JOINT NAVIGATION CONFERENCE

June 12-15, 2023
Town and Country Hotel
San Diego, California

Free Conference Wi-Fi:
Network: T&C Basic
Login: towncountry23

ONSITE PROGRAM

ion.org/jnc
## Technical Program Overview

**MONDAY, JUNE 12: CUI U.S. ONLY TUTORIALS AND SESSIONS**

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**TUESDAY, JUNE 13: CUI U.S. ONLY SESSIONS**

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**WEDNESDAY, JUNE 14: CUI U.S. ONLY SESSIONS**

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**THURSDAY, JUNE 15: CUI U.S. ONLY SESSIONS**

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Conference Information

Attendance Requirements: Technical Sessions

JNC 2023 is hosted at the Town and Country Hotel, 500 Hotel Circle N, San Diego, CA 92108, in a CUI U.S.-Only environment, June 12-15, 2023. To attend technical sessions, you must provide the following:

1. Proof of U.S. citizenship
2. Visit request - these were due to JNWC (DOD entry validation authority) by May 12. Currently, JNWC will only provide entry validation to those who can be cleared through DISS.
3. Photo ID
4. JNC conference badge and paid registration

Submit your Visit Authorization Request through DISS to DISS SMO: JNC-JNC-1. DISS visit request POC field must be filled with “JNC 2023” instead of a POC name.

A JNWC security officer will be present at JNC on Monday and Tuesday, 7:30 a.m. - 1:30 p.m., to process VARs through DISS. Those requiring security validation outside of these hours will be required to contact the JNWC Security Office at Kirkland AFB and plan for a delay in processing.

JNWC Visit Request Contact:
Danae Adams, Security Specialist
Joint Navigation Warfare Center
Office: 505-846-6143
Fax: 505-853-6677
Email: danae.adams.ctr@usspacecom.mil

Security Reminders

- The exhibit hall is hosted in a publicly releasable environment and technical sessions are CUI U.S.-Only.
- All CUI discussions should remain in session rooms, during scheduled session times, when entry to the room has been security checked and the doors are closed.
- Secure your conference badge. Badges will not be reprinted; remember to bring it with you each day.
- Photographing and/or audio/video recording or streaming of sessions is prohibited.

Free Wireless Internet Access

Complimentary wireless internet access will be available in public lobby areas and conference meeting rooms.

Network: T&C Basic
Login: towncountry23

JNC Mobile Website: m.ion.org

During the meeting, point your mobile device’s web browser to m.ion.org to access JNC information such as:

- Real-time conference program
- Customized schedule
- Current exhibit hall map
- Local area info/weather
- Restaurant reservations

Conference Dress

Battledress uniform or business casual.

Conference Proceedings

Electronic-only CUI conference proceedings are scheduled for distribution in July to all eligible conference participants. You will receive a link by email from registration@ion.org to the verified email address you used when registering. This link is unique to your account and cannot be shared. You will have 30 days to download the electronic proceedings, after which your link will expire. ION is unable to distribute conference proceedings after the 30 day period has expired.

Photography Policy

Your presence at JNC constitutes your agreement to be photographed, filmed, videotaped or otherwise recorded by conference management, or its agents, and your agreement that your image or voice may be distributed in print or electronic communications media without any compensation being paid to you. Video recording by participants is not allowed without written permission of ION during any portion of the conference. Photography, audio recording, or video recording of any CUI presentation is strictly prohibited.

JNC Conference Events

Monday, June 12
Informal Lunch
12:00 p.m. - 1:00 p.m.
Pacific Ballroom A
This event is included in full or Monday-only registrations.

Tuesday, June 13
Informal Lunch
12:15 p.m. - 1:15 p.m.
Exhibit Hall, Golden State Ballroom
This event is included in full or Tuesday-only registrations.

Exhibit Hall Evening Hours
5:30 p.m. - 7:00 p.m.
Exhibit Hall, Golden State Ballroom
A cash bar will be offered. This event is included with any type of registration. Spouses and traveling companions ages 21 years and older are welcome to attend.

Wednesday, June 14
Informal Lunch
12:15 p.m. - 1:15 p.m.
Exhibit Hall, Golden State Ballroom
This event is included in full or Wednesday-only registrations.

Thursday, June 15
Informal Lunch
12:00 p.m. - 1:00 p.m.
Pacific Ballroom A
This event is included in full or Thursday-only registrations.

Sponsored by:

BAE SYSTEMS
Pre-conference tutorials have been organized to provide in-depth learning prior to the start of the technical program. Course materials are the intellectual property of the instructor; an electronic copy of notes may be made available in the proceedings for qualified attendees at the instructor's discretion. Tutorials are included with the cost of a full registration. ION reserves the right to cancel a portion of the tutorial program based on availability of the instructor.

**GPS/GNSS 101**

**Date:** Monday, June 12, 2023  
**Time:** 8:30 a.m. - 10:00 a.m.  
**Location:** Ballroom A

This course presents the fundamentals of the GPS, and other GNSS, and is intended for people with a technical background who do not have significant GPS experience. Topics covered include time-of-arrival positioning, overall system design of GPS, signal structure, error characterization, dilution of precision (DOP), differential GPS, GPS modernization, and other GNSS systems.

**Dr. John Raquet** is currently the director of IS4S-Dayton. Previously, he was the founding director of the Autonomy and Navigation Technology (ANT) Center at AFIT. Dr. Raquet has a PhD in Geomatics Engineering from the University of Calgary, an MS in Aero/Astro Engineering from MIT, and a BS in Astronautical Engineering from the USAFA. He has published over 170 navigation-related conference and journal papers and taught 60 navigation-related short courses to over 3600 students in many organizations. He is an ION Fellow and past president.
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**An Introduction to Cryptography**

**Date:** Monday, June 12, 2023  
**Time:** 8:30 a.m. - 10:00 a.m.  
**Location:** Ballroom B

This tutorial offers a brief, broad and benign overview of cryptography. The first half of the course will explain the three main cryptographic methods: symmetric ciphers, hashes, and public key cryptography. We will illustrate these methods using a variety of non-navigation examples. We will then segue to the second part of the course, which shows where cryptography is used for navigation.

**Dr. Joe J. Rushanan** is a principal mathematician in the Communications, SIGINT, & PNT department of The MITRE Corporation. He was part of the M-code signal design team and the L1C signal design team. He was the 2019 recipient of ION’s Capt. P.V.H. Weems award for his sustained contributions to the design of GPS. He currently teaches cryptography for Northeastern University’s Khoury College Cybersecurity graduate program. He received his MS and PhD in mathematics from The Ohio State University and the California Institute of Technology, respectively.

**Dr. James T. Gillis, PhD** is a senior project Leader at The Aerospace Corporation. He has been involved with GPS since 1983. He was a member of the SAASM development team and co-chair of the GPS Modernization Signal Design Security Team.
Pre-Conference Tutorials

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PNT System Design and Deployment Process

Date: Monday, June 12, 2023
Time: 8:30 a.m. - 10:00 a.m.
Location: Ballroom C

This tutorial outlines the process for developing a PNT system, to both introduce new engineers to this process as well as introduce best practices for development through real examples. Research engineers from The Air Force Institute of Technology’s (AFIT) Autonomy and Navigation Technology (ANT) Center will outline and demonstrate the process of developing a PNT system for a research flight test. A problem requiring a PNT system will be presented and associated SysML digital engineering models will be reviewed. From these models, we will discuss how to design a real-world data collection process, an example of using simulated sensor data, and the trade-offs with each approach. From this sensor data, we will walk through an implementation of NavTK in Python and discuss some best practices for developing filter software using Docker with deployment in mind. Finally, we will demonstrate how the development practices used allows for near seamless deployment to the intended system.

Jeremy Gray is the engineering team lead at the Air Force Institute of Technology’s (AFIT) Autonomy and Navigation Technology Center (ANT). Jeremy holds a BS in Mechanical Engineering Technology from the University of Dayton and a MS in Systems Engineering from AFIT. For the last seven years at the ANT Center, Jeremy has researched complementary navigation system applications, small unmanned aerial system design and integration, modular open system architectures, digital engineering, cooperative navigation, and autonomous systems.

Josiah Watson has been a staff research engineer with the Autonomy and Navigation Technology (ANT) center at the Air Force Institute of Technology (AFIT) since 2018. He holds a BS in Computer Engineering (2018) from Cedarville University and a MS in Electrical Engineering (2020) from AFIT. He has been involved in projects exploring magnetic navigation and GPS-denied navigation for small unmanned aerial systems (UAS).

Jonathon Accurso is a software engineer with CAL Analytics focusing on aircraft simulation and analysis. He has worked with the ANT Center and AFRL to develop and integrate a variety of components and systems into different simulation software, such as AFSIM and JSBSim, to achieve anything from sensor performance analysis to training AI in flight controls.
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Introduction to Advanced Satnav Signal and Receiver Design using Python 1

**Date:** Monday, June 12, 2023  
**Time:** 8:30 a.m. - 10:00 a.m.  
**Location:** Ballroom D

This two-part course aims to provide attendees with a solid understanding of the fundamentals of satellite timing and navigation (satnav) systems. This includes their signal structure, how they’re generated and transmitted at the satellite, received and processed by user equipment, as well as system impairments caused by channel effects and interference. The course is divided into multiple modules – each comprised of a short lecture followed by a software demonstration that reinforces the topics covered.

This course employs a Python-based SDR platform known as PyChips. It introduces a prototype satnav system specification language written in JavaScript Object Notation (JSON). This allows the user to specify space vehicles (SVs) and other emitters with advanced signal structures, generate the received signals at the sample level, and then process and analyze these signals with one or more receivers whose architectures can be specified. In addition to the simulated signals, receivers also support the ION SDR Metadata Standard to process existing sampled data files. An introduction to PyChips can be found in [1].

