering an experimental version of its MADOCA-PPP augmentation signal for a PPP correction service. That service will start no later than 2024 said Satoshi Kogure of the Space Technology Directorate in the Japan Aerospace Exploration Agency.

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China currently has 45 satellites in its BeiDou system, of which 15 are BDS-2 satellites and 30 are BDS-3s. The program also has broad plans to promote the use of BeiDou signals in cell phones and for applications including traffic management, agriculture and precision construction, said Dr. Xiaochun Lu, deputy director of the China Satellite Navigation Office’s International Cooperation Center.

Among the many other interesting technical presentations was an update on the Chimera signal augmentation that will be broadcast on the Navigation Technology Satellite-3 (NTS-3) to be launched in 2023. In addition to testing signals designed to help make GPS spoof proof, the Air Force Research Laboratory is working on algorithms to sustain security even after quantum computing becomes a reality.

It wasn’t all work. Many met to discuss plans and papers they’d seen at the bar in the magnificent Grand Hall of the old Union Station. Built in 1894, the nation’s once-busiest train station has been converted to a hotel and what had been its famous platform housed the many ION GNSS+ exhibitors. On Wednesday attendees celebrated meeting in person again with barbecue, Ferris wheel rides and great blues music.

ION GNSS+ AWARD WINNERS

RED PENCIL RECOGNITION

The following were recognized with a bouquet of red pencils and an Amazon gift card for their outstanding contributions to the Institute this past year in their role as a peer reviewer for various ION activities:

Dr. Demoz Gebre-Egziabher, University of Minnesota
Dr. Sanjeev Gunawardena, Air Force Institute of Technology
Ms. Ranwa Haddad, The Aerospace Corporation
Dr. Clark Taylor, Air Force Institute of Technology

The ION would like to thank each of them for providing high-quality, timely reviews when called upon to do so!

Dr. Sanjeev Gunawardena, Dr. Frank van Diggelen (ION president), and Dr. Clark Taylor.
2021 Kepler Award

Presented to Dr. Mark Psiaki for setting a standard of rigor, clarity, and thoroughness in addressing key estimation and signal processing problems in PNT.

Dr. Mark Psiaki originated the technique of bit-wise parallel RF signal processing for use in general-purpose processors. This enabler of software-defined GNSS led to the first space deployment of a fully software-defined GNSS receiver on a general-purpose DSP and to the widespread adoption of software-defined GNSS across the aerospace industry.

Additionally, Dr. Psiaki’s real-time software radio expertise enabled the development of a spoofer cultivated in his research group. Dr. Psiaki subsequently led the development of spoofing detection algorithms based on cross-correlation of unknown P(Y) codes and based on direction-of-arrival sensing.

Dr. Psiaki was the lead signal processing designer/analyst for the IGPS program that combined Iridium L-band downlink signals, GPS signals, and INS data to enhance GPS anti-jam capabilities. Recent work on LEO-based navigation fuses observables from an existing global communications constellation with INS and other sensor data to provide a back-up to GPS. Another contribution demonstrates how Doppler-based navigation could replace pseudorange-based navigation if implemented using a large LEO constellation.

Dr. Psiaki has made many contributions to the practice of modeling, estimation, and detection applied to GNSS, including the study of GNSS carrier phase modeling for space-based applications. His campaign to decode the GIOVE-A L1 BOC(1,1) PRN codes enabled Galileo receiver manufacturers to test their systems before the ESA published the codes. His group’s work on ionospheric scintillations led to the first commercially-available scintillation simulators.

Professor Psiaki holds the Kevin T. Crofton Faculty Chair of Aerospace & Ocean Engineering at Virginia Tech. He studied at Princeton University, completing a B.A. in Physics in 1979 (magna cum laude) followed by an M.A. (1984) and a Ph.D. (1987) in Mechanical & Aerospace Engineering. He is a past recipient of the ION’s Burka Award, its Tycho Brahe Award, and the Pride at Boeing Accomplishment Award. He is a Fellow of both AIAA and ION.

2021 Parkinson Award

The 2021 Parkinson Award was presented to Dr. Lakshay Narula, of The University of Texas at Austin, for his thesis, “Towards Secure & Robust PNT for Automated Systems”.

The Bradford W. Parkinson Award is awarded annually to an outstanding graduate student in the field of Global Navigation Satellite Systems (GNSS). This award, which honors Dr. Parkinson for his leadership in establishing both the U.S. Global Positioning System and the Satellite Division of the ION, includes a personalized plaque and a $2,500 honorarium.

Recognition of the ION GNSS+ 2021 Technical Program Organizers and Hosts

Dr. Mohammed Khider, Satellite Division Secretary; Dr. Jason Gross, Track Chair; Dr. Zak Kassas, Track Chair; Dr. Di Qiu, Program Co-chair; Sandy Kennedy, Satellite Division Vice Chair; Patricia Doherty, Satellite Division Chair; Dr. Frank van Diggelen, ION President; and Dr. John Raquet, Tutorials Chair. Not pictured: Dr. André Hauschild, Program Co-chair; Dr. Jan Wendel, Track Chair; Ernesto Etienne, Track Chair; Dr. Ali Broumandan, Track Chair; Dr. Xiaochun Lu; Track Chair; Dr. Demoz Gebre-Egziabher, Satellite Division Treasurer; Dr. Chris Hegarty, Satellite Division Immediate Past Chair; Dr. Stefan Schlueter, International Technical Advisor; Dr. Jiyun Lee, International Technical Advisor and Publications Committee; and Dr. Allison Kealy and Dr. Terry Moore, Publications Committee.
ION GNSS+ 2021 Virtual: Altmetrics from the Technical Program

