Joint Navigation Conference 2017
Sponsored by the Military Division of The Institute of Navigation

June 5-8, 2017
Dayton, Ohio

FOUO US ONLY Tutorials: June 5
FOUO US ONLY Technical Sessions: June 6-7
Dayton Convention Center

US ONLY Classified Sessions: June 8
Air Force Institute of Technology (AFIT)
on Wright-Patterson Air Force Base

Registration Hours
• Monday, June 5 11:00 a.m. - 5:00 p.m.
• Tuesday, June 6 7:30 a.m. - 5:00 p.m.
• Wednesday, June 7 7:30 a.m. - 5:00 p.m.

Free Wireless Internet Access
• On your device, open up a list of available networks
• Choose Harborlink Public; there is no password required
• Open up a browser window
• When your browser redirects to the DCC’s internet landing page, click “Log In”

ONSITE PROGRAM
# Technical Program Overview

## ROOMS:
- **ROOM 307-309**
- **ROOM 305**
- **ROOM 302-304**
- **ROOM 306**

## TRACK AND CHAIR:
- **Track A:** Jan Anszperger, Draper
- **Track B:** Paul Olson, US Army CERDEC
- **Track C:** Eddy Emile, GPS Directorate, USAF
- **Track D:** John Del Colliano, US Army CERDEC

### MONDAY, JUNE 5: TUTORIALS

<table>
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<tr>
<th>Time</th>
<th>Room 307-309</th>
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</thead>
<tbody>
<tr>
<td>1:30 p.m. – 3:00 p.m.</td>
<td>GPS/GNSS 101</td>
<td>Contemporary and Emerging Inertial Sensor Technologies</td>
<td>Introduction to GNSS Software Defined Receivers</td>
<td>Human and Machine Readable ICDs</td>
</tr>
<tr>
<td>3:30 p.m. – 5:00 p.m.</td>
<td>Quantum Position Navigation and Timing 101</td>
<td>GPS/INS Integration</td>
<td>Intro to ASICs and FPGAs</td>
<td>Precision Guided Munitions</td>
</tr>
<tr>
<td>Break: 3:00 p.m. – 3:30 p.m.</td>
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### TUESDAY, JUNE 6: FOUO SESSIONS

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<tr>
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<th>Room 305</th>
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<tbody>
<tr>
<td>8:30 a.m. – 10:00 a.m.</td>
<td>A1: Inertial Measurement Unit (IMU) 1</td>
<td>B1: Open Architectures (OAs)</td>
<td>C1: GPS Modernization</td>
<td>D1: Multi-Sensor Solutions for Guidance, Navigation and Control</td>
</tr>
<tr>
<td>10:45 a.m. – 12:15 p.m.</td>
<td>Plenary Session 1 (Room 103 on First Floor)</td>
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<tr>
<td>1:45 p.m. – 3:15 p.m.</td>
<td>A2: Atomic Clocks and Timing Applications 1</td>
<td>B2: Warfighter Requirements and Solutions</td>
<td>C2: GPS Constellation Performance</td>
<td>D2: Complementary PNT 1: Vision-Aided</td>
</tr>
<tr>
<td>Break in Exhibit Hall: 10:00 a.m. – 10:45 a.m., Sponsored by Systron Donner Inertial</td>
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<tr>
<td>4:00 p.m. – 5:30 p.m.</td>
<td>A3: Atomic Clocks and Timing Applications 2</td>
<td>B3: Operational System Demonstrations</td>
<td>C3: Multi-GNSS Receivers for Military Applications</td>
<td>D3: Complementary PNT 2: RF Aided (Non-GPS)</td>
</tr>
<tr>
<td>Exhibitor Hosted Reception in Exhibit Hall: 6:00 p.m. – 8:00 p.m.</td>
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### WEDNESDAY, JUNE 7: FOUO SESSIONS

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<tr>
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<tbody>
<tr>
<td>8:30 a.m. – 10:00 a.m.</td>
<td>A4: Inertial Measurement Unit (IMU) 2</td>
<td>B4: Application/Impact of GPS Technologies in the Homeland Critical Infrastructure</td>
<td>C4: MGUE</td>
<td>D4: Precise Navigation and Orientation</td>
</tr>
<tr>
<td>10:45 a.m. – 12:15 p.m.</td>
<td>Plenary Session 2 (Room 103 on First Floor)</td>
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<tr>
<td>1:45 p.m. – 3:15 p.m.</td>
<td>A5: Space and Satellite Applications 1</td>
<td>B5: Modeling and Simulation</td>
<td>C5: Military GPS Receivers and Military GPS Receiver Technology</td>
<td>D5: Surface and Sub-Surface PNT – NEW</td>
</tr>
<tr>
<td>Break in Exhibit Hall: 10:00 a.m. – 10:45 a.m., Sponsored by Systron Donner Inertial</td>
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<tr>
<td>4:00 p.m. – 5:30 p.m.</td>
<td>A6: Space and Satellite Applications 2</td>
<td>B6: Collaborative Navigation Techniques</td>
<td>C6: Military GPS/Antenna Technologies and Interference Mitigation</td>
<td>D6: PNT for Autonomy and Autonomy for PNT – NEW</td>
</tr>
</tbody>
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### THURSDAY, JUNE 8: CLASSIFIED SESSIONS HELD AT KENNEY HALL AT THE AIR FORCE INSTITUTE OF TECHNOLOGY ON WRIGHT-PATTERSON AFB (All Sessions are Classified, U.S. Only)

