



# JOINT NAVIGATION CONFERENCE

# 2021

Enhancing Dominance  
and Resilience for  
Warfighting and  
Homeland Security PNT




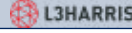




**August 24-27, 2021**

Northern Kentucky Convention Center  
Covington, Kentucky

## ONSITE PROGRAM

[ion.org/jnc](http://ion.org/jnc)

# Technical Program Overview

TRACK AND CHAIR:	Track A: John Del Colliano CCDC/CSISR	Track B: Dr. Keith McDonald The MITRE Corporation	Track C: Dr. Greg Reynolds US Army	Track D: David Wolfe US Coast Guard C3CEN
<b>TUESDAY, AUGUST 24: MORNING TUTORIALS AND AFTERNOON FEDCON - U.S. ONLY SESSIONS</b>				
8:30 a.m. - 10:00 a.m.	Resilient & Robust PNT Ballroom B	GPS/GNSS 101 Ballroom C	Introduction to SatNav SDRs using Python: Part 1 Ballroom D	CTS-153 Software Ballroom E
Refreshment Break: 10:00 a.m. - 10:30 a.m.				
10:30 a.m. - 12:00 p.m.	Integrity/Assurance of Navigation Systems Ballroom E	An Introduction to Cryptography with Attention to Navigation - Ballroom C	Introduction to SatNav SDRs using Python: Part 2 Ballroom D	D1a: NAVWAR: Counter PNT Ballroom B
Attendee Lunch: 12:00 p.m. - 1:00 p.m.				
1:45 p.m. - 3:15 p.m.	A1: Space and Satellite Applications, NTS-3 Overview - Ballroom E	B1: Collaborative Navigation Techniques Ballroom C	C1: Complementary PNT 1: Vision Aided Air Ballroom D	D1b: NAVWAR: Situational Awareness Ballroom B
Refreshment Break: 3:15 p.m. - 4:00 p.m., Sponsored By 				
4:00 p.m. - 5:30 p.m.	A2: Space and Satellite Applications Ballroom E	<b>NEW!</b> B2: PANEL: MGUE Integration Ballroom B	C2: Complementary PNT 2: LiDAR and Vision Aided Ground - Ballroom D	D2: Weapon Applications Ballroom C
5:30 p.m.	GAO Report on DOD Navigation – A conversation with the lead author. Sponsored by the Resilient Navigation and Timing Foundation - Ballroom B			
<b>WEDNESDAY, AUGUST 25: FEDCON - U.S. ONLY SESSIONS</b>				
8:30 a.m. - 10:00 a.m.	<b>NEW!</b> A3: Applications of Atomic Standards in DoD Time Transfer and Dissemination - Ballroom E	B3: Military GPS User Equipment Ballroom C	C3: Complementary PNT 3: Vision Aided Optical and RF/Stellar Ballroom D	D3: Navigating in Challenged Environments (e.g., Urban, Indoor and Sub-Surface Navigation) - Ballroom B
Refreshment Break: 10:00 a.m. - 10:45 a.m., Sponsored by 				
10:45 a.m. - 12:15 p.m.	A4: Novel Timing Technologies and Applications Ballroom E	B4: Multi-GNSS Receivers for Military Applications Ballroom C	C4: Complementary PNT 4: Naturally Occurring Measurement Sources – Including gravity, magnetic fields, lightning - Ballroom D	<b>NEW!</b> D4: PANEL: Rapid Agile Development and Manufacturing Ballroom B