While 260 attended ION GNSS+ in-person in St. Louis, an additional 500 participated in ION GNSS+ entirely virtually this year. A total of 318 papers were accepted to be presented from 373 abstracts received. Given the current pandemic concerns, 73 papers were presented in-person in St. Louis and 245 papers were presented virtually. All authors were encouraged to provide a video presentation for the virtual audience. As of the close of the in-person event, on September 24, the following were the most attended sessions:

Top 10 Technical Sessions for Video Views:
- Augmentation Services, Integrity and Authentication .............................................. 276
- Multisensor Integrated System Technologies ..................................................... 252
- Autonomous Applications .................................................................................... 244
- Signal Processing and Fusion Algorithms for Challenging Environments... 237
- Next Generation GNSS ..................................................................................... 186
- Navigation in Urban Environments .................................................................. 167
- GNSS Applications in Space .............................................................................. 161
- Smartphones Decimeter Challenge (Google) ..................................................... 158
- GNSS Integrity and Robustness in Safety-Critical Applications ......................... 143
- Navigation Using Environmental Features ......................................................... 132

Top Viewed Panel Discussions:
- Status of GPS, GLONASS, Galileo, BDS, and QZSS
- On the Road to Automated Vehicles
- GNSS Chipset Technology–Trends, Opportunities and Challenges

Top 10 Watched Videos:
- Triple-Band Automotive GNSS/INS Using Novel Silicon Photonic Optical Gyroscope and Custom Positioning Engine: Mike Horton
- Advanced Integrity Concept as One Step Further in GNSS-based Positioning for Autonomous Driving: Ana Gonzalez Sainz
- Exploiting Starlink Signals for Navigation: First Results: Mohammad Neinavae
- First Place Winner of the Smartphone Decimeter Challenge: Global Optimization of Position and Velocity by Factor Graph Optimization: Taro Suzuki
- Transforming Global High Accuracy Positioning with RTK From the Sky Technology: Jenn Busser
- Galileo Open Service Navigation Message Authentication: Preparation Phase and Drivers for Future Service Provision: Martin Goetzelmann
- A Machine Learning Multipath Mitigation Approach for Opportunistic Navigation with 5G Signals: Mohamad Orabi
- A New Approach of Detecting NLOS Signals Based on Modified Residual Error Check: Tomohiro Ozeki
- Simultaneous Tracking and Navigation with LEO Satellites: A Machine Learning Approach: Sharbel Kozhaya
- AUTO: Multiple Imaging Radars Integration with INS/GNSS for Reliable and Accurate Positioning for Autonomous Vehicles and Robots: Jacques Georgy

First Place Winner of the Smartphone Decimeter Challenge: Global Optimization of Position and Velocity by Factor Graph Optimization: Taro Suzuki
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Work Microwave GmbH
Xona Space Systems
ION GNSS+ 2021 Best Presentation Awards

Session A1a: Autonomous Applications
AUTO: Multiple Imaging Radars Integration with INS/GNSS for Reliable and Accurate Positioning for Autonomous Vehicles and Robots: Dylan Krupity, Abdelrahman Ali, Billy Chan, Medhat Omr, Abanob Salih, Amr Al-Hamad, Qingli Wang, Jacques Georgy, and Christopher Goodall, TDK, Canada

Session A1b: Navigation in Urban Environments
Machine Learning Based Overbound Modeling of Multipath Error for Safety Critical Urban Environment: Heekwon No and Carl Milner, ENAC Université de Toulouse, France

Session C1a: Navigation Using Environmental Features
Evaluation of Simultaneous Localization and Calibration of a Train Mounted Magnetometer: Benjamin Siebler, Andreas Lehner, Stephan Sand, German Aerospace Center (DLR), Germany; Uwe D. Hanebeck, Karlsruhe Institute of Technology, Germany

Session C1b: Collaborative and Networked Navigation
Decentralized Connectivity Maintenance for Multi-robot Systems Under Motion and Sensing Uncertainties: Akshay Shetty, Timmy Hussain and Grace Gao, Stanford University

Session D1: Signal and Fusion Algorithms for Challenging Environments
Euclidean Distance Matrix-based Rapid Fault Detection and Exclusion: Derek Knowles and Grace Gao, Stanford University

Session A2a: Augmentation Services, Integrity and Authentication
Blockchain for CORS Networks: Mike Horton, Anello Photonics, Xiaohua Wen and Yudan Yi, Tersus GNSS Inc., China

Session A2b: Marine Applications and Search and Rescue
VHF Data Exchange System On-air Trials: The Journey so far: Jan Safar and Alan Grant, The General Lighthouse Authorities of the UK and Ireland, UK

Session B2a: GNSS Augmentation Systems and Integrity
New Bounds on the Horizontal Protection Level for the Non-Zero Mean Case: Steven Langel, The MITRE Corporation

Session C2: Multisensor Integrated System Technologies
Conservative Estimation of Inertial Sensor Errors using Allan Variance Data: Kyle Leethander and Clark Taylor, ANT Center AFIT

Session A3a: Land-Based Applications
A New Point-Cloud-Based LiDAR/IMU Localization Method with Uncertainty Evaluation: Ali Hassani and Mathieu Joerger, Virginia Tech

Session A3b: Spectrum: Protection and Optimization
Evaluation of PNT Situational Awareness Algorithms and Methods: Sandeep Jada, Mark Piaiki, Sean Landerkin, Virginia Tech; Steven Langel, Arthur Scholz, The MITRE Corporation; Mathieu Joerger, Virginia Tech

Session B3: GNSS Integrity and Robustness in Safety-Critical Applications
Multi-layered Multi-constellation GNSS Interference Mitigation: Ciro Gioia and Daniele Borio, European Commission, Joint Research Centre (JRC), Italy