**Part 1:** Satnav frequency bands, signal structures, and link budgets; anatomy of a multi-frequency, multi-signal-component SV; modulating multiple signal components onto the same carrier using phase optimized constant envelope transmission (POCET); power spectral density (PSD) analysis of advanced signals; correlation.

Prerequisites: Basic understanding of digital signal processing, object-oriented programming concepts, and the Python programming language are useful but not required for this course. Participation in software demonstrations is optional. Please note that attendees intending to run the demos must ensure adequate laptop battery power since the meeting room will not be equipped with power outlets. Additional information regarding this course will be posted here. This will include the software environment setup guide and instructions for downloading the software for registered attendees.


**Dr. Sanjeev Gunawardena** is a research associate professor with the Air Force Institute of Technology (AFIT). He leads robust GNSS technology development – one of three major R&D thrusts of the Autonomy and Navigation Technology (ANT) Center at AFIT. His research interests include RF design, digital systems design, high performance computing, SDR, and all aspects of satnav and associated signal processing.

**Mark Carroll** is an electronics engineer with the Air Force Research Laboratory Sensors Directorate. He received his BS in Computer Engineering and MS in Computational Science and Engineering from Miami University, Oxford Ohio. His research interests include satnav, satnav SDRs, and machine learning.
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**Hands On Exploration of GPS Navigation Concepts**

**Date:** Monday, June 12, 2023  
**Time:** 10:30 a.m. - 12:00 p.m.  
**Location:** Ballroom A

In this tutorial the audience will participate in the creation of a room-sized, rudimentary navigation system using simple ropes, rings, and tripods. We will explore GPS navigation concepts such as measurement determination, dilution of precision, clock bias, clock drift, and finally solving the full position velocity and time (PVT) solution. This tutorial is suitable for curious individuals that wish to obtain a physical understanding of these navigation concepts.

**Tim Erbes** is the technical director at Orolia Defense & Security, an organization specializing in GNSS Testing & Simulation, GPS Jamming & Spoofing Detection, and Resilient PNT Solutions. Erbes’ professional pursuits have focused on simulation, embedded systems, and test automation for GPS in NAVWAR applications. Prior to Orolia, Erbes worked as the chief technology officer for Talen-X, overseeing technical development, quality assurance, and innovation. Earlier on, Erbes played an essential role at Rockwell Collins as a systems engineer for the well-known Military GPS User Equipment (MGUE) program. Erbes received BS degree in Aerospace Engineering from Iowa State University.
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**Quantum Technologies for PNT**

**Date:** Monday, June 12, 2023  
**Time:** 10:30 a.m. - 12:00 p.m.  
**Location:** Ballroom B

This tutorial will introduce quantum technologies for position, navigation, and timing (PNT). The advent of atomic clocks nearly 70 years ago brought about a revolution in PNT for civilian and military applications. It enabled the dissemination of precision timing and accurate positioning via the GPS constellation, which remains the gold standard in navigation. Recent advances in quantum sensing, timing, and enabling technologies promise a new paradigm in PNT. These advancements include the development of inertial sensors and atomic clocks with unprecedented sensitivity and precision, as well as robust lasers for the manipulation of quantum states. Many challenges remain in deploying devices for mobile applications. This tutorial will provide an overview of the field and how these challenges are being met.

**Dr. Brian Kasch** received his PhD in Tuebingen, Germany, using Bose-Einstein Condensates as near-field detectors of EM noise. His research focuses on ultracold atoms for inertial sensing, deployable miniaturized atomic clocks, and photonic integrated circuits for PNT applications. He joined the Air Force Research Laboratory as a civilian in 2014 and received the 2019 John L. McLucas Basic Research Award for his work in advancing precision sensors based on atomic physics.
Introduction to Advanced Satnav Signal and Receiver Design using Python 2

Date: Monday, June 12, 2023
Time: 10:30 a.m. - 12:00 p.m.
Location: Ballroom D

This two-part course aims to provide attendees with a solid understanding of the fundamentals of satellite timing and navigation (satnav) systems. This includes their signal structure, how they're generated and transmitted at the satellite, received and processed by user equipment, as well as system impairments caused by channel effects and interference. The course is divided into multiple modules – each comprised of a short lecture followed by a software demonstration that reinforces the topics covered.

This course employs a Python-based SDR platform known as PyChips. It introduces a prototype satnav system specification language written in JavaScript Object Notation (JSON). This allows the user to specify space vehicles (SVs) and other emitters with advanced signal structures, generate the received signals at the sample level, and then process and analyze these signals with one or more receivers whose architectures can be specified. In addition to the simulated signals, receivers also support the ION SDR Metadata Standard to process existing sampled data files. An introduction to PyChips can be found in [1].

Part 2: Acquisition engines; signal tracking techniques and control state machines; inter-frequency aiding; measurement computation; Monte Carlo analysis using PyChips.

Prerequisites: Basic understanding of digital signal processing, object-oriented programming concepts, and the Python programming language are useful but not required for this course. Participation in software demonstrations is optional. Please note that attendees intending to run the demos must ensure adequate laptop battery power since the meeting room will not be equipped with power outlets.

Additional information regarding this course will be posted here. This will include the software environment setup guide and instructions for downloading the software for registered attendees.


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### Machine Learning 101 and PNT

**Date:** Monday, June 12, 2023  
**Time:** 10:30 a.m. - 12:00 p.m.  
**Location:** Ballroom C

This course introduces the fundamentals of machine learning (ML) and how it applies to position, navigation, and timing (PNT). Basic machine learning concepts like types of ML, importance and collection of data sets, deployment strategies, and the development toolchain will be covered. Some of the common pitfalls in ML developments will be highlighted, along with strategies for avoiding falling victim to the pitfalls. Thru example, the ML concepts that are outlined will be employed to demonstrate how ML can be used to speed and facilitate PNT OODA loop closure. The PNT OODA loop will be discussed in the context of the system construct to include architectural elements and concepts of operation. Questions of how to collect, when to collect, and where to send the data will be explored, as well as how to respond and automated response options. ML unique requirement considerations and specifications will be outlined, as well as ongoing challenges. Foundational tools developed for addressing the unique challenges of ML applied to PNT will be introduced. Attendees will have the opportunity to experiment with the tools.

This course employs a package of readily available ML tools that are either created or assembled for government use. These tools include a data collection system, a set of reference ML algorithms as a good starting point in that they have a good performance history in a contested environment (affectionately called the model zoo), a ML development and test environment that employs standardized and compatible toolsets, and a set of vetted and conditioned data sets; everything that a ML developer or evaluator needs to get started on applying ML solutions to PNT in a contested environment. Prerequisites: Basic understanding of optimization and the Python programming language are useful but not required for this course. Those that want to follow-along can bring a laptop, but it is optional.

**Brian Zufelt** serves as the deputy director of Cosmiac from the University of New Mexico’s School of Engineering. His current work with the Air Force Research Lab focuses on using machine learning to detect, mitigate, and predict future threats to the GNSS. Also, Mr. Zufelt has experience in machine learning algorithm optimization for various hardware platforms (TPU, GPU, CPU [ARM,x86], FPGA). His interests include optimizing a machine learning solution for specific hardware architecture, critical to achieving a deployed system’s lowest possible size, weight, and power requirement.

**Renee Yazdi** currently primarily supports AFRL PNT projects in her role as a System Engineering Consultant for Canyon Consulting. Renee has spent most of her career in and around space. Besides GPS, she has had the privilege to contribute to a variety of system engineering and technology development efforts with emphasis in remote sensing, communications, and missiles.

**Clarizza Morales** started working with COSMIAC in 2019 collaborating with Slingshot Aerospace on the deployment of unmanned aerial vehicle (UAV) applications using computer vision, video, and image processing techniques. She currently works with the Air Force Research Laboratories (AFRL) Space Vehicles Directorate on the development, research, and testing of new hardware/software technologies to advance the GNSS and PNT infrastructure.
A1: Complementary PNT: Navigation by Celestial Objects
Date: Monday, June 12, 2023
Time: 1:45 p.m. - 3:15 p.m.
Location: Ballroom A

Session Chairs:

Scott Downs  
*Navigation Systems TWH, Naval Sea Systems Command*

Paul Samanant  
*Honeywell*


2:50. Atmopheric Polarization and Stellar Position as Kalman Updates to a Navigation Solution: Thomas Wheeler and Brian Michels, General Dynamics Mission Systems

Alternate Presentations:

1. Day-to-Night Celestial Positioning Solution Utilizing Multiple Celestial Tracking Methods for Increased Availability: Laura Eshelman, Adam Smith, Jacob Frando, and Katie McCann, Polaris Sensor Technologies


Break: 3:15 p.m. - 4:00 p.m., Sponsored By GPS Source
B1: PANEL: M-Code UE Fielding

Date: Monday, June 12, 2023
Time: 1:45 p.m. - 3:15 p.m.
Location: Ballroom D

Moderator:

Brian Louie
SSC/CGU

Over the next decade, the DoD will spend billions of dollars to replace its existing legacy military GPS User Equipment (UE) with modernized UE. Come learn from a panel for military representatives drawn from across the DoD how each of the services plans to do this and how these plans differ from one another. Learn about proposed time lines and limiting factors that pace the fielding of modernized platforms and systems to our US and allied warfighters. This panel will feature representatives from the services sharing fielding plans.