<table>
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<tr>
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<tbody>
<tr>
<td>7:30 a.m. – 8:25 a.m.</td>
<td>Security Checks and Morning Coffee</td>
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<tr>
<td>8:25 a.m. – 9:30 a.m.</td>
<td>Classified Plenary Session</td>
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<tr>
<td>9:30 a.m. – 9:50 a.m.</td>
<td>Break</td>
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<tr>
<td>9:50 a.m. – 11:50 a.m.</td>
<td>E8: NAVWAR 1</td>
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<tr>
<td>Lunch: 11:50 a.m. – 1:20 p.m.</td>
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<tr>
<td>1:20 p.m. – 2:50 p.m.</td>
<td>E9: Warfighter Cross-Talk Panel</td>
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<tr>
<td>2:50 p.m. – 3:10 p.m.</td>
<td>Break</td>
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<tr>
<td>3:10 p.m. – 5:10 p.m.</td>
<td>E10: NAVWAR 2</td>
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The Joint Navigation Conference is grateful for the support of:

- Boeing
- Northrop Grumman
- Harris
- Systron Donner Inertial

**JNC 2017 • June 5-8, 2017 • Dayton, Ohio • www.ion.org/jnc**
Conference Information

Conference Dress
Battledress uniform or business casual.

JNC Mobile Website
Point your mobile device’s web browser to m.ion.org to access JNC information such as:
- Real-time conference program
- Current exhibit hall map
- Local area info/weather
- Restaurant reservations

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Conference Proceedings
Official FOUO conference proceedings are scheduled for electronic 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.

Customized Schedule
Log in to the JNC website at www.ion.org/jnc to build a customized schedule of conference papers you wish to attend.

Marriott University of Dayton Shuttle
Complimentary shuttle bus transportation will be provided between the Dayton Convention Center and the Marriott University of Dayton. Buses will depart from the entrance of the Marriott on the hour and 30 minutes past the hour. Buses will depart from the Fifth St. entrance of the Dayton Convention Center at 15 and 45 minutes past the hour.

<table>
<thead>
<tr>
<th>Day</th>
<th>First Bus Departs Marriott</th>
<th>Last Bus Departs DCC</th>
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<tbody>
<tr>
<td>Mon. June 5</td>
<td>9:30 a.m.</td>
<td>5:45 p.m.</td>
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<tr>
<td>Tues. June 6</td>
<td>7:00 a.m.</td>
<td>8:45 p.m.</td>
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<tr>
<td>Wed. June 7</td>
<td>7:00 a.m.</td>
<td>5:45 p.m.</td>
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Classified Session Shuttle
Complimentary bus transportation will be provided from the Crowne Plaza and the Marriott University of Dayton to/from WPAFB on Thursday. Buses will depart the Marriott at 6:45 a.m., and the Crowne Plaza at 7:00 a.m., returning after the conclusion of the classified session. No midday shuttle will be offered.

Taxi Access to Wright Patterson AFB
Attendees wishing to take a taxi from the classified session to the airport should contact Charter Vans at 937-898-4043. This is the only taxi service cleared to enter Wright-Patterson Air Force Base. Taxis must be scheduled in advance, and a limited number are available. Book early to ensure that you do not encounter travel delays.

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 FOUO presentation is strictly prohibited.
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John Langer
The Aerospace Corporation

Program Chair
Neeraj Pujara
AFRL Sensors Directorate

Program Co-chair
Greg Graham
US Army AMRDEC

Track: A
Jan Anszperger
Draper

Track: B
Paul Olson
US Army CERDEC

Track: C
Eddy Emile
GPS Directorate, USAF

Track: D
John Del Colliano
US Army CERDEC

Tutorials Chair
Dr. Thomas Powell
The Aerospace Corporation

Bill Bolwerk
Naval Observatory

Kevin Lloggins
US Army

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Draper

Robert Greenlee
Joint Navigation Warfare Center

Capt Russell Holmes
USCG NAVCEN

Jalal Mapar
DHS Science and Technology Directorate

Joseph Schnecker
SSC Pacific

2018

JOINT NAVIGATION CONFERENCE

Military Navigation Technology
The Foundation for Military Ops

Jul 9–12, 2018
Tutorials: Jul 9
Show Dates: Jul 10–11

Hyatt Regency
Long Beach, California
Classified Session: Jul 12
The Aerospace Corporation

Sponsored by the Military Division of the Institute of Navigation

JNC 2017 • June 5-8, 2017 • Dayton, Ohio • www.ion.org/jnc
Tuesday, June 6
10:00 a.m. - 8:00 p.m. Exhibit Hall Open
12:15 p.m.-1:45 p.m. Lunch in Exhibit Hall
6:00 p.m. - 8:00 p.m. Exhibitor Hosted Reception

All conference refreshments will be served in the exhibit hall during hall hours on Tuesday and Wednesday.

Exhibit Hall Information

Tuesday, June 6
10:00 a.m. - 8:00 p.m. Exhibit Hall Open
12:15 p.m.-1:45 p.m. Lunch in Exhibit Hall
6:00 p.m. - 8:00 p.m. Exhibitor Hosted Reception

Wednesday, June 7
10:00 a.m. - 4:00 p.m. Exhibit Hall Open
12:15 p.m.-1:45 p.m. Lunch in Exhibit Hall

JNC Conference Events
Tuesday, June 6
Informal Lunch with Exhibitors:
12:15 p.m. - 1:45 p.m., Exhibit Hall
This event is included in the price of a full registration.
Exhibitor Hosted Reception:
6:00 p.m. - 8:00 p.m., Exhibit Hall
Join exhibitors as they host an evening of information and cuisine. 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 7
Informal Lunch with Exhibitors:
12:15 p.m. - 1:45 p.m., Exhibit Hall
This event is included in the price of a full registration.