Session D3: GNSS Authentication and Anti-Spoofing 1

Session B4a: Trends in Future Satellite Navigation Technology, System Design and Development
Ranging and Demodulation Performance of QZSS L1C Signal in Forest/Urban Environments: Taro Suzuki, Chiba Institute of Technology, Japan; Yuki Ichikawa, Akira Komine, AISAN Technology Co. Ltd., Japan; Kiyoshi Takejima, Chubu University, Japan; Shigeru Matsuoka, Satellite Positioning Research and Application Center (SPAC), Japan; Kyohei Akiyama, Jun Matsumoto, National Space Policy Secretariat, Cabinet Office, Japan

Session B4b: Applications of GNSS Measurements from Smartphones
An Application for Detecting GNSS Jamming and Spoofing: Nicholas Spens, Dong-Kyeong Lee, Dennis Akos, University of Colorado Boulder

Session C4a: Next Generation GNSS
RFI Considerations for Utility of the Galileo E6 Signal: Aiden J. Morrison, Nadezda Sokolova, SINTEF, Norway; Nicolai Gerrard, Anders Rodningsby, Norwegian Defence Research Establishment, Norway; FFI Christian Rost, Norwegian Space Agency, Norway; Laura Ruotsalainen, The University of Helsinki, Finland

A Machine Learning Multipath Mitigation Approach for Opportunistic Navigation with 5G Signals: Mohamad Orabi, Ali A. Abdallah, Joe Khalife, and Zaher M. Kassas, University of California, Irvine
Session D4: GNSS Receiver and Antenna Technologies
Interference and Jammer Suppression of High Bandwidth Signals using an Array of Spatially Distributed Subarrays: Marius Brachvogel, Michael Niestroj, Soeren Schoenbrod, RWTH Aachen University, Germany; Michael Meurer, RWTH Aachen University and German Aerospace Center (DLR), Germany; Syed N. Hasnain, Ralf Stephan, Matthias A. Hein, Technische Universität Ilmenau, Germany

Session A5: GNSS Applications in Space

Session C5: Smartphones Decimeter Challenge, Sponsored by Google
FIRST PLACE WINNER: Global Optimization of Position and Velocity by Factor Graph Optimization: Taro Suzuki, Chiba Institute of Technology, Japan

Session D5a: Atmospheric Effects on GNSS
Space Weather at Mid-latitudes: Leveraging Geodetic GPS Receivers for Ionospheric Scintillation Science: Sebastijan Mrak, Joshua Semeter, Toshi Nishimura, Boston University; Anthea J. Coster, MIT Haystack Observatory; Keith Groves, Boston College

Session D5b: Remote Sensing, Space Applications, Timing and Scientific Applications

Session A6: Aviation and Aeronautics
Miniature Short-Term Navigation Grade Quartz MEMS Accelerometer: Sergey Zotov, Semen Shitluz, John Paxton, and David Hoyh, EMCORE Corp - Systron Donner Inertial

Session B6: Alternate Localization Technologies in GNSS Challenged Environments
Universal Receiver Architecture for Blind Navigation with Partially Known Signals of Opportunity: Joe Khalife, Mohammad Neinavaie, and Zaher M. Kassas, University of California, Irvine

Session C6: Alternative Technologies for GNSS-Denied Environments
Performance Analysis of GNSS/INS/VO/Odometry Sensor Fusion Algorithms for Tracked Agricultural Vehicles: Eva Reitbauer, Christoph Schmied, Institute of Geodesy, Graz University of Technology, Austria

Session V9a: GNSS Augmentation and Robustness for Autonomous Navigation
Improved Observation Interval Bounding for Multi-GNSS Integrity Monitoring in Urban Navigation: Jingyao Su and Steffen Schön, Leibniz Universität Hannover

Session V9b: Urban and Indoor Positioning, Navigation and Mapping
Robust Vehicle Positioning in Multipath Environments Based on Graph Optimization: Taro Suzuki, Chiba Institute of Technology, Japan

Session V9c: GNSS Authentication and Anti-Spoofing 2
GNSS Spoofing Detection through Metric Combinations: Calibration and Application of a General Framework: Fabian Rothmaier, Leila Taleghani, Yu-Hsuan Chen, Sherman Lo, Eric Phelts, Todd Walter, Stanford University

SAVE THE DATE

ION 2022
September 19-23, 2022
Show Dates: September 21 and 22
Hyatt Regency Denver at Colorado Convention Center
Denver, Colorado
NAVIGATION to an OA platform will speed the delivery of timely PNT research, without the restrictions of paywalls or price barriers, to a worldwide audience,” said Lisa Beaty, the journal’s managing editor and executive director of ION. “We want all scientists and engineers to be able to collaborate, analyze, and build upon each other’s work for society’s common good,” Beaty added.

The size and scope of NAVIGATION will remain unchanged. ION will continue to own the copyright. The editorial staff and peer review process will remain the same.

NAVIGATION will continue to be fully accessible through the ION website. Printed/paper copies of NAVIGATION will be discontinued at the end of 2021. The Winter 2021 issue will be the last printed mailed issue.

NAVIGATION will fund OA by modest Article Publishing Charges (APC) assessed to authors and from the ION’s general fund. NAVIGATION will charge an APC of $1,000 per paper to members, and $1,500 per paper to non-members, for an average length paper of 20 pages or fewer.

Waivers of APCs will be provided for authors based in a low-income country, for authors that have no institutional affiliation or funding, for short manuscripts of four pages or fewer, or for manuscripts representing a technology review article. APCs will be phased in during the first year to accommodate papers submitted prior to the implementation of the new APC program.

**OA Journal Impact to ION Membership**

ION recognizes that NAVIGATION has been a premier membership benefit, which will now be available to the entire PNT community, free of charge.