Panel Members:

1. COL Jason Tussey, APNT/S CFT, Signature Effort for APNT, Army Platforms
2. Mr. Gregory Panas, JPEO A&A - Gun Launched PGMs
3. Lt. Cmdr Akwasi Fosu, PMW/A-170 - Navy Ships
4. Mr. Patrick Hanrahan, PMW/A-170 - Navy Air Platforms
5. Lt Col Robinson Hughes, AFLCMC/WNY - Air Force Platforms
6. Mr. Aaron Bartlett, AFLCMC/EB - Air Launched PGMs

Break: 3:15 p.m. - 4:00 p.m., Sponsored By GPS Source
**Technical Program**

**C1: Antenna Technologies (CRPA) and Interference Mitigation for Robust PNT**

**Date:** Monday, June 12, 2023  
**Time:** 1:45 p.m. - 3:15 p.m.  
**Location:** Ballroom C

**Session Chairs:**

Denice Jacobs  
AFRL  

William Lies  
UHU Technologies

1:50. Small Foot-Print CRPA for all Signal GNSS Receivers: Inder “Jiti” Gupta and Teh-Hong Lee, ElectroScience Laboratory, The Ohio State University

2:10. Small SWap 4-Channel GPS AJ System: William LeComte and Cedric Logan, Mayflower Communications Company, Inc.; Jorge Otero-Mendez and Joseph (Mike) Stock, Naval Air Warfare Center – Aircraft Division (NAWCAD) Communications and GPS Navigation Program Office (PMW/A 170)


**Alternate Presentations:**

1. **Maximizing the capability of the Hexagon NovAtel GPS Anti-Jam Technology (GAJT):** John Guenard, Hexagon US Federal; Thomas Taylor, Adam Cox, NovAtel Aerospace & Defense

Break: 3:15 p.m. - 4:00 p.m., Sponsored By GPS Source
D1: Complementary PNT: Navigation by Terrain as well as Magnetic and Gravity Fields 1
Date: Monday, June 12, 2023
Time: 1:45 p.m. - 3:15 p.m.
Location: Ballroom B

Session Chairs:
Dr. Simone Bortolami
Penn State Applied Research Lab
Dr. Robert Leishman
Draper


2:30. Real-time Magnetic Anomaly Navigation using Open Architecture Components: Kevin Brink, Adam Rutkowski, Pam Card, Ryan Sherrill, AFRL

Alternate Presentations:

Break: 3:15 p.m. - 4:00 p.m., Sponsored By GPS Source
A2: Future Space-based Sources of PNT: Signal Design

Date: Monday, June 12, 2023
Time: 4:00 p.m. - 5:30 p.m.
Location: Ballroom A

Session Chairs:

Dr. Joanna Hinks  
AFRL Space Vehicles

Dr. Edward LeMaster  
Lockheed Martin Advanced Technology Center

4:05. Military Lightweight SATNAV Study: Phase II: Scott Minas, Madeleine Naudeau, Jon Anderson, Space Vehicles Directorate


5:05. Agile New Signal Development and Demonstration - Frequency Spatial Polarization Time (FSPT) Hopping: Andrew Cochrane, Greg Myer, Jim Aarestad, Luis Hernandez, The University of New Mexico; Alex Hostick, Ares Corporation

Alternate Presentations:

1. LEO PNT Impacts to Signal Detection: John Acheson, BAE Systems and Will Travis, IS4S
2. NTS-3 Cryptonet Experiments: Joanna Hinks, Air Force Research Laboratory; James T. Gillis, Aerospace Corporation; Perry Loveridge, The MITRE Corporation (currently at Qualcomm); Joseph J. Rushanan, The MITRE Corporation
B2: PANEL: PNT Policy and Force Design
Date: Monday, June 12, 2023
Time: 4:00 p.m. - 5:30 p.m.
Location: Ballroom D

Moderator:

Dr. Sonya McMullen
DoD CIO

This panel includes introductions to PNT policy topics and a guided discussion with leaders that drive national policy and force design that is shaping PNT capability development and operational fielding. Panel members will provide their perspective and engage in an open discussion of the ongoing joint policy and force design efforts aimed at addressing challenges and opportunities in PNT capability advances. Attendee engagement will be encouraged.

Panel Members:

Vice Admiral Frank Whitworth, Director of the National Geospatial-Intelligence Agency
**C2: Antenna Technologies (Other) and Interference Mitigation for Robust PNT**

**Date:** Monday, June 12, 2023  
**Time:** 4:00 p.m. - 5:30 p.m.  
**Location:** Ballroom C

**Session Chairs:**
- Bryan Hoffman  
  NIWC Pacific  
- Christine Rini  
  The MITRE Corporation

4:05. **Quad-Band GPS/GNSS Anti-Jam Antenna Electronics System (Q-GAAS):** William LeComte, Mayflower; Michael P. Berarducci, AFRL/RWYN WPAFB

4:45. **Multi-Channel Antenna Interference Suppression by Means of Dual Linear Polarized Element Antenna Arrays:** Gilberto Sada, David Post, Alejandro Camacho, Justin Yakura, L3Harris Technologies

5:05. **A Test Set for GPS Anti-Jam Antennas:** Jaime Radulovich, Son Dinh, Jefferson Willis, Naval Information Warfare Center (NIWC) Pacific
D2: Complementary PNT: Navigation by Terrain as well as Magnetic and Gravity Fields 2

Date: Monday, June 12, 2023
Time: 4:00 p.m. - 5:30 p.m.
Location: Ballroom B

Session Chairs:
Todd Kawakami  Dr. Susannah Dickerson
NGA  Draper


4:45. Ship Based Magnetic Anomaly Navigation and Characterization Test Results: Richard B. Choroszucha, Jim Landon, Torfinn Johnsrud, Dave Tylutki, Phong Bach, Raytheon Technologies

5:05. Unsupervised Learning for MagNav Calibration and Mapmaking: Mitch Hezel, Ian Fletcher, Adam Kelsey, Miles Coe, Leo Gallo, Aneesa Sonawalla, Andrew Spielvogel, Robert C. Leishman, Draper

Alternate Presentations:


A3: Future Space-based Sources of PNT: LEO Constellations and Signals

Date: Tuesday, June 13, 2023
Time: 8:30 a.m. - 10:00 a.m.
Location: Ballroom A

Session Chairs:

Amy Dykstra  
USN

Dr. Shelby Savage  
The MITRE Corporation

8:35. Expanded Cislunar PNT and Communication Architecture for NASA LunaNet Operations: James Lake, Laura Duffy, Philip Kossin, Canyon Consulting, LLC


9:15. A Resilient PNT Payload for pLEO Communications: Stefania Römisch, Gregory Jenkins, Juan Carlos Oliveros, Michaela Villarreal, Northrop Grumman Systems Corporation

9:35. PNT and the Space Development Agency through the Tranches, T1, T2, and T3: Edward Powers, SDA/Aerospace Corp; Gregory Weaver, SDA/JHUAPL

Alternate Presentations:

1. Leveraging commercial SATCOM services as Signals of Opportunity to provide PNT as a Service (PNTaaS): Alison Brown, Dien Nguyen, Tom Silva, Jarrett Redd and Adrin Linan, NAVSYS Corporation


Break: 10:00 a.m. – 10:45 a.m., Exhibit Hall - Sponsored by EMCORE
B3: PNT Open Systems Architecture

Date: Tuesday, June 13, 2023  
Time: 8:30 a.m. - 10:00 a.m.  
Location: Ballroom B

Session Chairs:
Lynetta Grajeda  
NIWC Pacific  
Douglas Burch  
Collins Aerospace


8:55. OUSD PNT Reference Architecture: Incorporating NAVWAR Compliance: Adam Schofield, DEVCOM ARL; Meghan Bentz, DEVCOM C5ISR Center; Leah Davis, Strategic Technology Consulting

9:15. AFRL OpenPNT Testbed, an Open System Architecture Enabling a Network of Interoperable PNT Elements: Timothy J. Kelly, Luke Littleton-Strand, Microchip; Jeremy D. Warriner, Agalti; Andrew T. Baster, AFRL/RYWN; John Raquet, IS4S

9:35. Resilient Navigation Configuration Analysis with Real-Time Assurance Capability: Andrew Appleget, ANT Center, Air Force Institute of Technology; Jared Kresge, Jonathon Accurso, CAL Analytics; Clark Taylor, Air Force Institute of Technology; Sean Calhoun, CAL Analytics

Alternate Presentations:

1. Implementation of Open System Architecture Software: Brian Youngman and Brent Abbott, Orolia Defense and Security

2. Design and Test Results of a Modular, Open Architecture Software Defined Radio for Position, Navigation and Timing: Alison Brown, Jarrett Redd, Tom Silva and Dien Nguyen, NAVSYS Corporation

3. Use of MOSA Approach for Rapid Integration of Psionic SurePath into Army PNT System: Jeffrey Monaco, Jason Hull, Mark Christman, Jon Ward, Corin Sandford, Phil Works, Brian Devey, Psionic Daniel Marietta, Joseph Rufo, Michael Dillon, Natasha Norris, Emma Burgess, John Raquet, Integrated Solutions for Systems

Break: 10:00 a.m. – 10:45 a.m., Exhibit Hall - Sponsored by EMCORE
C3: Military PNT User Equipment Advances
Date: Tuesday, June 13, 2023
Time: 8:30 a.m. - 10:00 a.m.
Location: Ballroom C

Session Chairs:
Lt. Col. David Edsen
SSC/CGU2
Dr. David Goldstein
The Aerospace Corporation


9:15. Development and Integration of M-Code Capable Embedded GPS INS Systems and Lessons Learned: Andy Huizinga, Honeywell