Thursday, June 8
Informal Lunch for Attendees of Classified Sessions:
12:10 p.m. - 1:40 p.m., AFIT
This event is included in the price of a full registration, or a Thursday single-day registration.
Tutorials, Monday, June 5

1:30 p.m.–3:00 p.m.

All tutorials will be held in an FOUO US ONLY environment. Tutorials are included in a full registration or Monday single day registration.

GPS/GNSS 101 (Room 307-309)

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 the director of the Autonomy and Navigation Technology (ANT) Center at the Air Force Institute of Technology, where he is also a professor of electrical engineering. He has been involved in navigation-related research for over 25 years, has published over 160 navigation-related conference and journal papers and taught 50 navigation-related short courses to over 2600 students in many different organizations. He is the recipient of numerous awards, has served in a number of positions within the ION, currently ION president, and is an ION Fellow. He received his PhD in Geomatics Engineering from the University of Calgary and MS in Aeronautical/Astronautical Engineering from MIT.

Contemporary and Emerging Inertial Sensor Technologies (Room 305)

This course will present an overview of current state-of-the-art inertial navigation technologies with an emphasis on contemporary and emerging inertial sensor designs. A general overview of inertial navigation principles will be presented, followed by a discussion of current gyroscope and accelerometer instruments. The sensor discussion will initially focus on the recent developments in MEMS-based designs and how MEMS technology is revolutionizing the inertial guidance navigation and control (GN&C) industry. Current industry trends will be discussed along with examples of MEMS inertial technology in the commercial, military and space sectors, including advanced systems which integrate inertial MEMS with GPS.

New developments in inertial instrument design will follow with discussion of how advanced microfabrication methods, new solid state optical component developments and cold atom interferometry are being exploited in the next generation of precision gyro and accelerometer designs.

Suitable for experienced inertial instrument practitioners, it will also be of interest to novice developers as it will cover an overview of basic inertial sensing principles, and detailed discussion of gyroscope and accelerometer designs. This course will appeal to R&D, systems and manufacturing engineers, managers and executives, and will conclude with a discussion on the future direction of advanced inertial technologies.

Dr. J.P. Laine is the Division Leader for Positioning, Navigation and Timing (PNT) at Draper where he leads the development of advanced PNT technology solutions, as well as optical sensor systems, with a specific focus on rapid implementation of novel technologies into new system concepts. Dr. Laine has held technical leadership roles on a variety of programs related to PNT, imaging, and free-space/guided-wave optics. Dr. Laine is the author of many scientific papers and holds several patents in the field of optical sensing.

Introduction to GNSS Software Defined Receivers (Room 302-304)

This tutorial starts by covering the fundamentals of GNSS receiver operation and their practical implementation using state-of-the-art RF and digital signal processing technologies. The concept of a GNSS software defined receiver (SDR), its pros and cons and implementation are covered next. We will then examine technical requirements for military GNSS SDRs for current and emerging applications. The course will conclude by examining the features, capabilities and notional architectures of military GNSS SDRs based on these requirements.

Dr. Sanjeev Gunawardena is a Research Assistant Professor of Electrical Engineering with the Autonomy & Navigation Technology (ANT) Center at AFIT. His research interests include RF design, digital systems design, high performance computing, software-defined radio (SDR), and all aspects of GNSS receivers and associated signal processing. Dr. Gunawardena earned B.S. in engineering physics, B.S.E.E., M.S.E.E. and Ph.D. in electrical engineering from Ohio University.

Human and Machine Readable ICDs (Room 306)

This tutorial looks to provide tools for designing, building PNT systems in the current open-architecture focused environment. Currently, most Interface Control Documents (ICD) provided by PNT sensor vendors (or developed by the government as a specification for communicating with a specific platform) are delivered as a human-readable document, which may leave room for interpretation. Using examples from the DARPA All Source Positioning and Navigation effort, as well as the Open Mission Systems and Future Airborne Capability Environment (FACE), this tutorial will outline best practices for representing and interchanging PNT observables in a manner that is still human-readable, but can also be used in an automated code generation toolchain to build an implementation of an open architecture. In this tutorial, we will adapt a legacy ICD (ICD-GPS-153) to a notional human/machine readable format, and generate an open architecture that captures data from a legacy sensor and adapts it to an open PNT architecture being used for research by the Air Force Research Laboratory.

Dr. Donald Venable is currently an Electronics Engineer in the Navigation and Communications branch of the Air Force Research Laboratory Sensors Directorate. His primary research areas are GPS-denied navigation, estimation theory, and enabling technologies such as open architectures. Don received his PhD from the Air Force Institute of Technology in 2016, where his research implemented a camera-based airborne navigation system that was capable of providing GPS-quality position estimates in a challenged environment. Don was also a Subject Matter Expert on the DARPA All Source Positioning and Navigation effort, and helped design and implement an open architecture for complementary PNT technologies.

Break: 3:00 p.m. - 3:30 p.m.
Tutorials, Monday, June 5

3:30 p.m.–5:00 p.m.

All tutorials will be held in an FOUO US ONLY environment. Tutorials are included in a full registration or Monday single day registration.

Quantum Position Navigation and Timing 101 (Room 307-309)

This tutorial will delve into ideas from quantum mechanics that hold great promise for improved position, navigation and timing accuracy. We will cover cold-atom physics and applications in detail, as well as challenges to creating cold-atom based PNT devices such as inertial navigation systems and advanced atomic clocks. This tutorial will also cover relevant advances in photonics, especially the frequency comb, to illustrate how lasers are changing the landscape for tomorrow's PNT solutions.