Beginning in January 2022, ION’s membership benefits will be modified as follows:

ION members will receive a link with a compiled electronic issue of NAVIGATION for download (non-members will need to access/download article-by-article).

The number of paper downloads associated with each class of ION membership will increase. ION members will receive 12 free downloads per month (up from 12 per year) from the ION database of technical articles, with premium members receiving 50 free downloads per month (up from 25 per month).

Membership rates for all members, regardless of their country of residence, shall be set at the current 2021 USA rates ($95 professional members, $70 retired, $40 student, and $180 premium).

Current ION members do not need to do anything to affect the change. The change in membership rates for ION members currently residing outside of the USA will be automatically adjusted and will be reflected in your next renewal cycle. The additional monthly download allotments, based on membership levels, will be increased the first week of January 2022.

The Institute expresses its appreciation to the ION Editorial Board and Council for making OA a reality for the worldwide PNT community!
ACCESS BEGINS JANUARY 1, 2022

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- Increased citations
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- PNT research provided to a worldwide audience

Submit YOUR abstract to NAVIGATION at ion.org/navi
This is the first of two articles on the pre-Socratic contributions of the philosophers from the Milesian School founded by Thales.

Ancient Greece is widely credited as the wellspring for many elements of modern Western culture with some of its greatest accomplishments emerging during Greece’s Golden Age from roughly 500 to 300 B.C.

The seeds of that Golden Age were planted two centuries earlier in Miletus—a city in Asia Minor within the Ionian peninsula in modern day Turkey. Miletus was the cradle of the Greek philosophical (and scientific) tradition and the birthplace of many advances in the scientific method and, especially, in mathematical geography. It was in Miletus that Thales (624-546 BC)—followed by his students Anaximander (610-546 BC) and Anaximenes (585-528 BC) (known collectively as the Milesian School)—began to speculate about the material that made up the world around them. They then proposed, for the first time, naturalistic, as opposed to supernatural or mythological, explanations for phenomena such as astronomical motions and chemical reactions.

Most of what we know about Thales comes from the writings of Aristotle (384-322 BC) who labeled Thales the “first scientist” for his new and bold hypotheses. Thales, an engineer by trade, was the first of the Seven Sages or wise men of ancient Greece. As a young man Thales went to Egypt where he studied the geometrical forms of the pyramids, tombs, and palaces. Unlike the Egyptians who attributed all phenomena to gods, Thales searched for mathematical and evidentiary explanations. He was interested in almost everything—studying philosophy, history, science, mathematics, engineering, geography, navigation, and politics. His prowess in analytical geometry was demonstrated when he applied his theorems on triangles and ratios to the problems of determining the distance to ships at sea and calculating the height of pyramids.

Thales was deeply involved in the study of the stars and provided several explanations of cosmological events. Legend has it that he was so entranced with his observation of the night sky that he fell into a well while staring upward. His questioning approach to the understanding of heavenly phenomena was the beginning of Greek astronomy and he is acclaimed for having predicted an eclipse of the sun.

Modern astronomers were able to extrapolate backwards to pinpoint the date of the eclipse as being 28 May 585 BCE. That eclipse, which was total, happened during a conflict between two Greek cities and its umbra must have passed over the battlefield.

“The ‘un-naturalness’ of a solar eclipse is eerie and chilling,” said Patricia O’Grady in an article on Thales in the Internet Encyclopedia of Philosophy. “All becomes hushed and there is a strong uncanny sensation of impending disaster, of being within the control of some awful power. In ancient times, the awesome phenomenon must have aroused great fear, anxiety, and wonder. The combatants saw the eclipse as disapproval of their warfare, and as a warning. They ceased fighting and a peace agreement was reached between the two kings.”

Thales proposed answers on the dates of the solstices, the size of the sun and moon as well as how the Earth was supported and its size and shape. Although written proof does not exist, there is reason to believe that Thales recognized the sphericity of the Earth.

Through his work in astronomy he would almost certainly have become familiar with the night sky and the motion of the heavenly bodies. There is evidence that he gave advice to navigate by Ursa Minor which includes Polaris, the North Star. As a result of observations made over a long period of time, Thales could have realized that the motions of the fixed stars could not be explained within the idea of the observable hemispherical dome. During the determination of the size of the rising sun, and again while watching its risings and settings during his work on fixing the solstices, Thales may have realized that much natural phenomena could be explained only within the understanding of the Earth as a sphere. Furthermore, from his earlier calculations of the distance of ships from shore, a ship can be seen to be descending, gradually, below the horizon, with the hull disappearing first, to be followed by masts and sails. If one had a companion observing from a higher point, the companion would see the ship for a long period before it disappeared from view, again implying sphericity.

Thales was one of the first of a long line of Greek philosophers who pondered the
material composition of the world. There are many types of monism, but Thales’ philosophy can be classified as substance and materialist monism. Substance monism is the idea that everything in the world can be traced back to a single substance. For Thales of Miletus, this substance was water. Since he also appeared to believe that matter, in the form of water, was above abstract ideas, like the soul, he was also a materialist. The monism of

Thales does not mean that Thales did not recognize the existence of other substances. It rather means that he held that the primary source of everything was to be found in water. Although this sounds preposterous in the context of modern science, from an ancient perspective water was required by all living organisms and water can be observed in all its forms, liquid, solid, and gas. Water is absorbed into the Earth, and Earth into the sea.

Thales’s theories were new, bold, exciting, comprehensible, and amenable to further examination—most notably by Aristotle.

“The most outstanding aspects of Thales’s heritage,” wrote O’Grady, “are: The search for knowledge for its own sake; the development of the scientific method; the adoption of practical methods and their development into general principles; his curiosity and conjectural approach to the questions of natural phenomena.”