Alternate Presentations:
1. Architecting Resilience Aircraft PNT – R-EGI GRA and Detailed Design Prototype (DDP): Mikel Miller, John Larson, John Raquet, IS4S; Jacob Campbell, Morgan Raymond, John Bowling, AFLCMC

2. Resilient Antenna Electronics (RAE) Emerging Concept Technology Demonstration (ECTD): Brett Dickson, Frank Tipton, The MITRE Corporation; Justin Kuric, Shane Smith, Inder Gupta, The Ohio State University; George Woodworth, AFLCMC/WNY

Break: 10:00 a.m. – 10:45 a.m., Exhibit Hall - Sponsored by EMCORE
**D3: Application/Impact of PNT Technologies in the Homeland Critical Infrastructure**

**Date:** Tuesday, June 13, 2023  
**Time:** 8:30 a.m. - 10:00 a.m.  
**Location:** Ballroom D

**Session Chairs:**  
Misty Finical  
NASA  
Dr. Dean Bruckner  
Chelton

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8:35. **Maritime Administration PNT Resiliency Pilot Program:** Karen Van Dyke, USDOT/OST-R; George Mantis, Stephen Mackey, Eric Wallischeck, Andrew Hansen, Hadi Wassaf, Chris Scarpone, USDOT Volpe Center; James Aviles, USDOT/OST-R; John Flake, Zeta Associates; Roger Ishimoto, Zeta Associates

8:55. **Time Interval Counter Kit (TICK) for Distributed Persistent Surveillance of IRIG Signals in Timing Networks:** Wil Myrick, Charlie Vines, ENSCO, Inc.; James Patterson, US Space Force

9:15. **Canonical Use Cases for Critical Infrastructure:** John W. Betz, Brady W. O’Hanlon, Bradley A. Moran, Homeland Security Systems Engineering & Development Institute, operated by The MITRE Corporation

9:35. **A Leap to Sub-Nano Second Clock Synchronization:** Alaiya Tunte-meke-Winter, Brent Abbott, Orolia Defense & Security

**Alternate Presentations:**

1. **U.S. DOT IDM Real World PNT-SA Event Case Comparison:** James S. Aviles Karen L. Van Dyke, US Department of Transportation

2. **U.S. DOT PNT Resilience Initiative on Complementary PNT:** Andrew Hansen, Stephen Mackey, Hadi Wassaf, Chris Scarpone, Eric Wallischeck, DOT/OST-R/Volpe Center; Karen Van Dyke, DOT/OST-R

**Break:** 10:00 a.m. – 10:45 a.m., Exhibit Hall - Sponsored by EMCORE
A4: Future Space-Based Sources of PNT: LEO Signal Processing

Date: Tuesday, June 13, 2023
Time: 10:45 a.m. - 12:15 p.m.
Location: Ballroom A

Session Chair:

Ryan Cassel
The MITRE Corporation


11:30. Characteristics and Benefits of High-Performance Proliferated LEO (pLEO) PNT Waveforms: Taehwan Kim, Brent Bateman, Ethan Hayes, David Ropp, Jeffrey Dickman, Northrop Grumman Corporation


Attendee Lunch: 12:15 p.m. – 1:15 p.m. - Exhibit Hall
B4: Integrity and Assurance: Fault Detection and Exclusion
Date: Tuesday, June 13, 2023
Time: 10:45 a.m. - 12:15 p.m.
Location: Ballroom B

Session Chairs:
Jonathan Neu  
US Air Force  
Kamal Joshi  
Northrop Grumman

10:50. Experimental Validation of ARAIM+: A Reliable Assured PNT using Multi Constellation GNSS: Samer Khanafseh, Logan Bednarz, and Boris Pervan, TruNav LLC; and Eric Vinande, Air Force Research Lab - RYWN


11:50. Testing COTS GNSS Receivers Using Only a Subset of Supported Signals: Benon Gattis, Jacob Spagnolli, University of Colorado Boulder; Dennis Akos, University of Colorado Boulder and Stanford University; Sherman Lo, Yu-Hsuan Chen, and Todd Walter, Stanford University

Alternate Presentations:

1. Multi-GNSS Long Term Orbit and Clock (LTOC) and Integrity Experimentation with NTS-3 User Equipment: Chris Brannon, Wen Han, Riverside Research; Eric Vinande, AFRL Sensors Directorate; Jason Drotar, NSWC Dahlgren Division

2. Experimental Validation of Generalized Integer Aperture Bootstrapping: Nathan Green, Coherent Technical Services, Inc.

Attendee Lunch: 12:15 p.m. – 1:15 p.m. - Exhibit Hall
C4: Military PNT User Equipment Program Status
Date: Tuesday, June 13, 2023
Time: 10:45 a.m. - 12:15 p.m.
Location: Ballroom C

Session Chairs:

Patrick Hanrahan  
NIWC Pacific
Brent Abbott  
Defense and Security

10:50. BAE Systems Program Status and Product Line Update for M-Code User Equipment: Charles A Popeck and Shawn P. Ryan, BAE Systems

11:10. Raytheon Military GPS User Equipment (MGUE): Today and Future Capabilities: Elisabeth Hosmer, Raytheon Intelligence & Space

11:30. MGUE Program Status: Rick Bieniak, L3Harris

11:50. Operational Fielding of Modernized Avionics M-Code Receivers: Neal Fedora, Stephen McGrath, Mark Rimlinger, Scott Sorber, TMAS

Attendee Lunch: 12:15 p.m. – 1:15 p.m. - Exhibit Hall
D4: PANEL: National Critical Infrastructure Threat

Date: Tuesday, June 13, 2023
Time: 10:45 a.m. - 12:15 p.m.
Location: Ballroom D

Moderator:
Karen Van Dyke
US DOT/OST-R

This CUI panel will focus on PNT threats to the national critical infrastructure. Discussion topics may include threats to the electrical grid, communication, transportation, finance, and domestic DoD support infrastructure as well as emerging infrastructure for domestic employment of UAV systems that create a challenge for safeguarding national assets and maintaining homeland security.

Panel Members:

1. **Ken Alexander**: Chief Scientific Technical Advisor for Satellite Navigation, Federal Aviation Administration
3. **Space-Based Interference Trends and Events**: Misty Finical, Deputy Principal Advisor, Enterprise Protection, National Aeronautics and Space Administration
4. **DOT IDM Santa Monica (KSMO) Event Case**: James S. Aviles, U.S. Department of Transportation/FAA
5. **Dr. Sonya Anne Hall McMullen**: Deputy Director of PNT DoD CIO C3
6. **Mike Roskind**: Director for PNT, Strategic Defense Initiatives, National Risk Management Center, DHS/CISA
7. **Joe Brule**: Cyber-Engineering, National Cybersecurity Center of Excellence, NIST

Attendee Lunch: 12:15 p.m. – 1:15 p.m. - Exhibit Hall
PLENARY 1
Date: Tuesday, June 13, 2023
Time: 1:45 p.m. - 3:15 p.m.
Location: Ballroom A/B

Moderator:
David Wolfe
USCG C5ISC

Keynotes:
Dr. Jeffrey Hebert, Senior Scientist for Positioning, Navigation, and Timing, Sensors Directorate, Air Force Research Laboratory

Dr. David Voss, Director of the Spectrum Warfare Center of Excellence, Space Warfighting Analysis Center (Invited)

Break: 3:15 p.m. – 4:00 p.m., Exhibit Hall - Sponsored by LinQuest
PLENARY 2: Warfighters
Date: Tuesday, June 13, 2023
Time: 4:00 p.m. - 5:30 p.m.
Location: Ballroom A/B

Moderators:

COL Jason Tuessey  
US Army

Sean Memmen  
Booz Allen Hamilton

Panel Members:

1. ETVCM Joseph Calhoun, U.S. Navy
2. Lt Sarah Clancy, U.S. Space Force
3. SGM Joshua Gendron, U.S. Army
4. LT Michael Halperin, U.S. Navy
5. LT Bryce Hawley, U.S. Navy
6. QMCM Aurora Robles, U.S. Navy
7. Deputy Jason Russell, U.S. Army

Exhibit Hall Evening Hours and Cash Bar: 5:30 p.m. – 7:00 p.m.
A5: Reconfigurable and Reprogrammable SatNav

Date: Wednesday, June 14, 2023
Time: 8:30 a.m. - 10:00 a.m.
Location: Ballroom A

Session Chairs:

Doug Martoccia
The Aerospace Corporation
Elliott Kaplan
The MITRE Corporation

8:35. Mission Operations for Reprogrammable SatNav: Jeremy Holder, AFRL; Abby Deeter, Axient; Eric O’Connor, AFRL; Joshua Undlin, AFRL

8:55. GPS III Hosted Payload Antenna and Amplifier to Demonstrate On-orbit Reprogrammability: Erik Lier, Tom Hollenbach, Mark Crews, Chuck Frey, Lockheed Martin Space; Al Katz, Paul Drexler, Roger Dorval, MACOM, Linear Products

9:15. NTS-3 Spectrum Safety Test Results: Joanna Hinks (AFRL/RV), Greg Myer, James Lake, Canyon Consulting, LLC; Elliott Kaplan, The MITRE Corporation

9:35. BPSK vs BOC: Phil Dafesh, The Aerospace Corporation, John Acheson, BAE Systems

Alternate Presentations:


Break: 10:00 a.m. – 10:45 a.m., Exhibit Hall - Sponsored by L3Harris
B5: Integrity and Assurance: Spoofing Detection

Date: Wednesday, June 14, 2023
Time: 8:30 a.m. - 10:00 a.m.
Location: Ballroom B

Session Chairs:

Aaron Nascimento  
NAVARSYSCOM

Ann Witt  
Honeywell

8:35. Implementation of an Innovation Monitor Bank and Cinner for GNSS Fault Detection and Survivability: Samuel Hunt, Connor Brashar, Sandia National Laboratories


9:35. GNSS Spoofer Detection with Carrier Phase Measurements Using a Multi-Constellation Software Defined Radio Receiver: Zhen Zhu, East Carolina University; Sanjeev Gunawardena, AFIT; Eric Vinande, Jason Pontious, AFRL

Alternate Presentations:

1. High-Integrity PNT in the Android Mobile Platform: Ethan Pyke, Evan Gattis, Dennis Akos, University of Colorado Boulder

2. Validation of Cinner Spoofer Survivability Algorithm in Anechoic Chamber Testing: Connor Brashar and Prabodh Jhaveri, Sandia National Labs

Break: 10:00 a.m. – 10:45 a.m., Exhibit Hall - Sponsored by L3Harris
C5: Military PNT User Equipment Test Results
Date: Wednesday, June 14, 2023
Time: 8:30 a.m. - 10:00 a.m.
Location: Ballroom C

Session Chairs:

Lt Col Greg Smith  
SSC/CGU

Rob Simsiman  
The MITRE Corporation

8:35. PNT Assessment Exercise (PNTAX) Results from Aiding Acquisition for an Increment 1 MGUE Receiver Using a Frequency-Hop Acquisition Using Secure TRANSEC (FAST) Prototype: Terry Ferrett and Philip Dafesh, The Aerospace Corporation

8:55. Advanced GPNTS Threat Testing: Kyle Swanson and Jake Bencke, NIWC Pacific

9:15. Flight Test Results for Embedded GPS Inertial Modernization (EGI-M): Jonathan Lincoln, Northrop Grumman; Kamal Joshi, Northrop Grumman; Michael Hathaway, Northrop Grumman; Patrick Young, Northrop Grumman; Joe Franiak, Northrop Grumman; Joseph B. Lorkowski, Maj. USAF

9:35. M-Code Receiver Jamming Test Results: John Weger and Mike Cook, BAE Systems

Alternate Presentations:

1. A Resilient Navigation Solution To Enable BVLOS UAS Missions in Jamming Conditions: Ben Mohr, Honeywell; Ben Sandford, Infinidome; Marek Fojtach, Honeywell; Moshe Kaplan, Infinidome; Mohan Jacob, Honeywell; Omer Sharar, Infinidome

2. Raytheon Technologies Static Antenna Test Range (SATR) Anti-Jam Demonstration Results for M-Code enabled GPS Receiver and AJ Applique: Kelsey Fitzgibbons, Resilient Navigation, Raytheon Intelligence & Space

Break: 10:00 a.m. – 10:45 a.m., Exhibit Hall - Sponsored by L3Harris
D5: AI/Machine Learning (ML) for PNT Determination

Date: Wednesday, June 14, 2023
Time: 8:30 a.m. - 10:00 a.m.
Location: Ballroom D

Session Chairs:

Dr. David Woodburn  
AFIT

Dr. Rebecca Russell  
Draper


8:55. Increasing CNN Findable Features in Imagery via Labeling Obscured Features: Jeffrey Choate, Scott Nykl, Air Force Institute of Technology

9:15. GNSS Machine Learning Toolset (MLT): Luis Hernandez, Clarizza Morales, Jim Aarestad, Brian Zufelt, Cosmiac, UNM; Renee Yazdi, Kevin Slimak, Canyon Consulting; Madeleine Nadeau, David Choi, Colton Mott, AFRL


Alternate Presentations:

1. Transformer Networks for Robust, Cross-Modal Visual Terrain Relative Navigation: Eric Amoroso, Curtis Boirum, Andrew Ashley, Fraser Kitchell, Kerry Snyder, KEF Robotics

Break: 10:00 a.m. – 10:45 a.m., Exhibit Hall - Sponsored by L3Harris
A6: SatNav System Experimentation  
**Date:** Wednesday, June 14, 2023  
**Time:** 10:45 a.m. - 12:15 p.m.  
**Location:** Ballroom A

**Session Chairs:**

[Image of John Langer]  
John Langer  
The Aerospace Corporation  
[Image of Mark Crews]  
Mark Crews  
Lockheed Martin


11:10. **NTS-3 Data Signal Test Results:** Greg Myer, Formerly Canyon Consulting; Jerrid Plymale, Canyon Consulting; Joanna Hinks, AFRL Space Vehicles Directorate

11:30. **The NTS-3 On-Orbit Experiment Schedule:** Joanna Hinks (AFRL/RV), Brittany Wells (AFRL/RY), Arlen Biersgreen (AFRL/RS), Laura Duffy (Canyon Consulting), Craig Pollock (Canyon Consulting)

11:50. **Analysis of NTS-3 Satellite Clock Stability Using Ground-Based Measurements:** Natalia Shu, Charles Zhou, Kyle Martin, John Elgin, Joanna Hinks, AFRL

**Alternate Presentations:**

1. **Development of an Advanced Satnav Signal Synthesizer and Transmitter for Test and Validation Applications:** Eric Hahn, Sanjeev Gunawardena, Logan Reich, Tristan Williams, Air Force Institute of Technology; Joanna Hinks, AFRL Space Vehicles Directorate

2. **Lunar Trade Space Analysis for In-Space Rescue Applications Part 1:** Benjamin Johnis, Kaitlin Roberts, Sanjeev Gunawardena, Robert Bettinger, Air Force Institute of Technology; Eric Pellegrini, Draper

**Attendee Lunch:** 12:15 p.m. – 1:15 p.m. - Exhibit Hall
B6: Novel Clock Technologies and Timing Applications 1

**Date:** Wednesday, June 14, 2023  
**Time:** 10:45 a.m. - 12:15 p.m.  
**Location:** Ballroom B

**Session Chairs:**

Andrew Baster  
AFRL  
Dr. Kari Moran  
NIWC Pacific

10:50. ±5 ppb TCXO Technology for PNT Applications: Carl Arft, Gary Giust, SiTime


11:30. Leveraging the Advantages of Software Defined Timing for Robust Fusion and Integrity of Multiple Clocks/Timing Sources: John Raquet, Joshua Blackburn, Natasha Norris, Daniel Ripperger, Michael Dillon, Jonathan Rohde, Ken Fisher, Kyle Kauffman, IS4S; Adam Schofield, US Army DEVCOM Army Research Laboratory; Meghan Bentz, US Army DEVCOM C5ISR Center

11:50. GPS Level Time Synchronization via Two-way RF Time Transfer Over Meteor Trail Links: Joseph Strus, Jesse Wodin, Justin Landrum, Robert Sparr, David Watt, Mark Schutzer, Boskin Erkocevic, SRI International

**Alternate Presentations:**

1. **Scalable Sub-nanosecond Distributed Clock Synchronization through White Rabbit:** Brent Abbott, Orolia Defense & Security Alaiya Tuntemeke-Winter, Orolia Defense & Security

Attendee Lunch: 12:15 p.m. – 1:15 p.m. - Exhibit Hall
C6: PANEL: Rapid Agile Development and PNT Technology Transition

Date: Wednesday, June 14, 2023
Time: 10:45 a.m. - 12:15 p.m.
Location: Ballroom D

Moderator:

Dr. Adam Schofield
Army Research Lab

Representatives from the services and industry will describe their approach to respond to urgent requirements from field and to transition emerging technologies. Panelists will contrast the established process with rapid agile development techniques that are being implemented in order to accelerate transitions. Topics of discussion will include: innovative means of rapidly transitioning technology to the field; application of a PNT Open Systems Architecture (OSA) in order to promote the ability to plug and play new sensors/software applications; transition through government/industry partnerships; and how to best position promising technology for transition.

Panel Members:

1. Dr. Jacob Campbell, PNT Tech Area Lead, AFRL Sensors Directorate
2. Mr. Ben Peddicord, Chief Intel Technology and Architecture Branch, Army DEVCOM CSISR Center
3. LCDR A. Fosu, Assistant Program Manager GPS-based Position, Navigation, and Timing Service (GPNTS) PMW/A170
4. Mr. Gentry Gardner, Chief Engineer, Space & Intel, General Dynamics Mission Systems

Attendee Lunch: 12:15 p.m. – 1:15 p.m. - Exhibit Hall
D6: AI/Machine Learning (ML) for PNT Situational Awareness

Date: Wednesday, June 14, 2023
Time: 10:45 a.m. - 12:15 p.m.
Location: Ballroom C

Session Chairs:

Dr. Chen Lai  
DEVCOM C5ISR

Brian Zufelt  
COSMIC/The University of New Mexico


11:50. Machine Learning for GPS Integrity Using Chipshape Observations: Mark Carroll, Air Force Research Laboratory (AFRL); Sanjeev Gunawardena, Air Force Institute of Technology (AFIT)

Alternate Presentations:

1. AI/ML GPS Jamming Detection & Classification: Deepika (Dee) Chona, DEVCOM C5ISR Center, and Laura Peters, T2S Solutions

2. Deep Learning for GNSS Jammer Classification*: Cedric Logan and Christopher Zarowski, Mayflower Communications Company, Inc.

Attendee Lunch: 12:15 p.m. – 1:15 p.m. - Exhibit Hall
PLENARY 3  
Date: Wednesday, June 14, 2023  
Time: 1:45 p.m. - 3:15 p.m.  
Location: Ballroom A/B  

Moderator:  
David Wolfe  
USCG CSISC  

Keynote: CDR Maegan Schwartz, Deputy Sector Commander/Air Station XO for USCG SECTOR NORTH BEND

CDR Maegan Schwartz currently serves as the Executive Officer of Air Station North Bend, OR. CDR Schwartz graduate of the United States Coast Guard Academy and holds a Master of Science in Aeronautics from Embry-Riddle Aeronautical University.  