Dr. John H. Burke received his PhD in 2010 from University of Virginia in Atomic Physics, for developing a proof-of-principle gyroscope using coherent matter waves sourced from a Bose-condensed, laser-cooled source. He has worked at the Air Force Research Laboratory's Space Vehicles Directorate ever since, working on a combination of cold-atom inertial navigation and optical atomic clocks. The latter topic utilizes advanced photonic devices such as frequency combs to create very stable, low-phase-noise microwaves for a variety of applications.

GPS/INS Integration (Room 305)

This tutorial demonstrates the rapid development of an integrated GPS/INS filter. In order to do so we will utilize the Scorpion software suite, a freely available open-source software package consisting of modular and re-useable components for navigation systems. We begin by building a simple EKF-based loosely-coupled GPS/INS filter with interchangeable sensor data sources. Next, we will swap out the loosely-coupled integration for a tightly-coupled solution, demonstrating the pluggability of the filter's algorithms. Finally, we will show how to leverage advanced buffering and networking Scorpion components to build a real-time filter that processes data live.

Dr. Kyle Kauffman is a Research Assistant Professor at the Air Force Institute of Technology. He received a BS in Computer Engineering and an MS in Computer Science from Miami University, and a PhD in Electrical Engineering from the Air Force Institute of Technology. His current research interests include alternative navigation sensors, sensor fusion, and algorithm efficiency.

Intro to ASICs and FPGAs (Room 302-304)

This course will provide attendees with an introduction into Application Specific Integrated Circuits (ASICs) and Field Programmable Gate Arrays (FPGAs) and their use in Military GPS User Equipment (MGUE). It will introduce students to common terminology used by ASIC and FPGA engineers, and will offer an understanding of the trade space in determining whether an ASIC or FPGA should be selected. Discussion will include a high-level overview to ASIC/FPGA design methodology and milestones. The class will provide a survey of available options for ASIC and FPGA technologies available in the MGUE and space environments, and will deliver insight into the trust and assurance focused requirements that impact microelectronics design.

Christine Rink is a member of the Aerospace Corporation's Engineering Technology Group, providing microelectronics focused support, including development and anomaly resolution, to a wide variety of DoD programs. She has worked in the development and assessment of microelectronics for 20 years. She has developed commercial ASICs for industries including disk drives, networking and cellular devices. She has developed rapid lifecycle development and design flows, and has defined standards for development of ASICs and FPGAs that are used as contractual compliance documents. Ms. Rink holds a BS in Biomedical and Electrical Engineering and a MS in Electrical Engineering from the University of Southern California.

Precision Guided Munitions (Room 306)

This presentation provides a history of precision guided munitions (PGMs) for both air and ground launched applications. Specifically, this tutorial will examine the evolution of navigation methods and their unique challenges for the PGM application.

Dr. Sultan Mahmood is the Subject Matter Expert (SME) for GPS/INS Navigation and Technologies for the USAF Armament Directorate where he provides expert technical engineering advice, guidance and direction in the areas of GPS and inertial navigation for all the weapons and test/training range programs in the Air Armament Center (AAC), and AFRL. He is currently working on projects to integrate M-Code GPS capability into AF weapons and aircraft.
Tuesday, June 6
8:30 a.m. - 10:00 a.m.

Session A1: Inertial Measurement Unit (IMU) 1 - Room 307-309

Alternate
1. A Silicon Photonic Integrated Resonant Accelerometer: S. Bramhavar, D. Kharas, W. Loh, and P. Juodawlkis, MIT Lincoln Laboratory

Session B1: Open Architectures (OAs) - Room 305
8:35 Resilient EGI Prototyping Initiative: J. Campbell, AFRL/RYWN; C. Garrett, AFLCMC/EZAC; J. Hebert, AFRL/RYWN
9:15 Field Demonstration of Plug and Play Navigation System Using Scorpion and Smart Sensors/Cables: K. Kauffman ANT Center/VRA; D. Marietta, ANT Center/MacC; J. Krese, ANT Center/CAL; M. Veth, ANT Center/VRA; R. Patton, ANT Center/CESI; J. Gray, J. Raquet, ANT Center; A. Schofield, U.S. Army

Alternate

Session C1: GPS Modernization - Room 302-304
8:35 GPS IIR-M Modernized Capabilities and Testing: W.A. Marquis, Lockheed Martin Space Systems Company
8:55 GPS III Modernized Space Segment: M. Crews, C. Frey and S. McMurtry, Lockheed Martin
9:15 An Advanced Maintenance Model for GPS Modernization: S. Pentecost and M. Reith, USAF AETC AFIT/ENG

Alternate
1. Continuous Phase Modulation for GPS Codes: P.S. Kossin, Harris Corporation

Session D1: Multi-Sensor Solutions for Guidance, Navigation and Control - Room 306
8:55 Low Bandwidth Representation for Cross-Platform Localization: C. Schutz, C. Abriola, J. Hardy, J. Douglas, Systems & Technology Research; J. Fisher III, Massachusetts Institute of Technology; M. Elders, Air Force Research Laboratory
9:35 Raytheon GAINS-II Receiver for MALD: D. Gieseking and J. Fleming, Raytheon

Alternate
1. Automated Aerial Refueling Flight Testing and Data Collection Engineering: N. Seydel and S. Nykl, Air Force Institute of Technology
2. World Magnetic Model Capability Continuity: D. Mullaney, National Geospatial-Intelligence Agency

Break in Exhibit Hall: 10:00 a.m. - 10:45 a.m., Sponsored by Systron Donner Inertial
Tuesday, June 6

Session P1: Plenary Session 1 - Room 103
10:50  Mike Emerson: Director, Marine Transportation Systems, USCG
11:30  Kevin Coggins: SES, PNT Program Manager, US Army

Lunch in Exhibit Hall: 12:15 p.m. - 1:45 p.m.