Amongst the sites used to research this article was: Thales of Miletus | Internet Encyclopedia of Philosophy (utm.edu)

Marvin B. May taught navigation courses for fifty years for the Naval Air Development Center, Temple, Wilkes and Pennsylvania State Universities. He is Professor Emeritus of navigation at Pennsylvania State University. His emails are mayven4@comcast.net and mbm16@psu.edu.

Anaximander, a student of Thales and a founder of the Milesian School.

Anaximenes, a student of Thales and a founder of the Milesian School.
The Department of Homeland Security (DHS) announced this summer that it had transitioned its effort to develop international industry standards for resilient PNT user equipment to the Institute of Electrical and Electronics Engineers (IEEE).

The development and pursuit of standards has many benefits. From the perspective of equipment design, standards serve as fundamental building blocks that contribute to compatibility and interoperability, reduce risk and speed development. Standards also make it easier to understand and compare competing products. Additionally, they are often used as references in procurement contracts to baseline a product’s requirements and measure the degree of conformance.

Until the June 30, 2021 announcement the Resilient Positioning, Navigation, and Timing (PNT) Conformance Framework had been a joint project of DHS’s Science and Technology Directorate (S&T) and the Cybersecurity and Infrastructure Security Agency National Risk Management Center.

The transition marked “a major milestone for the department,” said Kathryn Coulter Mitchell, S&T’s acting under secretary in a press release, and would “impact the future design, acquisition, and deployment of resilient PNT systems within our national critical infrastructure.”

Standards From the Start

Indeed, standards played a key role in making GPS what it is today, a fact reflected in the Clinton-era Presidential Decision Directive (PDD NSTC-6) which said the U.S. would “advocate the acceptance of GPS and U.S. Government augmentations as standards for international use.”

This first national GPS policy document also made standards part of the work of the Department of Transportation. DOT, “in cooperation with the Departments of Commerce, Defense and State,” NSTC-6 said, was to “take the lead in promoting commercial applications of GPS technologies and the acceptance of GPS and U.S. Government augmentations as standards in domestic and international transportation systems.”

The Coast Guard had already been working with the Radio Technical Commission for Maritime Services (RTCM) developing the maritime “Standards for Differential Navstar GPS Service” through Special Committee 104 (SC 104). Similarly, the Federal Aviation Administration was developing the Wide Area Augmentation System (WAAS) Minimum Operating Performance Standards (MOPS) with the Radio Technical Commission for Aeronautics (RTCA).

These signal-in-space, service-related augmentation standards, when coupled with the GPS Standard Position Service (SPS) Performance Standard, were powerful tools in achieving the goal of making GPS the world’s “Gold Standard” for delivering PNT information.

But the success of GPS has now led to overdependence. Although multiple national policy statements on space-based PNT have addressed the need for backup PNT capabilities in case of GPS disruption, none of the viable options that have been evaluated and recommended have been adopted or advocated for general use by responsible civil government agencies.

This new DHS S&T initiative is a very positive development. It will leverage the capabilities of IEEE’s Standards Association (SA), one of the world’s largest standards organizations. It actually parallels how the DoD has taken on the challenge of dealing with its own over-dependence challenge in the Strategy for the Department of Defense PNT Enterprise (Public Release August 15, 2019). The strategy is to pursue an open system architecture that enables the incorporation of plug and play PNT devices to meet the demands of diverse mission scenarios.

The Details

The IEEE effort, called Project 1952 (P1952), held its first kickoff meeting on Wednesday, September 15, 2021.

The standard being developed, as defined in the Project Authorization Request (PAR), will specify “technical requirements and expected behaviors for resilient Positioning, Navigation, and Timing (PNT) User Equipment (UE).” The scope is limited, according to the PAR, to “the reception, ingestion, processing, handling, and output of PNT data, information, and signals” and does not include standards relating to the characteristics of continued next page
Prodigy’s Graduation Highlights STEM Education Efforts

The recent high school graduation of Alena Wicker, a 12-year-old Texas prodigy with aspirations to become a NASA engineer, brought fresh attention to efforts to boost science, technology, engineering, and math (STEM) education with a special emphasis on programs that could nurture both talent and diversity.

Buoyed by a full scholarship, Wicker has begun pursuing a double major in astronomical and planetary science at Arizona State University. The scholarship was made possible by support from the Phoenix Mercury women's basketball team, Desert Financial Credit Union and Arizona State.

Wicker is already laying the groundwork to pay it forward. She recently launched theBrownSTEMGirl.com to encourage and support girls of color under the age of 18 to pursue their interests in STEM.

Wicker is not the only one looking to bolster STEM opportunities. Groups like the ones below, often locally focused, have built programs to inspire, encourage and support students from grade school through college as they launch their professional lives in STEM.

STEM NOLA — New Orleans, LA

A grassroots New Orleans nonprofit with a long list of corporate partners, STEM NOLA designs and delivers events and other learning opportunities for grades K-12 with an emphasis on reaching kids in the city's under-served communities. Through the schools they offer students demonstrations and hands-on experience with experiments, building kits, and collaborative projects. There are also weeks of robotics summer camps, which are free to those who qualify based on location or need. To support STEM learning during COVID, STEM NOLA offered weekly at-home programs on STEM topics like rockets, biology and weather.

New Orleans has other STEM efforts as well. The Greater New Orleans STEM Initiative supports teacher training, a LEGO league and a robotics competition that teaches skills in business as well as hardware.

There is also the Greater New Orleans Science & Engineering Fair for middle and high school students. Launched in 1956 it is one of the oldest such events in the United States and now offers more than $60,000 in cash and prizes.