Attendee Lunch: 12:15 p.m. - 1:30 p.m. - Event Center I				
1:45 p.m. - 3:15 p.m.	Plenary Session 1: Featuring Mr. William B. Nelson and Mr. Ray Chartier, Jr. - Ballroom B			
Coffee Break: 3:15 p.m. - 4:00 p.m., Sponsored by 				
4:00 p.m. - 5:30 p.m.	<b>NEW!</b> A5: Integrity and Assurance Ballroom E	B5: GPS Modernization Ballroom C	C5: Complementary PNT 5: RF Aided/SDR (Non-GPS) - Ballroom D	D5: NAVWAR: User Technologies Ballroom B
5:30 p.m. - 7:00 p.m.	Free Time in Exhibit Hall			
7:00 p.m. - 8:00 p.m.	Informal Barbecue Dinner, Event Center I			
<b>THURSDAY, AUGUST 26: FEDCON - U.S. ONLY SESSIONS</b>				
8:30 a.m. - 10:00 a.m.	<b>NEW!</b> A6: Reconfigurable SatNav Ballroom E	B6: PNT Open Systems Architecture 1 Ballroom C	C6: Modeling and Simulation Ballroom D	D6: Application/Impact of PNT Technologies in the Homeland Critical Infrastructure - Ballroom B
Refreshment Break: 10:00 a.m. - 10:45 a.m., Sponsored by 				
10:45 a.m. - 12:15 p.m.	A7: Operational System Demonstrations 1 Ballroom E	B7: PNT Open Systems Architecture 2 Ballroom C	C7: Inertial Measurement Unit (IMU) Ballroom D	<b>NEW!</b> D7: PANEL: National Critical Infrastructure Threat - Ballroom B
Attendee Lunch: 12:15 p.m. - 1:30 p.m.				
1:45 p.m. - 3:15 p.m.	Plenary Session 2: Featuring General David D. Thompson and Dr. Bradford Parkinson - Ballroom B			
Refreshment Break: 3:15 p.m. - 4:00 p.m. 				
4:00 p.m. - 5:30 p.m.	A8: Operational System Demonstrations 2 Ballroom E	<b>NEW!</b> B8: Software Defined Radios for PNT Ballroom C	C8: Autonomous Systems and PNT Ballroom D	D8: Antenna Technologies & Interference Mitigation for Robust PNT - Ballroom B
5:30 p.m.	ASPN Community Involvement Working Group - Ballroom B			
<b>FRIDAY, AUGUST 27: JNWC FACILITATED SESSIONS HELD AT NKYCC, BALLROOM B, CONFERENCE LEVEL (U.S. ONLY SESSIONS)</b>				
Refreshments: 7:30 a.m. - 8:30 a.m., Sponsored by 				
8:30 a.m. - 8:45 a.m.	Welcome - Ballroom B			
8:45 a.m. - 10:10 a.m.	E9: JNWC Facilitated Program: Keynote Address Featuring Major General DeAnna M. Burt - Ballroom B			
Refreshment Break: 10:10 a.m. - 10:50 a.m., Sponsored by 				
10:50 a.m. - 12:20 p.m.	<b>NEW!</b> E10: PANEL: Combatant Command Joint Urgent Operational Need (JUON): Warfighter Requirement and Solutions - Ballroom B			
Attendee Lunch • 12:20 p.m. - 1:50 p.m. - Event Center I				
1:50 p.m. - 3:20 p.m.	E11: PANEL: Warfighters			
3:20 p.m. - 3:40 p.m.	E12: JNWC Facilitated Program			
Refreshment Break: 3:40 p.m. - 4:10 p.m., Sponsored by 				
4:10 p.m. - 5:10 p.m.	E12: JNWC Facilitated Program (Continued)			