Receive up to 25 Complimentary Paper Downloads Each Month
The Institute of Navigation’s (ION) database has more than 10,000 highly-specialized technical papers, proceedings from Institute of Navigation technical conferences, and peer-reviewed articles related to the art and science and technology of positioning, navigation and timing.

www.ion.org
Tuesday, June 6

1:45 p.m. - 3:15 p.m.

**Session A2: Atomic Clocks and Timing Applications 1 - Room 307-309**

1:50 Flight Test Results for Clock Steering Using Frequency Estimates from GPS Carrier Phase Processing: L. Boehnke, Microsemi, T.Q. Nguyen, AFRL/RYWN; F. van Graas, Ohio University; E. Byrne, Microsemi; P. Howe, MBO Partners

2:10 Pioneering Two-way Time Transfer Embedded within Communication Modems: N. Adams, G. Weaver, W. Millard, O. Okusaga, E. Adles, D. Caughran, Johns Hopkins University/APL

2:30 Precision Time and Position Transfer Over Tactical Data Links: C. Obranovich, Raytheon BBN Technologies


Alternate


**Session B2: Warfighter Requirements and Solutions - Room 305**


2:30 Tactical Common Operational Picture, COP, for Pseudolite Command and Control, PL C2: J.S. Skinner, Booz Allen Hamilton; US Army CERDEC A PNT Pseudolite Program Office


Alternates

2. Integrating GPS Modernization with Legacy Architecture: R. Horton, GPS Source, Inc.

**Session C2: GPS Constellation Performance - Room 302-304**

1:50 Some Investigations in the Impact of Earth Gravity Models and Geodetic Parameters on GPS Satellite Orbits: J.N. Markiel, National Geospatial-Intelligence Agency (NGA); J. Lundberg, E. Swift, Naval Surface Warfare Center; J. Berg, The Aerospace Corporation; C. Minter, J. Factor, NGA

2:10 Improved Prediction of GPS Satellite Clock Variations Based on Daily Repeat: K. Strandjord and P. Axelrad, University of Colorado Boulder

2:30 Improved Algorithm for On-Orbit GPS III Clock Correction: J.P. Janis and M.R. Jones, Harris Corporation


Alternates

1. GPS III L1, L2 and L5 TRIPLEXER: T.J. Wurth and C. Losey, NuWaves Engineering Ltd.
2. Including SVN49 in an Operational M Code Constellation: A. Tetewsky, Draper; W. Marquis, Lockheed Martin; J. Anszerperger and J. Ardini, Draper

**Session D2: Complementary PNT 1: Vision Aided - Room 306**

1:50 Statistical Predictive Rendering for Robust Six-degree of Freedom Object Tracking: M.J. Veth, Veth Research Associates, LLC


2:30 Aerial Visual-Inertial Odometry Performance Evaluation: D. Carson, Perduco/ANT Center; J. Raquet, Air Force Institute of Technology ANT Center; K. Kaufman, VRA/ANT Center


Alternate


Break in Exhibit Hall: 3:15 p.m. - 4:00 p.m., Sponsored by Harris
Tuesday, June 6

4:00 p.m. - 5:30 p.m.

Session A3: Atomic Clocks and Timing Applications 2 - Room 307-309


5:05 Superconducting Cavity Oscillator: K. Moran, A. Siripuram, E. Bozeman, T. Emery-Adleman, L. Lemay, SSC Pacific

Session B3: Operational System Demonstrations - Room 305

4:05 Testing a Jamming and Spoofing Sensor Network in Real Time: T. Erbes, Talen-X

4:45 TRX NEON Signal Mapper Operational System Demonstration: C. Politi and T. Young, TRX Systems

Session C3: Multi-GNSS Receivers for Military Applications - Room 302-304

4:05 GNSS Multipath Detection and Estimation with a Small Antenna Array: T. Ertan and M.L. Psiaki, K. Crofton, Virginia Tech

4:25 Robust Multi Constellation GNSS Carrier Phase Solution Using RANSAC: B. Tucker and Z. Zhu, East Carolina University

4:45 A New Architecture of Software Defined GNSS Anti-Spoofing Receiver with Guidance Database: K. Zhao, Emplicity

5:05 High Gain Remote GNSS Integrity Monitoring Using Chip Shape Analysis: E. Vinande, AFRL/RYWN; R. Armstrong, University of Dayton; S. Gunawardena, Air Force Institute of Technology; J. MacDonald, AFRL/RYWN

Alternate

1. Physics-Based Data-Consistent Multi-Frequency GNSS Simulators for Strong Equatorial Ionospheric Scintillation Signals: Y. Jiao, D. Xu, Colorado State University; C. Rino, Colorado State University & Boston College; C. Carrano, Boston College; Y. Morton, Colorado State University

Session D3: Complementary PNT 2: RF Aided (Non-GPS) - Room 306


4:45 An Alternative Source of Timing and Location using the Low Earth Orbit Iridium Satellite Constellation: J.V. Cordaro, D. Shull, DOE Savannah River National Lab; G. Gutt, M. O’Connor, Satelles

5:05 Multi-Function Tactical Data Links and Communication Receivers for PNT: G.A. McGraw, G. Reyes, A. Stratton, Rockwell Collins

Alternate

1. The Augmented Positioning System (APS) for PNT in GPS Challenged Environments: Overview and Field Test Results: J. Carlson, M. Alles, J. Kennedy, Echo Ridge, LLC; M. Smearehead, Air Force Research Laboratory


Exhibitor Hosted Reception in Exhibit Hall: 6:00 p.m. - 8:00 p.m.
Wednesday, June 7
8:30 a.m. - 10:00 a.m.