STEMSTL — St. Louis, MO

The St. Louis Regional STEM Learning Ecosystem (STEMSTL) has built a network of 16 partner organizations to help it offer STEM learning opportunities. It helps connect teachers with lesson plans and other resources and is building a website to aid students and families in finding STEM opportunities outside of school.

PNT sources.

Based on technical requirements, the new standard will define different levels of resilience to enable users to select a level that is appropriate based on their risk tolerance, budget, and application criticality. This standard applies to user equipment that outputs PNT solutions and includes “PNT systems of systems, integrated PNT receivers, and PNT source components (such as Global Navigation Satellite System (GNSS) chipsets).”

“This standard defines expected behaviors in resilient PNT UE and facilitates development and adoption of those behaviors through a common framework that enables improved risk management, determination of appropriate mitigations, and decision making by PNT users,” the need statement says. “The standard allows stakeholders to define and communicate resilient PNT UE needs and evaluate proposed resilience solutions in a consistent, uniform manner.”

The stakeholders for the standard include manufacturers of PNT UE, public and private sector users of PNT UE, and providers of PNT services focused on critical infrastructure, says the PAR. “These include Power Generation and Utility, Telecommunications, Finance, Transportation, Agriculture, Space, and Emergency Services sectors.”

The engagement of the IEEE in this effort, which is expected to take a year, promises that the future critical infrastructure needs for resilient PNT user equipment beyond just GPS will finally be addressed. We can all be optimistic that this will be the case and should continue to encourage the IEEE to expeditiously complete this project.
This column features one of ION's Technical Representatives each quarter to highlight the depth and breadth of their work, research, and interests. During their two-year terms, the ION's Technical Representatives guide and advise the Institute of Navigation and the positioning, navigation, and timing (PNT) community. — Interview and write-up by Dr. Kyle Wesson

Laura Norman is a geomatics engineer in the Safety Critical Systems group at NovAtel, part of Hexagon’s Autonomy & Positioning Division, where she works on improving positioning services for the automotive and aviation industries.

We spoke after Laura returned to the “office” (also known as home) from a vacation visiting her parents in Northwestern British Columbia, Canada. Laura attended the University of Calgary where she undertook the rigorous engineering program while also transitioning from cross country skiing to junior varsity rowing. When I asked about the change from skiing to rowing, she said the closest place to ski from the university was about an hour away, while there was a rowing reservoir close to campus. Despite significant national and international skiing experience, including a race in Norway, the lack of a car meant that training ground convenience won her over.

Outside of work for Hexagon and hiking with her dogs, Laura enjoys weekly gaming with friends and watching new movies such as “Free Guy.” She plans to resume training for her pilot’s license soon, having taken a break due to her academic course load. Laura and her family are avid hikers, completing Mount Meru/Mount Kilimanjaro in Tanzania, Kangchenjunga in Nepal, the Camino de Santiago in Spain, and both the West Coast and Chilkoot trails in Canada. And in case she’s not busy enough already, she also has her teaching accreditations for classical piano.

Laura served as a session co-chair at PLANS 2018, ION GNSS+ 2019 and 2020 and has been invited to be a track chair for the 2022 GNSS+ conference. Read on to learn more about Laura.

--Kyle Wesson

**1. How did you first get involved with ION?**

I completed both my Bachelor of Science and Master of Science in geomatics engineering from the University of Calgary. During this time, I had the opportunity to attend local ION lectures.

**2. What is your favorite aspect of being a member of ION?**

Being a member of ION provides me with the opportunity to continue to grow my knowledge within the entirety of the navigation field instead of only the subarea I work in. I also enjoy attending conferences as it is a great way to network with others in the industry.

**3. What type of GNSS work do you do currently or have you done in the past?**

My graduate research focused on investigating the performance of low-cost consumer-grade GNSS receivers for position and trajectory length estimation. Since 2017, I have been a geomatics engineer within Hexagon’s Autonomy & Positioning Division’s Safety Critical Systems Group. In this role, I have worked in hardware-agnostic positioning, GNSS integrity and protection levels, and functional safety. I have contributed to products in both the automotive and aviation industries, with a major focus in developing safety-critical software for automotive applications.

**4. What do you consider to be some of the most important current research, education, policy, or technical topics in GNSS for the next year?**

As the world becomes more autonomous, I am interested to watch how the public perception of this matter progresses. So far, when discussing with others outside of the field, I have received mixed reactions when it comes to their trust level regarding autonomous navigation. Earning the public’s trust will be of critical importance in the field of autonomy, and those working to develop the technology must be conscious of the need to do so. Educating the end users of autonomous technology so that they understand what protections exist to ensure their safety will be extremely important to the acceptance of the technology in the long term. Since GNSS is more widely accepted by society compared to other autonomous technology, I believe it will have a critical role to play in gaining the public’s trust as a primary navigation sensor for autonomous applications.

**5. What areas of ION have you been involved in and what areas do you hope to see grow in the future?**

While attending university, I attended local chapter lectures as a student. I served as a session co-chair at both
TECHNICAL REPRESENTATIVE SPOTLIGHT

PLANS (2018) and ION GNSS+ (2019) and again at the 2021 ION GNSS+ conference. This last year I was elected as a technical representative for the current 2021-2023 term and was invited to be a track chair for the 2022 ION GNSS+ conference.

6. If you were not in your current field, what would you want to do for a living?

From a young age, I had a keen interest in entering the field of navigation as I accompanied my dad on flights, in his float plane, around the area of Northern British Columbia where I grew up. During these flights he showed me all of the instruments involved with piloting the aircraft, and what they were for. If it had not been for the geomatics engineering discipline, I most likely would have ended up becoming a pilot. I actually began my ground course training the summer before university and started my flight hours in the first year of undergrad; however, due to a busy course schedule I had to put this pursuit on pause.