**ION Military Division Chair**  
John Langer  
*The Aerospace Corporation*



**ION Military Division Vice Chair**  
Jan Anszperger  
*Draper*



**Program Chair**  
Joseph Schnecker  
*NIWC Pacific*



**Program Vice-chair and Track: A**  
John Del Colliano  
*CCDC/CSISR*



**Track: B**  
Dr. Jacob Campbell  
*AFRL Sensors Directorate*



**Track: C**  
Dr. Greg Reynolds  
*US Army*



**Track: D**  
David Wolfe  
*US Coast Guard CSISC*



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*CCDC/CSISR*



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**Dr. Steven Lewis**  
*The Aerospace Corporation*



**Dr. Keith McDonald**  
*The MITRE Corporation*



**Dr. Madeleine Naudeau**  
*AFRL*



**Chad Pinkelman**  
*NIWC Pacific*

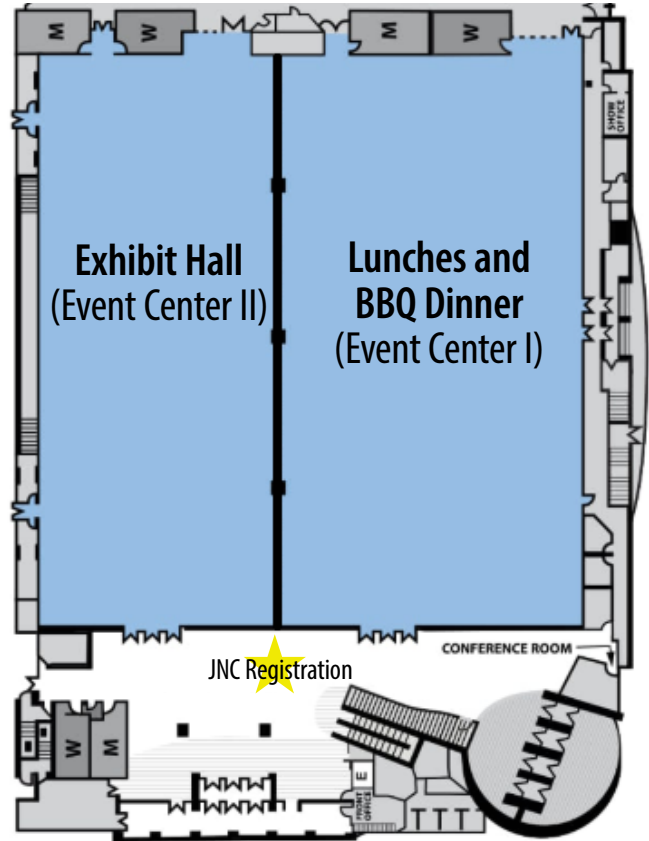


**Fay Spellerberg**  
*Joint Navigation Warfare Center*

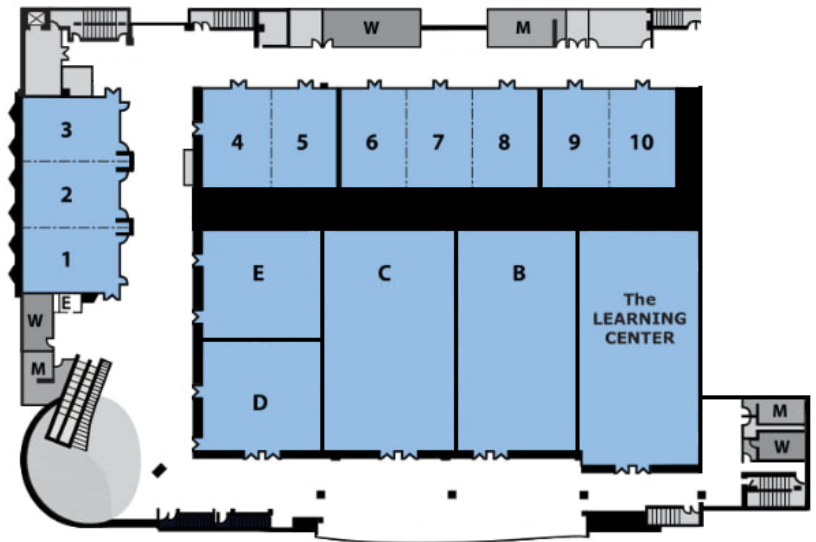


**Ben Wash**  
*Joint Navigation Warfare Center*

## Lower Level (First Floor)



## Conference Level (Third Floor)



# Conference Information

## Conference Dress

Battledress uniform or business casual.

## 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
- Current exhibit hall map
- Local area info/weather
- Restaurant reservations

Sponsored by:  **HEXAGON**



## Conference Proceedings

Electronic FEDCON conference proceedings are scheduled for distribution in September to all eligible conference participants. You will receive an emailed link 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 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 FEDCON presentation is strictly prohibited.

## Customized Schedule

Log into the JNC website at ion.org/jnc to build a customized schedule of conference presentations you wish to attend.

## Free Wireless Internet Access

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

**Network ID: NKYCC-Public**

**Password: No password needed**

Sponsored by:



**HEXAGON**



## Security Note

**Technical Session Rooms:** JNC technical sessions at the NKYCC are hosted in a U.S. Only, Federal Employees and Contractors Only (FEDCON), environment. Photography, audio or video recording of any FEDCON presentation is strictly prohibited. Entry is restricted. Conference badges are controlled, will not be replaced, and must be visible at all times. Photo ID may be requested at any time. Conference badges must be visible at all times.

**Exhibit Hall:** The JNC exhibit hall will be accessible by all conference participants, exhibiting organizations, and related organizations who possess a valid conference badge, as well as accompanying guests during the exhibitor-hosted reception. All materials displayed in the exhibit hall shall be publically releasable (Publicly Releasable AFTER Review). All JNC participants shall restrict all conversations to those permissible in the public domain.

# Clearance Information

## FEDCON U.S. ONLY SESSIONS

(Tuesday, August 24 - Friday, August 27)

All sessions will be held in a Federal Employee and Contractors Only (FEDCON) environment at the Northern Kentucky Convention Center. To attend you must provide the following:

1. Proof of U.S. citizenship
2. Visit Request/including a Need-to-Know Statement (Need-to-Know not required if using DISS)
3. Photo ID
4. JNC Conference Badge and Paid Registration

## Visit Request and Need-to-Know Statements:

All Visit Requests must be received by July 23, 2021 and be verified by the JNWC Security Office. Visit authorization requests received after July 23, 2021 may not be processed.