After receiving her commission, CDR Schwartz served at Coast Guard Sector San Francisco as a Search and Rescue Controller and Assistant Command Center Supervisor. She coordinated Coast Guard and local agency responses to multiple search and rescue cases and maritime events throughout the San Francisco Bay area. In 2007, CDR Schwartz received orders to Navy Flight School in Pensacola, FL. After earning her wings in 2008, she transitioned to the HH-65C Dolphin helicopter and was stationed in Barbers Point, HI where she achieved an Aircraft Commander designation.  

CDR Schwartz has over 3,000 hours of combined military and civilian flight time and holds FAA certifications as an Airline Transport Pilot and Certified Flight Instructor. She is also a certified Level III DHS Program Manager.  

Keynote: Ms. Makena Young, Center for Strategic and International Studies

Ms. Makena Young is an associate fellow with the Aerospace Security Project at the Center for Strategic and International Studies, where her research interests include international collaboration, space security, and orbital debris.  

Break: 3:15 p.m. – 4:00 p.m., Exhibit Hall - Sponsored by Inside GNSS
A7: PANEL: Cislunar Navigation in the Age of Artemis

Date: Wednesday, June 14, 2023
Time: 4:00 p.m. - 5:30 p.m.
Location: Ballroom D

Moderators:

MSgt Benjamin Johnis
Air Force Institute of Technology
Kenneth Davis
Qualcomm Gov Solutions

NASA will return us to the Moon in the Artemis Missions. The National Cislunar Science and Technology Strategy uses a whole-of-government approach to address unique challenges associated with the proliferation of human space exploration to the Moon and beyond. One of the four objectives is to “implement cislunar communications and navigation capabilities with scalable and interoperable approaches to enable a cooperative and sustainable ecosystem in cislunar space.” NASA will rely heavily on LunaNet, which requires precise PNT services. This panel discusses international agreements, space law, public policy, and strategic competitions between the U.S. and China/Russia that steer technological requirements in Cislunar navigation and promote resilient cislunar PNT services.

Panel Members:

1. Astronaut: Dr. James Reilly, USN Retired, 17th Director of the United States Geological Survey
2. NASA GSFC: Ms. Cheryl Gramling, Mission Engineering and Systems Analysis Division - Assoc. Chief for Technology, Goddard Senior Fellow
3. NASA JPL: Dr. Stephen M. Lichten, Chief Engineer, Interplanetary Network Directorate (900)
4. AFRL/RVBYT: Dr. John Elgin, Research Physicist, Clock and Timing Lead
5. NGA: Dr. Trevor Garner, Senior GEOINT Officer for Space, Lunar Geodetic System Lead
6. Draper: Dr. J.P. Laine, Director PNT and Space Portfolio
B7: Novel Clock Technologies and Timing Applications 2
Date: Wednesday, June 14, 2023
Time: 4:00 p.m. - 5:30 p.m.
Location: Ballroom B

Session Chairs:

Dr. Kimberly Frey  
AFRL/RV

Heidi Graziano  
The Aerospace Corporation

4:05. Testing an Optical Atomic Clock in the Field: Kyle W. Martin, River Beard, Blue Halo; John Elgin, United States Space Force

4:25. Results from the 5071A Cesium Primary Frequency Reference Refresh Project: David Chandler, Christopher Liessner, Peter Cash, Mark Trainoff, Cody Dutra, Steve Dimare, Michael Juppe, Jackie Ellett, Microchip Technologies

4:45. Vapor with Pulsed Optical Readout (VaPOR) clock – a Pulsed-laser Optically Pumped Rb Vapor Cell Clock: Miao Zhu, Emily Altiere, Alan Bell, Kisra Egodapitiya, Dong-Ik Lee, Thang Tran, George Trio, Alexander Tuganov, and Thomas Yi, AOSense

C7: Navigating in Challenged Environments (e.g., Urban, Indoor and Sub-Surface Navigation)
Date: Wednesday, June 14, 2023
Time: 4:00 p.m. - 5:30 p.m.
Location: Ballroom C

Session Chairs:

Robert McDermott  
USCG C5ISC

Dr. David Allen  
The Aerospace Corporation

4:05. Belief Space Planning for Robust Navigation: Timothy I. Machin, Clark N. Taylor, AFIT/ENG; Robert C. Leishman, Draper

4:25. Dismounted Personnel Position Tracking in GPS-Denied Environments: Davy Figaro, Jay Trojan, PNI Sensor


D7: PNT Situational Awareness Using Antenna Arrays

Date: Wednesday, June 14, 2023
Time: 4:00 p.m. - 5:30 p.m.
Location: Ballroom A

Session Chairs:

Greg Panas  
US Army JPEO AA / DEVCOM AC

Arthur Scholz  
The MITRE Corporation

4:05. Application of Sparse Representation to Geolocate RF Emitters Using an Airborne Antenna Array: Inder “Jiti” Gupta and Jacob Compaleo; ElectroScience Laboratory, The Ohio State University

4:25. Anti-Jam Electronic Support for Operational PNT: Deepika (Dee) Chona, CCDC/C5ISR

4:45. GNSS Spoofing Detection and Recovery via Blind Processing of Antenna Array Signals: Mark L. Psiaki, Virginia Tech; John R. Bowman, Virginia Tech; Mathieu Joerger, Virginia Tech

5:05. Detecting, Locating, and Mitigating PNT Threats Using a Modular and Scalable Digital Antenna Electronic System: Joshua Starling, William Travis, IS4S, David M. Bevly, Auburn University; Greg Reynolds, U.S. Army Combat Capabilities Development Command Aviation & Missile Center

Alternate Presentations:

1. CRPA-Based Layer 1 Robust Spoofing Detection and Mitigation Augmentation to GNSS Receivers*: Cedric Logan, Christopher Zarowski, Huan-Wan Tseng, Nareshbabu Jarmale, Manuel Soto Santiago, Mayflower Communications Company, Inc.

2. Integrated Military GPS User Equipment Antenna System (IMAS)*: William LeComte and Nareshbabu Jarmale, Mayflower Communications Co., Inc.; Bryan Hoffman, Naval Information Warfare Center Pacific
A8: Modeling and Simulation of Satnav and Complementary PNT

Date: Thursday, June 15, 2023  
Time: 8:30 a.m. - 10:00 a.m.  
Location: Ballroom A

Session Chairs:

Jacob Bencke  
NIWC Pacific

Dr. Renee Yazdi  
Canyon Consulting

8:35. **Chrys – A Modular Simulation Library for ASPN PNT Systems**: Jeremy Gray, CTR AFIT ANT Center HII; Jonathon Accurso, CTR AFIT ANT Center Cal Analytics; Clark Taylor, AFIT ANT Center; David Woodburn, AFIT ANT Center

8:55. **mGNSS Modeling Work at APL**: Parker White, Stephen Mitchell, Justin Bradfield, Connor Thompson, Olukayode Okusaga, JHU/APL

9:15. **Military GPS User Equipment Modeling Simulation**: James Fitch, Laura Lusero, Kaleb Bodisch, LinQuest Corporation


Alternate Presentations:

1. **SPACEJAM-3D**: Paul Osadchy, AFRL; Denice Jacobs, Dana Howel, Dan Dresher, George Lee, Paul Osadchy, Kyle Mason, Steve Brezensi, Northrop Grumman Corp.

2. **Integrating and Testing M-Code GPS Receivers in Navigation and Time/Frequency Products**: Paul E. Myers, Orolia Defense and Security

3. **Camera Aided Position Tracking for Anechoic Inertial Navigation (CAPTAIN)**: Sean Herrera, US ARMY DEVCOM Analysis Center

Break: 10:00 a.m. – 10:30 a.m., Sponsored by Lockheed Martin Space Systems Co
B8: Complementary PNT: Terrestrial RF Aided (Non-GPS)
Date: Thursday, June 15, 2023
Time: 8:30 a.m. - 10:00 a.m.
Location: Ballroom B

Session Chairs:
John Edwards  
USCG CSISC  
Dr. Wilbur L Myrick  
ENSCO

8:35. State Estimation from Time-Difference-of-Arrival and Range-Rate Measurements: Grace Norrix, Timothy Pitchko, Pedro A. Capo-Lugo, Qualis-Corporation

8:55. Multidomain Resilient Collaborative PNT: Mike Badamo, Carole Teolis, Carol Politi, TRX Systems; Samuel Steed, David Nelson, Eddie Mobley, L3Harris Technologies, Communication Systems West; Yoonkee Kim, Nhut Vo, CSIS Center R&TID PNT DIV

9:15. Osiris: Simultaneous Localization Mapping Based on RF Signals: Anh Luong, Keith Morris, Kevin Cohen, Brandon White, Prabodh Jhaveri, Sandia National Laboratories


Break: 10:00 a.m. – 10:30 a.m., Sponsored by Lockheed Martin Space Systems Co
C8: GPS in Military Applications/NAVWAR
Date: Thursday, June 15, 2023
Time: 8:30 a.m. - 10:00 a.m.
Location: Ballroom C

Session Chairs:

Dr. Anne Le
The Aerospace Corporation
Kelly Fang
CSISR

8:35. USSF/ SWAC PNT Force Design Update: Joshua Harnisch, Daniel DeVargas, USSF NAVWAR Division SWAC

8:55. Assessment of Future Jamming Threats: Phil Dafesh and Gourav Khadge, The Aerospace Corporation