Session A4: Inertial Measurement Unit (IMU) 2 - Room 307-309

8:35 IWOG-Integrated Waveguide Optical Gyroscope: R. Yahalom, J. Moody, InFiber Technology; W.K. Bischof, M. Kouchmir, Gener8
9:15 GPS-Denied IMU/INS for Missiles, Guided Projectile and UAV Applications: M. Tanenhaus, Tanenhaus and Associates; T. Geis and M. Slavin, Consultants
9:35 1.5 cu. in. Tactical-Grade IMU Development for Medium Caliber Munitions: D. Endean and B. Roberts, Honeywell International

Alternates
1. SDI600, Industry’s 1st “All-Causes” Tactical-Grade MEMS IMU for Weapons Systems: M. Williams and D. Hoyh, Systron Donner Inertial

Session B4: Application/Impact of GPS Technologies in the Homeland Critical Infrastructure - Room 305

8:35 Secure GPS Data for Critical Infrastructure and Key Resources: Cross Layered Integrity Processing and Alerting Service: S. Lewis, L. Maynard, C.E. Chow, University of Colorado at Colorado Springs; D. Akos, University of Colorado at Boulder
9:15 The Role of STL in Protecting Critical Infrastructure: L. Perdue and D. Sohn, Spectracom

Alternates
1. Airport Surveillance: Tracking Airplane Runway Movements with LiDAR Sensors: D.A. Grejner-Brzezinska, C. Toth, Z. Koppanyi, The Ohio State University

Session C4: MGUE - Room 302-304

8:35 Modernized PGM Receiver Performance and Test Results: A. Mulvoy, PEO Ammo; J. Miller, L3 Interstate Electronics Corporation
8:55 2025: R. Bieniak, L3 Interstate Electronics Corporation
9:15 Raytheon MGUE Development: J. Choi and J. Fleming, Raytheon, Space and Airborne Systems
9:35 Resiliency Approach for MGUE: C. Popeck and J. Nielson, Rockwell Collins

Alternates
1. Physical and Operational Constraints on GPS M-code Navigation Message Size and Broadcast Frequency: J. McCanless and T. Tu, Booz Allen Hamilton

Session D4: Precise Navigation and Orientation - Room 306

8:35 Centimeter-level Vehicular Trajectory Estimation in RF-Denied Environments: M.J. Veth, Veth Research Associates, LLC and A. Soloviev, QuNav, LLC

Alternates
2. Proper Calibration of the Simulated GPS RF Signal Environment: J. Bencke, SPAWAR System Center Pacific

Break in Exhibit Hall: 10:00 a.m. - 10:45 a.m., Sponsored by Systron Donner Inertial
Wednesday, June 7

10:45 a.m. - 12:15 p.m.

Session P2: Plenary Session 2 - Room 103

10:50 Col Edward Hospodar: Chief, GPS Directorate's User Equipment Division, USAF
11:30 CAPT Sean Memmen: Deputy Navigator of the Navy, PNT Branch, Navy

Lunch in Exhibit Hall: 12:15 p.m. - 1:45 p.m.

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Wednesday, June 7 1:45 p.m. - 3:15 p.m.

Session A5: Space and Satellite Applications 1 - Room 307-309

1:50 An Overview of Air Force Research Laboratory Space Vehicles Directorate PNT Portfolio: D.C. Chapman, Air Force Research Laboratory, Space Vehicles Directorate

2:10 An Overview of Air Force Research Laboratory Advanced GPS Technology Developments for Future GPS Satellite Payloads: M. Naudeau, M. Finical, K. Slimak, AFRL

2:30 GPS III Signal Availability at Geosynchronous Orbits as a Function of Beamwidth: D.J. Goldstein, J.T. Gillis and M.V. Dixon, The Aerospace Corporation

2:50 Robust GNSS Receiver Carrier Tracking for Receivers on LEO Satellites Traveling inside Ionosphere Plasma Structures: D. Xu, Y. Morton, Colorado State University

Alternate

1. Envelope Tracking Power Amplifier and L1 & L2/L5 Diplexer for GPS III: B. Ghajari, T. Nakatani, J.J. Yan, D.F. Kimball, H. Ghajari, MaXentric Technologies LLC.

Session B5: Modeling and Simulation - Room 305


2:30 UAS Payload Simulation Tool: T. Pitt, G. Reynolds, US Army AMRDEC; B. Thompson, Dynetics; A. Simmons, J. Jones, L. McCrain, NTA Inc.


Alternate

1. Quantifying the Effect of Boom Occlusion on Stereo Vision Relative Positioning for Automated Aerial Refueling: Z. Paulson and S. Nykl, Air Force Institute of Technology

Session C5: Military GPS Receivers and Military GPS Receiver Technology - Room 302-304


2:10 Exploitation of Multi-Band Split-Spectrum Signals for Direct Acquisition: C. Yang, A. Soloviev, QuNav; J.C. Ha, AFRL/RYWN


Alternate


Session D5: Surface and Sub-Surface PNT - Room 306

1:50 Navy PNT Overview: S. Memmen, Navy

2:10 Navy PNT Reference Architecture, Performance Requirements and GPS Modernization: P. Hanrahan and A. Nascimento, SSC Pacific

2:30 GPNTS Update: J. Winny, PMW/A 170; C. Pinkelman, SSC Pacific

2:50 STELLA and Other Celestial Navigation Products and Services of the USNO: J. Bartlett, N. Oliversen, G. Kaplan, and W. Puatua, US Naval Observatory

Alternate


Break in Exhibit Hall: 3:15 p.m. - 4:00 p.m., Sponsored by Northrop Grumman
Wednesday, June 7  
4:00 p.m. - 5:30 p.m.