STEM EDUCATION

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STEMSTL is one of 94 STEM ecosystems across 40 states in the United States. These and organizations outside the U.S. get guidance and resources from the STEM Learning Ecosystem to help them build communities that support education in STEM subjects.

One of the programs getting attention across the ecosystem network is the Robotify Mars Challenge. Teams of kids compete with each other, learning about computer science and robotics in the process, by coding a virtual Mars robot. No robotics hardware is required and team coaches get training.

Latino STEM Alliance — Greater Boston, MA Area

Robotics is also a focus of the Latino STEM Alliance. Operating in the Boston and Merrimack Valley areas of Massachusetts, LSA sponsors an annual robotics competition and family science festival.

Serving kids in grades K-12, LSA develops project-based learning opportunities, holds university student-led workshops and organizes field trips to STEM organizations. LSA also offers an introduction to computer-aided design (CAD) and Scratch programming. To support learning during the pandemic the Alliance also created an interactive 18-week course on robotics.

Girls in Technology — Greater Washington, DC

The professional association Women in Technology (WIT) launched Girls in Technology (GIT) to provide girls in grades 6 through 12 with mentors, resources and opportunities.

GIT has one-day evening workshops where students can see hands-on demonstrations, play networking games, and hear women discuss their experiences of combining their love of STEM with passions such as art, geography, science, education, and security. Girls in grades 9-12 can apply for opportunities for monthly one-on-one mentoring sessions. There is also a scholarship program made possible through funding by STEM for Her (SFH), another Washington, DC organization that, according to its website, has invested $500,000 so far in over 150 programs.

GIT and the University of Maryland are also co-sponsoring CyberPatriot Girls to support middle and high school girls who want to participate in the Air Force Association’s CyberPatriot program, a national high school cyber defense competition.
IMPACT FACTOR GROWTH FOR ION’s JOURNAL

The Institute of Navigation is pleased to share that NAVIGATION: Journal of the Institute of Navigation, has recorded its sixth consecutive year of growth of its Journal Impact Factor (JIF); now reported to be 2.08. The JIF, an index that calculates the yearly average number of citations to recent articles published in a journal, is considered a metric of the relative importance of a journal within its field. A journal with a higher impact factor generally is viewed as being more important than those with a lower impact factor due to its citation rate. NAVIGATION is the leading peer-reviewed scientific indexed journal publishing articles on all areas related to the science and art of Positioning, Navigation and Timing (PNT). The increase in the NAVIGATION’s JIF again places the journal in the top ten academic engineering and aerospace journals.


DAYTON SECTION NEWS

The Dayton Section suspended most of its activities in March 2020 due to COVID-19. After more than a year, the section held virtual meetings in April and May 2021. Fifteen attendees connected in April to hear Dr. Sabrina Ugazio, Ohio University (OU), update her previous talk from November 2019 on the satellite Bobcat-1, the OU CubeSat for GNSS inter-constellation time-offset determination. The vehicle had been in orbit for several months, and data had been collected from tracking over 200 GNSS satellites. In May, Maj. Jonathon Gipson, of the Air Force Institute of Technology’s ANT Center, spoke on “Resilience for Multi-filter All-source Navigation Framework with Integrity”. Thirteen people attended.

On August 12, the section met outdoors for a family-style picnic and entertainment and to elect officers for the coming term. The 2021-2022 elected officers are Mr. Jeremy Gray, chair; Mr. Jason Pontious, vice chair; Mr. Branden McNally, executive secretary; and Mr. Boyd Holsapple, treasurer. Twenty-nine people attended this event.

The Section met again virtually on September 16. Dr. David Woodburn of AFIT gave an interesting presentation titled “Sensor Component Noise Parameter Extraction”. His work built on previous results by Jurado, Schubert, Kabban, and Raquet that used regression-based methods to improve estimation of inertial sensor errors using Allan Variance data.

ION EXPANDS POPULAR WEBINAR SERIES and VIDEO ABSTRACTING INITIATIVES FOR NAVIGATION

The Institute of Navigation (ION) continues to build on its popular webinar and video abstract initiatives, aimed at engaging and informing members and the greater public about topics of interest to the Positioning, Navigation, and Timing (PNT) community.

Since introducing its webinar series in December 2019, ION has produced 19 timely and engaging presentations. Many of the webinars highlight and expand on prominent papers published in recent issues of NAVIGATION: Journal of the Institute of Navigation. Others spotlight PNT-related events that make national and global headlines, like the hugely popular March 2021 webinar on navigating NASA’s Perseverance Rover to Mars.

The following webinars have been recorded thus far in 2021 and are available free for online viewing at www.ion.org/publications/webinars.cfm or on ION’s YouTube channel, https://www.youtube.com/user/InstOfNavigation/featured:

How Insect Brains Perform Dead Reckoning. Presented by Dr. Barbara Webb of University of Edinburgh, Professor of Biorobotics.


Multi-slices navigation approach for unknown 3D environments using micro aerial vehicles. Presented by Dr. Haytham Mohamed, Department of Geomatics Engineering, University of Calgary.
GNSS interference mitigation: A measurement and position domain assessment. Presented by Dr. Daniele Borio and Dr. Ciro Gioia, both with the European Commission Joint Research Center.


Performance assessment of GNSS diffraction models in urban areas. Presented by Guohao Zhang and Dr. Li-Ta Hsu.


GNSS Spoofing Detection through Spatial Processing. Presented by Fabian Rothmaier.

Factor Graph Optimization for GNSS/INS Integration: A Comparison with the Extended Kalman Filter. Presented by Dr. Li-Ta Hsu.