9:15. Carrier Phase and MGUE: John Weger, BAE Systems

9:35. Solutions for Disadvantaged GPS Operations: John Acheson of BAE Systems; Steven Brown, Mark Crews, and Tom Hollenbach, Lockheed Martin Space

Alternate Presentations:

1. GPS Time Dissemination for Military Applications: Charles Brothers, Kami Okusaga, Parker White, Stephen Mitchell, Stephen Mitchell JHU/APL

Break: 10:00 a.m. – 10:30 a.m., Sponsored by Lockheed Martin Space Systems Co
**D8: PNT Situational Awareness 1**

**Date:** Thursday, June 15, 2023  
**Time:** 8:30 a.m. - 10:00 a.m.  
**Location:** Ballroom D

**Session Chairs:**  
Lt. Col. Nicolas Estep  
*USAF*  
Dr. Keith McDonald  
*The MITRE Corporation*

8:35. **PNT SA vs. NAVWAR SA for Resilient and Robust Navigation Architectures:** Megan McMarrow, Dana Howell, and Denice Jacobs,  
*AFRL/RYWN*

8:55. **NAVWAR Situational Awareness and Jammer Geolocation:** David Easterling and Andrew Thompson, University of Dayton Research Institute; Michael Corey and William Deike, AFRL/RYWN

9:15. **GSWEB: A Web Application for GNSS Situational Awareness and Signal Monitoring:** Ethan Friedman, Aaron Kerkhoff, Johnathan York,  
*Applied Research Laboratories, The University of Texas at Austin*

9:35. **Automating NAVWAR Performance thru Machine Learning:** Kevin A. Schaal, Mr. Paul C. Manz, Thomas J Blenk Jr., Ekta R. Patel, JPEO Armaments and Ammunition, Mrugesh Patel, Frank Fabian, Ian McMichael, Christian Minor, Rachel Cooper,  
*The MITRE Corporation*

**Alternate Presentations:**

1. **Spectral Compression for RF Capture and Forward:** David Noll, Derek Anton, William Woodworth, Lockheed Martin

Break: 10:00 a.m. – 10:30 a.m., Sponsored by Lockheed Martin Space Systems Co
A9: Operational System Demonstrations 1

Date: Thursday, June 15, 2023
Time: 10:30 a.m. - 12:00 p.m.
Location: Ballroom A

Session Chairs:

Dan Weinman
AFRL/DEVCOM C5ISR

Paul Olson
DEVCOM C5ISR

10:35. Enabling Rapid PNT Integration with AgilePod, ASPN, and pntOS: Mark Smearcheck, Branden McNally, Benjamin Fain, Kevin Brink, Air Force Research Laboratory (AFRL); Adriel Fillippini, Josh Stevenson, Cole Hedden, Andy Thompson, University of Dayton Research Institute (UDRI); Natasha Norris, Daniel Marietta, Ken Fisher, Integrated Solutions for Systems (IS4S)

11:15. Testing the Expeditionary Joint Precision Approach and Landing System With a Retail Flight Simulator: Joseph Chang, Stan Chen, Rob Courville, Matt Keti, Timothy Schempp, Jeffrey Schmitendorf, Dave Tochtrop, Raytheon Technologies

Alternate Presentations:


Attendee Lunch: 12:00 p.m. – 1:00 p.m., Pacific Ballroom, Sponsored by BAE Systems and Spirent Federal Systems
B9: Complementary PNT: Vision Aided/Optical Ground

Date: Thursday, June 15, 2023
Time: 10:30 a.m. - 12:00 p.m.
Location: Ballroom B

Session Chairs:
Navin Mathur  
CSISR RTI
Nik Hartney  
Honeywell


11:15. **Vision based Navigation using Cross-View Geo-registration for Outdoor Augmented Reality and Navigation Applications**: Rakesh Kumar, Supun Samarasekera, Niluthpol Mithun, Kshitij Minhas, Taragay Oskiper, Kevin Kaighn, Mikhail Sizintsev, Han-Pang Chiu, SRI International

11:35. **Evaluation of Diverged Optics for Optical Multilateration**: Kevin N. Stanzione, Eric Bozeman, Nathan S. Barnwell, Elizabeth Izaguirre, Kari Moran, Angelica Sarmiento, Li Sun, NIWC-Pacific

Alternate Presentations:


2. **Restricting Inertial Navigation System Position Error Growth Using High Accuracy Vehicle Velocity Vectors**: Stephen Sandford, Jason Hull, Diego Pierrottet, Jeff Monaco, Jon Ward, Corin Sandford, Phil Works, Brian Devey, Connor Huffine, Brendan Smith, Mark Christman, Donald Erbschloe

Attendee Lunch: 12:00 p.m. – 1:00 p.m., Pacific Ballroom, Sponsored by BAE Systems and Spirent Federal Systems
C9: Inertial Measurement Unit/Applications

Date: Thursday, June 15, 2023
Time: 10:30 a.m. - 12:00 p.m.
Location: Ballroom C

Session Chairs:

[Images of Session Chairs: Dr. Jenna Chan and Capt. Paul Heim]

Dr. Jenna Chan  
DEVCOM Army Research Lab  
Capt. Paul Heim  
WR Systems


11:35. Rocket Science “Made Easy” in DEVCOM AvMC Navigation Technology Lab: Brian Irelan, Stephen Pethel, Scott David, NTA, Inc.; Patrick Renfroe, DEVCOM Aviation & Missile Center

Alternate Presentations:


Attendee Lunch: 12:00 p.m. – 1:00 p.m., Pacific Ballroom, Sponsored by BAE Systems and Spirent Federal Systems
D9: PNT Situational Awareness 2
Date: Thursday, June 15, 2023
Time: 10:30 a.m. - 12:00 p.m.
Location: Ballroom D

Session Chairs:

Amanda Humphrey  
JNWC

James Yockey  
DEVCOM C5ISR

10:35. Recommendations on PNT Situational Awareness for Intelligence, Military, and Civilian Applications: Keith McDonald, Dane Wilburne, The MITRE Corporation and Scott Fearheller, NSIC

10:55. DEEP: A Proliferated LEO PNT Situational Awareness Threat Monitor: Scott Jones, Peter Shagnea, David Fiske, Aaron Pung (Slingshot Aerospace)

11:15. Using Commercial Data and Advanced Models for GNSS Disruption Detection: Olivia Koski

11:35. The Global Situational Awareness Capability of the SDA Tranche 1: Edward Powers, SDA/Aerospace Corp.; Gregory Weaver, SDA/JHUAPL

Alternate Presentations:

1. High Bandwidth Processing and Analysis of GPS C/A Chipshapes using a High Gain Dish Antenna: Sanjeev Gunawardena, Sean Quiterio, Air Force Institute of Technology/ANT Center; Mark Carroll, Air Force Research Labs/RYWN

Attendee Lunch: 12:00 p.m. – 1:00 p.m., Pacific Ballroom, Sponsored by BAE Systems and Spirent Federal Systems
A10: Operational System Demonstrations 2
Date: Thursday, June 15, 2023
Time: 1:00 p.m. - 2:30 p.m.
Location: Ballroom A

Session Chairs:

![Dan Weinman](image1.jpg)  
**Dan Weinman**  
AFRL/DEVCOM C5ISR

![Paul Olson](image2.jpg)  
**Paul Olson**  
DEVCOM C5ISR


1:45. CBIP: Contextual Behavioral Intelligence Platform for Localization and Navigation in GPS Denied Environment.: Michael Park, Devu  
M. Shila, Unknot.id Inc.; Frank M Tucker, U.S. Army CCDC SC

Break: 2:30 p.m. - 3:00 p.m.
B10: Complementary PNT: Vision Aided/Optical Air

Date: Thursday, June 15, 2023
Time: 1:00 p.m. - 2:30 p.m.
Location: Ballroom B

Session Chairs:

Dr. Clark Taylor  
AFIT

Dr. Shahram Moafipoor  
Geodetics, Inc.

1:05. Vision-Based Navigation Integration and Testing on a UAS Army Manned Rotorcraft: Greg Reynolds and Clint Blankenship - U.S. Army Combat Capabilities Development Command Aviation & Missile Center; Patrick O'Leary, Jonathan Ryan, Matthew Castleberry, Clayton Graves, Faizan Zafar, Joshua Shannon, Kevin Betts, and Velislav Stamenov, Leidos


1:45. Crewed & Uncrewed Navigation in Denied & Contested Communications Environments: Chris Pickett, Aerocine Ventures / Vermeer

2:05. Quantifying Feature Richness of Aerial Imagery Through Learned Deep Embeddings: Dylan Bowald, Air Force Research Laboratory RYWN (PNT Branch); Isaac Ege, University of Dayton Research Institute

Alternate Presentations:


2. Improvements to Pose Estimation for AAR with YOLO and Perspective-n-Point: Dawson Friesenhahn, Derek Worth, Jeff Choate, Air Force Institute of Technology

Break: 2:30 p.m. - 3:00 p.m.
C10: Modeling and Simulation: CRPAs and Wavefront Simulators

Date: Thursday, June 15, 2023
Time: 1:00 p.m. - 2:30 p.m.
Location: Ballroom C

Session Chairs:

Jacob Jost  
The Aerospace Corporation
Tim Erbes  
Orolia Defense & Security

1:05. CRPA Analysis and Visualization: Laura Lusero, James Fitch, Kaleb Bodisch, Chris Denissen, Matt Oliver, LinQuest Corporation

1:25. Jammer Antenna Wavefront Simulator (JAWS): Steve Brezenski, Kyle Mason, Paul Osadchy, George Lee, Dan Dresher, Northrop Grumman; Denice Jacobs, Dana Howell, Air Force Research Laboratory