**Session A6: Space and Satellite Applications 2 - Room 307-309**

**4:05 Flexible Satellite Navigation Payloads:** K. Slimak, Air Force Research Laboratory; N.P. DeVilbiss, ATA Aerospace; J.M. Anderson, Canyon Consulting

**4:25 Effective 12 dB Gain in Contested Regions by Adjusting On-Orbit Pseudorange Characteristics:** M. Naudeau, J. Hinks, Air Force Research Lab, Space Vehicles Directorate; T. Luke, University of Colorado

**4:45 On-Orbit Re-Programmable Digital Waveform Generator for Modernization of Future GPS Payloads:** A. Ho, Boeing Satellite Developmental Center

**5:05 Wideband PNT OORDWG for the Next Generation Space Segment:** J. Koeniger and D. Andaleon, Innoflight; C. Mosley, Consultant; K. Carroll, AFRL/RV

**Alternates**
2. Solution to the Optimum Pocet Constellation for GNSS Waveforms: D. Le Fevre, Saphir Electronics; J. Koeniger, Innoflight.com; K. Carroll AFRL/RV

**Session B6: Collaborative Navigation Techniques - Room 305**


**4:45 NetAssure Demonstration Results: Providing High-Integrity Navigation Solutions in the Presence of GPS Interference:** D. Hodo, W. Travis, Integrated Solutions for Systems; D. Bevly, Auburn University; K. Johnson, US Army CERDEC

**5:05 An Evaluation of the PeerAppear Framework for Large-Scale Collaborative Image-Based Localization:** A.J.M. Compton and J.M. Pecarina, Air Force Institute of Technology

**Session C6: Military GPS/Antenna Technologies and Interference Mitigation - Room 302-304**

**4:05 A Novel, Light-Weight, Broadband, Multipath-Rejection GNSS Antenna Design:** B. Clark, Raytheon Co.; C-C. Chen, The Ohio State University; S.E. Bucca, P.A. Zidek, BerrieHill Research Corporation

**4:25 Multi-platform Anti-jam GPS Navigation Antenna (MAGNA):** W. LeComte, Mayflower Communications Company, Inc.; W. Joo, SSC Pacific


**5:05 Adaptive Antenna Electronics for All GNSS Receivers:** I.J. Gupta, J.D. Kuric, The Ohio State University; J.M. Hebert, AFRL/RYWN

**Alternates**
2. RF-Digital Anti-Jam (AJ) GPS ASIC: D. Howell, AFRL/RYWN; R. Siferd, S. Ren, M. Emmert and G. Lee, RBS

**Session D6: PNT for Autonomy and Autonomy for PNT - Room 306**

**4:05 A Behavior-Based Control Architecture for Autonomous Aerial Vehicles:** T. Bodin, J. Bindewald, D. Jacques, G. Peterson, Air Force Institute of Technology


**4:45 Autonomous Range-Only Terrain Aided Navigation:** T.L. Caylor, J.T. Landon, J.G. Geier, Raytheon Missile Systems

**5:05 Aircrew Situational Awareness in GPS-denied Operations (ASIAGO) Presentation:** W. Deike, AFRL/RYWN; T. Pestak, The Perduco Group; J. Hebert and J. Campbell, AFRL/RYWN

**Alternates**
2. Small Fixed-wing Aerial Positioning Using Inter-Vehicle Ranging Combined with Visual Odometry: B. Fain, J. Raquet, Air Force Institute of Technology (AFIT), ANT Center; J. Gray, MacB/ANT Center; D. Jacques, AFT, ANT Center; R. Patton, CESI/ANT Center
Thursday, June 8

8:25 a.m. - 5:10 p.m.

US Only Classified Session Agenda: Kenney Hall, Air Force Institute of Technology, WPAFB

Security Checks and Morning Coffee: 7:30 a.m. - 8:25 a.m.

**Session E7: CLASSIFIED PLENARY SESSION**

*Time: 8:25 a.m. - 9:30 a.m.*

8:25 Opening Remarks: Benjamin Wash, Joint Navigation Warfare Center

8:30 Dr. Brian Teeple: Acting Department of Defense Deputy Chief Information Officer for Command, Control, Communications and Computers and Information Infrastructure Capabilities

9:20 Recent Threats and Developments - A Status Briefing: Fay Spellerberg, Director of Staff, Joint Navigation Warfare Center

**Break:** 9:30 a.m. - 9:50 a.m.

**Session E8: NAVWAR 1**

*Time: 9:50 a.m. - 11:50 a.m.*

9:50 Multiple Element Jamming Mitigation Results using a Modernized GPS Receiver with Integrated Space-Time Adaptive Processing: G. Watson, I. Johnston, and G. Sada, L3-Interstate Electronics Corporation

10:10 Counter Unmanned Aerial Systems Solutions: R. Earwood, Joint Navigation Warfare Center (JNWC); N. Rakoczy, A. Humphrey, NAVAR, JNWC; R. Kaczanowski, JNWC; J. Fontanella, M. Russell, SRC


11:10 Heavyweight Match: EGI vs. ET: D. Howell, D. Jacobs, AFRL/RYWN; J. Neu and N. Boss, AFMC AFLCMC/EZAC


**Lunch:** 11:50 a.m. - 1:20 p.m.

**Session E9: Warfighter Cross-Talk Panel**

*Time: 1:20 p.m. - 2:50 p.m.*

An interactive discussion between the audience and a panel of warfighters who have had recent operational experience that informs the community on how to better formulate military PNT systems. Warfighters will make an opening statement that addresses the nature of their specialty or how current PNT systems are meeting the needs of their missions; be prepared to be “wowed” by film and photographs of their experiences. After the opening statements, questions will be taken from the audience.