To be notified of future webinars, members may sign up for ION’s email list or follow us on social media. Links to those options are available on the ION Webinars page.

ION also continues to expand its use of video abstracts for papers published in NAVIGATION. Video abstracts allow authors to present their research in their own words. This multimedia format communicates the background and context of authors’ research in a quick and easy way, elevating research from simple print delivery. The use of video abstracts is backed by studies that show a relationship between video abstracts and article usage. Beginning January 1, 2022, video abstracts will be required for all articles accepted to NAVIGATION: Journal of the Institute of Navigation.

The following video abstracts highlight articles from the Fall 2021 NAVIGATION and are available for online viewing at https://www.ion.org/publications/journal.cfm:


Video for “Sensitivity of advanced RAIM performance to mischaracterizations in integrity support message values,” by Young Lee, Brian Bian, Ali Odeh, and Jianming She.

Video for “Air data fault detection and isolation for small UAS using integrity monitoring framework,” by Kerry Sun and Demoz Gebre-Egziabher.

Video for “Data-driven protection levels for camera and 3D map-based safe urban localization,” by Shubh Gupta and Grace Gao.
I first heard about the ION’s AAAS Congressional Fellowship back in 2015. I was working on my PhD at Purdue University, had just taken a course on space policy, and immediately knew I was interested. I made a rough calculation of when I might graduate, added the three years of work experience required, and put a note on my calendar: “Hey 2020 Ben, look into the ION Government Fellowship Program.” Over the next few years, I defended my dissertation (the use of GNSS multipath for relative state estimation during spacecraft docking), started as a civil servant at NASA Goddard Space Flight Center, and moved to Washington, DC.

Goddard is an incredible place: over 10,000 scientists and engineers studying the Earth, the solar system, and the universe. I quickly got involved with exciting flight projects, first as a flight dynamics lead for NASA’s 13th Tracking and Data Relay Satellite (TDRS-M), and then as part of the navigation team for the asteroid sample-return mission, OSIRIS-REx. But I also stayed active in research and policy related to GNSS through Goddard’s Position, Navigation, and Timing (PNT) Policy Team. I regularly participated in ION conferences, represented civil space users of GNSS at the UN International Committee on GNSS (ICG), and attended space-related hearings on Capitol Hill whenever my schedule allowed.

What’s so interesting about public policy? As a graduate student I knew that performing and publishing original research was one way to, as Bill Nye is fond of saying, change the world. But I began to realize, that’s only the beginning of the process. Change often lags far behind research conclusions. At NASA I saw examples of research being applied to enable new feats of space exploration, but I still found myself wondering why and how one mission was selected over another, or what led to NASA receiving funding over other national priorities.

In 2020, per my calendar reminder, I started the fellowship application process. Of course, 2020 did not proceed as expected for anybody. The global Covid-19 pandemic halted many plans, including my fellowship aspirations, but the inequities it exposed and the concurrent protests against police brutality and institutional racism only underscored the importance of public policy. On October 20th, OSIRIS-REx successfully touched down on the surface of the asteroid Bennu (within one meter of the target site!) and retrieved a sample to return to Earth. I participated from the mission operations center at Lockheed Martin outside Denver, Colorado, and the mood was one of joy and relief. The achievement was all the more meaningful to our team in the midst of that year’s crises, both public and personal – it was impossible to separate our work from world events and I felt more eager than ever to pursue this fellowship.

This year I was selected as ION’s 2021-2022 Congressional Fellow. I had arranged for a year of leave without pay from NASA, and at the end of August I started fellowship orientation. ION is just one of the professional societies who sends a fellow to participate in the Science and Technology Policy Fellowship (STPF) program administered by the American Association for the Advancement of Science (AAAS). Each year, AAAS oversees more than 250 executive, legislative and judicial branch STPF fellows. Most participants are in the executive branch; this year I’m one of 29 legislative fellows.

I’d read the ION Newsletter articles by former ION fellows, Dr. Gerald Mader (2015-2016) and Dr. Kyle Wesson (2016-2017), so I knew something about the orientation and placement process. But of course, Covid-19 and the surging Delta variant made things a bit different this year. Orientation took place virtually over two weeks and covered a wide range of topics:
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For more information on corporate membership in the Institute of Navigation, please contact Kenneth P. Esthus at 703-366-2723 extension 1004.

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from political history, to the federal budget process, to the idea of justice-centered STEM. Despite the virtual orientation format, fellows were required to move to DC for the fellowship itself, and my legislative cohorts quickly became close through Slack and weekly outdoor gatherings around the city.

After orientation, legislative fellows spend a week interviewing with prospective Congressional offices. It was a whirlwind week. I interviewed with eight offices, some personal offices and some committees, some House and some Senate. In addition to the interviews, I spoke with anyone I could find who’d worked with or for each office, especially former fellows. The following Monday I accepted an offer to work in the office of Sherrod Brown, a Senator from my home state of Ohio. I grew up in Dayton, Ohio and got a B.S. in electrical engineering from Ohio University, so I care about the labor and economic issues the Senator is working to address.

At the CGSIC meeting prior to this year’s ION GNSS+ conference, I gave a talk about plans to use GNSS at the Moon. I described the new era of lunar exploration, in which exploration efforts are more diverse and collaborative than ever before. But this mix of government agency and private industry partnerships is not unique to space exploration, nor is it new to the GNSS community. Governments, academia, and industry have always worked in close cooperation in our field. The need for PNT is so universal, and the use of GNSS so ubiquitous, that policy implications arise across many sectors and disciplines. I will be spending this year learning about the public policy end of the change-making process. What do you want to hear about in a future newsletter? Is there a PNT-related issue working through Congress that I should be aware of? Please reach out at any time: ben.ashman@aaas-afpi.com.
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