1:45. Real-Time Low-Latency HIL Trajectories on a Configurable Multi-Vehicle BroadSim Wavefront: Jaemin Powell, Orolia Defense & Security

2:05. Live Validation of an Anti-Jam-GPS receiver and Hardware in the Loop Test Environment at PNTAX 2022: David Post, Jeannie Ho, Randall Jaffe, L3Harris (IEC)

Alternate Presentations:

1. Fieldable Antenna Wavefront Simulator Next Generation (FANG): Andi Thomas, Josh Felde, Joe Fargey, George Lee, Dan Dresher, Northrop Grumman; Dana Howell and Denice Jacobs, Air Force Research Laboratory/RYWN

Break: 2:30 p.m. - 3:00 p.m.
D10: Inertial Measurement Unit (IMU) 1

Date: Thursday, June 15, 2023
Time: 1:00 p.m. - 2:30 p.m.
Location: Ballroom D

Session Chairs:
Patrick Renfroe
DEVCOM AvMC

Dr. Sergey A. Zotov
EMCORE

1:05. Dual-Use Navigation-Grade MEMS IMU: John Reinke, Patrick Duffy, Markus Gnerlich, Todd Braman, Lee Wienkes, Honeywell International

1:25. (U) New Solid-State Technology Based Compact IMU for Navigation of GPS Challenged Platforms: Alex Trusov, Daniel Rampacek, Farzin Dinyarian, Albert Choi, Cole Umemura, Lawrence Linick, Northrop Grumman; Scott David, Stephen Pethel, Brian Ireland, NTA; Patrick Renfroe, DEVCOM AvMC

1:45. Key Technology Choices for EMCORE's High Performance MEMS, FOG, and RLG Inertial Systems: Andrew Popp, Tom Monte, Doug Blischok, EMCORE

2:05. GE's MEMS-based Inertial Reference Unit for GPS-Denied Navigation Applications: Matthew Alberda, Jeremy Popp, David Lin, Robert Macdonald, GE

Alternate Presentations:


2. High-end, pure inertial navigation demonstration using Hemispherical Resonator Gyroscopes and MEMS accelerometers.: Alvah Aldrich and Brent Abbott, Orolia Defense Systems

Break: 2:30 p.m. - 3:00 p.m.
A11: Modeling and Simulation: LEO
Date: Thursday, June 15, 2023
Time: 3:00 p.m. - 4:30 p.m.
Location: Ballroom A

Session Chairs:

Dan Healey
JNWC
Dr. Thomas Blenk
US Army JPEO AA / DEVCOM AC

3:05. **Time-Phased Analysis of PNT Services for Warfighting Using the Digital Thread**: Greg Werhane, Drew Schafer, Dillon O’Neal, Infinity Systems Engineering


3:45. **ANSR: Alternative Navigation Simulated Receiver**: Jacob Stewart, Caleb Perry, Adam Simmons, Navigation Technology Associates; Edwin Hogan, DEVCOM AvMC; Dan Smith, JPEO A&A

4:05. **Testing of LEO PNT for Resilience in GNSS Contested Environments**: Paul Crampton, Roger Hart, Felix Krefft, Mark Holbrow, Spirent Federal & Spirent Communications; Lily Huang, Mounir Adjrad, Sandy Kennedy, Hexagon Autonomy & Positioning; Andrew Neish, Robert Grayson, Bryan Chan, Paul Tarantino, Brian Manning, Tyler Reid, Xona Space Systems

Alternate Presentations:

1. **An Implementation of Commercial LEO Navigation Signals into a Software-defined GNSS Simulator**: Kevin Gruhlke, Orolia Defense and Security; Andrew Neish, Robert Grayson, Tyler Reid, Xona Space Systems

2. **LEO Alternative RF Simulation**: Phillip Bonilla, Spirent Federal Systems
B11: Complementary PNT: Unique Applications
Date: Thursday, June 15, 2023
Time: 3:00 p.m. - 4:30 p.m.
Location: Ballroom B

Session Chairs:
Roger Fuller  
USCG Office of C5I Capabilities
Kevin Cammie  
USCG – Office of Navigation Systems

3:05. Lightweight / Soldier Friendly Survey System: Brian Fly, Joe Franiak, Darryl Larson, Northrop Grumman


3:45. Self Positioning off Targeted Anti GPS Emitters (SPOTAGE): Michael Ferguson and Carl Ito, Naval Information Warfare Center - Pacific

4:05. IFSAR Navigation Overview: Aaron Canciani, Leidos

Alternate Presentations:

1. Fast Multi-View 3D Reconstruction of Large Objects with an AprilTag Calibration: Joshua Krutz, Adam Nasi, Air Force Institute of Technology
C11: Modeling and Simulation: Other

**Date:** Thursday, June 15, 2023

**Time:** 3:00 p.m. - 4:30 p.m.

**Location:** Ballroom C

**Session Chairs:**

![Dr. Connor Brashar](image1.png)  
Dr. Connor Brashar  
*Sandia Laboratories*

![Aneesa Sonawalla](image2.png)  
Aneesa Sonawalla  
*Draper*

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**3:05. Analysis of PNT Resiliency Using Rapid Analysis & Prototyping Toolkit for Resiliency (RAPTR):** Kyle Fullerton, LMI


**3:45. Certification of the Navigation Suite Installed in U.S. Navy Destroyers through Simulation and Model Based Systems Engineering:** Timothy M. Walker, Teague K. Coonan, Naval Information Warfare Center Atlantic; Howard J. Kohl IV, Digital Modeling Naval Surface Warfare Center Dahlgren Division

**4:05. Unlocking the Benefits of Model-Based Systems Engineering (MBSE) and Digital Engineering (DE):** Stephen Miller, Victor Aguilar, MBSE Services at Strategic Technology Consulting

**Alternate Presentations:**

1. **High Performance vs Low Cost APNT Solutions:** Timothy Farber, Collins Aerospace
D11: Inertial Measurement Unit (IMU) 2
Date: Thursday, June 15, 2023
Time: 3:00 p.m. - 4:30 p.m.
Location: Ballroom D

Session Chairs:
Kenneth Morrison  ANELLO Photonics
Chris Tuozzolo  Draper

3:05. World Record Environmental Performance using Fiber Optic Gyro Technology: Marc Smiciklas, Glen Sanders, Honeywell International, Aerospace Advanced Technology; Kirk Peake, Scott David, Chris Roberts, Jeff Williams, NTA, Inc.; Patrick Renfroe, U.S. Army Combat Capabilities Development Command (DEVCOM) Aviation & Missile Center (AvMC)

3:25. Extended Indoor Navigation Using Battery-Operated Optical Gyroscope-Based System: Kirstin Schauble and Mike Horton, ANELLO Photonics

Exhibit Hall Information

Exhibit Hall Access
Exhibits are hosted in a public release environment in the Golden State Ballroom.
Conference registration and valid identification are required for entry.

Exhibit Hall Hours
Tuesday
10:00 a.m.- 7:00 p.m.
Exhibits Open
5:30 p.m. - 7:00 p.m.
Evening Exhibit Hours & Cash Bar

Wednesday
10:00 a.m.- 4:00 p.m.
Exhibits Open

Current Exhibitors
704th Test Group (Booth 104)
Acutronic USA Inc. (Booth 321)
Aevex (Booth 309)
Air Force Research Laboratory (Booth 100)
Anello Photonics (Booth 216)
Autonomy & Navigation Technology Center at AFIT (Booth 409)
BAE Systems (Booth 209)
Brandywine Communications (Booth 518)
CAST Navigation, LLC (Booth 207)
Center for Homeland Defense and Security (Booth 220)
Chelton Limited (Booth 408)
Collins Aerospace (Booth 208)
EMCORE Corporation (Booth 109)
ENSCO, Inc. (Booth 528)
exail (Booth 317)
Fibermetics LLC (Booth 218)
FIBERPRO, Inc. (Booth 221)
Fizoptika Malta - Sentechn Malta FP LTD (Booth 526)
Frequency Electronics, Inc. (Booth 319)
General Dynamics Mission Systems (Booth 416)
Gladiator Technologies (Booth 116)
GPS Networking Inc. (Booth 417)
GuideTech, Inc. (Booth 504)
Hexagon/NovAtel/Antcom (Booth 400)
Honeywell (Booth 506)
Ideal Aerosmith (Booth 124)
Inertial Labs (Booth 318)
Inside GNSS (Booth 421)
Integrated Solutions for Systems (Booth 407)
Jackson Labs Technologies, LLC, a Viavi Solutions company (Booth 308)
JAVAD GNSS (Booth 516)
Kearfott Corporation (Booth 217)
L3Harris (Booth 307)
LinQuest Corporation (Booth 118)
Lockheed Martin Space Systems Co (Booth 200)
Mayflower Communications Company, Inc. (Booth 406)
Microchip Technology Inc. (Booth 108)
NAL Research (Booth 107)
NAVSYS Corporation (Booth 420)
NavtechGPS (Booth 229)
NextNav (Booth 106)
NIWC Pacific (Booth 429)
Northrop Grumman (Booth 316)
Orolia Defense & Security (Booth 500)
Oscilloquartz (Booth 121)
PNI Sensor (Booth 120)
Psionic LLC (Booth 225)
Raytheon (Booth 206)
Septentrio (Booth 219)
SiTime (Booth 119)
Spirent Federal Systems (Booth 300)
Syntony GNSS (Booth 520)
UDINFO CORP. (Booth 328)
UHU Technologies LLC (Booth 418)
US Army CSISR Center (Booth 425)
Vector Atomic (Booth 419)
VectorNav Technologies (Booth 306)
Vermeer (Booth 324)
Xona Space Systems (Booth 117)

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