**Break:** 2:50 p.m. - 3:10 p.m.

**Session E10: NAVWAR 2**

*Time: 3:10 p.m. - 5:10 p.m.*

3:10 NAVWAR Sensor – Early Test Results: D. Howell and D. Jacobs, AFRL/RYWN

3:30 Gypsy Lightning 16-01 PNT Analysis: G. Klaus, O. Kami Okusaga, E. Adles, D. Stark, M. Sommerville, D. Chamberlin-Long, JHU/APL; W. Vincent, JNWC; C. Laliberte, B. Leisge, NUWC; R. Hill, COMSUBPAC / Undersea Warfare Development Center (UWDC); G. Ramsey, Northrop Grumman


4:10 Analysis of GNSS Signal Chip Shape Asymmetries: S. Stafford and M. Sommerville, The Johns Hopkins University/APL


Clearances and Attending the Classified Sessions

FOUO US ONLY SESSIONS
(Monday, June 5 - Wednesday, June 7)

All sessions and exhibits will be held in an US ONLY FOR OFFICIAL USE ONLY (FOUO) environment at the Dayton Convention Center. To attend you must provide the following:
1. Proof of US citizenship
2. Visit Request including a Need-to-Know Statement (Need-to-Know not required if using JPAS)
3. Photo ID
4. JNC Conference Badge and Paid Registration

Visit Request and Need-to-Know Statements:

All Visit Requests must be verified by the JNWC Security Office. Prospective attendees must submit their Visit Authorization Requests through JPAS to JPAS SMO: STRATJNWC. JPAS visit request POC field must be filled with “JNC 2017” instead of a POC name. For your convenience, if JPAS is not an option, a Visit Request Form can be found at www.ion.org/jnc.

Fax all FOUO Visit Requests to:
Mark Correll, Security Specialist
JNWC/JFCC SPACE/USSTRATCOM
1351 Wyoming Blvd SE, Bldg 20201
Kirtland AFB, NM 87117
Phone: 505-853-1166; Fax: 505-853-6677
Email: mark.correll.2.ctr@us.af.mil

CLASSIFIED US ONLY SESSIONS
(Thursday, June 8)

The classified sessions will be held in a CLASSIFIED US ONLY environment at the Air Force Institute of Technology (AFIT) on Wright-Patterson AFB. Information required for clearances is as follows:
Classification: Secret
Visit Type: One Time
Request Type: Facility Invitation
Request Category: Government
Anticipated Level of Classified Information: Secret
Visit Dates: 8 June 2017
Purpose of Visit: Attend the 2017 Joint Navigation Conference, Dayton, Ohio
Facility Information: Kenney Hall, Air Force Institute of Technology on Wright-Patterson AFB
Way to Contact: E-mail
Name: Joint Navigation Warfare Center/USSTRATCOM
Program/Agreement: Navigation Warfare MOU
Knowledgeable US POC:
Mark Correll, Security Specialist
JNWC/JFCC SPACE/USSTRATCOM
1351 Wyoming Blvd SE, Bldg 20201
Kirtland AFB, NM 87117
Phone: 505-853-1166; Fax: 505-853-6677
Email: mark.correll.2.ctr@us.af.mil

Accessing the Classified Session

Below are the options for accessing Wright-Patterson Air Force Base to attend the classified session on Thursday:

If you have a Common Access Card (CAC):
1. You may enter the base in a private vehicle.
2. You may utilize the conference-provided shuttle bus transportation to/from Wright-Patterson Air Force Base.

If you do not have a Common Access Card (CAC):
1. You may enter the base in a private vehicle, escorted by a CAC Card holder (preferably your government sponsor).
2. You may utilize the conference-provided shuttle bus transportation to/from Wright-Patterson Air Force Base.

Shuttle Buses: Complimentary shuttle bus transportation will be provided to and from the classified session in the morning prior to the start of the classified session, and in the evening at the conclusion of the classified session. No midday transportation will be provided. The shuttle bus will depart from the Marriott University of Dayton at 6:45 a.m., and from the Crowne Plaza at 7:00 a.m. Buses will depart from AFIT at the conclusion of the classified session at 5:30 p.m., and will drop off passengers first at the Crowne Plaza and then at the Marriott.

Driving Directions to AFIT from the Dayton Convention Center (10 miles):
1. Take US-35 East
2. Merge onto I-675 N toward Columbus
3. Take Exit 15 toward WPAFB Area B/ Col Glenn Hwy
4. Follow signs for WPAFB Area B
5. Proceed through Gate 22B
6. Take slight right onto Lopp Rd. W
7. Continue onto Hobson Way
8. AFIT is located at 2950 Hobson Way, Wright-Patterson Air Force Base, OH 45433

For attendees that choose to follow alternate routes: Please note that Gate 19B (National Gate Road) will be closed June 8. Gate 16B, the gate located by the Wright Brothers Memorial Park on Kaufman Avenue near Route 444, will be open Monday through Friday from 6:00 a.m. - 9:00 a.m., for inbound traffic only. Gate 1B (Springfield Street) and Gate 22B (Col. Glenn and I-675) are other alternate gates that can be used to enter Area B.
Systron Donner introduces the industry’s first “All-Causes” tactical-grade SDI600 MEMS IMU. The SDI600 features a breakthrough High-Bandwidth (HBW) gyro-design that is proven to significantly reduce vibration sensitivity and improve 1°/hr gyro & 1mg accel bias stability under >25Grms captive carry environments. Designed specifically for easy integration into missile and munition applications, the SDI600 is shorter, delivers full performance in 1 second, and features industry standard serial communication, TOV sync, and 95% BIT coverage. SDI600 is the better alternative to older generation optical RLG/FOG technologies.