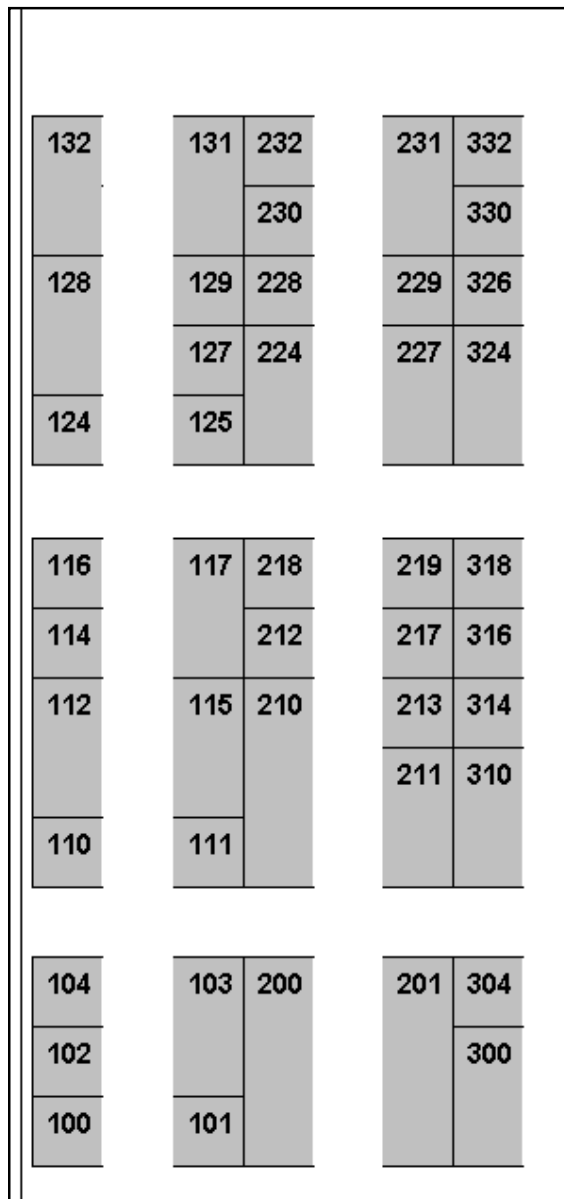
Prospective U.S. attendees must submit their Visit Authorization Requests through DISS to DISS SMO: JNC. DISS visit request POC field must be filled with "JNC 2021" instead of a POC name. For your convenience, if DISS is not an option, a Visit Request Form can be found at ion.org/jnc.

Fax all FEDCON Visit Requests to:

Deborah Renteria, Security Specialist  
Joint Navigation Warfare Center  
Phone: : 505-853-6360  
Fax: 505-853-6677  
Email: Deborah.Renteria.ctr@us.af.mil

# JNC Exhibitors and Exhibit Hall Information

## JNC 2021 Floor Plan



Entrance

Exhibit Hall is Publicly Releasable; please restrict all conversations to those permissible in the public domain.

## List of Exhibitors

- ACUTRONIC USA, Inc. (Booth 111)
- AEVEX Aerospace - Geodetics Products (Booth 316)
- Air Force Research Laboratory (Booth 210)
- Analog Devices (Booth 114)**
- Antcom (Booth 229)**
- Autonomy & Navigation Technology Center/AFIT (Booth 218)
- BAE Systems (Booth 112)**
- Brandywine Communications (Booth 127)
- CAST Navigation (Booth 300)**
- Chelton Limited (Booth 132)**
- Collins Aerospace (Booth 324)**
- EMCORE Corporation (Booth 211) ★**
- ENSCO, Inc. (Booth 102)**
- Fibernetics (Booth 217)
- Frequency Electronics, Inc. (Booth 213)**
- General Dynamics Mission Systems (Booth 110) ★**
- GPS Networking (Booth 124) ★
- Honeywell International (Virtual Exhibitor)**
- Ideal Aerosmith (Booth 228)**
- Inertial Labs Inc. (Booth 230)
- Inside GNSS (Booth 100) ★**
- Integrated Solutions for Systems (Booth 131)
- iXblue Defense Systems, Inc. (Booth 128)**
- Jackson Labs Technologies, Inc. (Booth 125)**
- KBR (Booth 232)**
- Kearfott Corporation (Booth 219)**
- KVH Industries, Inc. (Booth 224)**
- L3Harris (Booth 310) ★**
- LinQuest Corporation (Booth 227) ★**
- Lockheed Martin Space Systems Co. (Booth 201) ★**
- Mayflower Communications Company, Inc. (Booth 330)**
- Microchip Technology (Booth 101)**
- NAL Research (Booth 115) ★**
- Northrop Grumman (Booth 314) ★**
- NovAtel, Inc. (Booth 231) ★**
- Orolia Defense & Security (Booth 117)**
- Raytheon Intelligence and Space (Booth 326) ★**
- Sechan Electronics, Inc./ NAVSYS Corporation (Booth 103)
- Silicon Designs, Inc. (Booth 116)
- Spirent Federal Systems (Booth 200)**
- The Institute of Navigation (Booth 104)
- US Army DEVCOM C5ISR Center (Booth 129)
- VectorNav Technologies (Booth 318)**
- Vermeer (Booth 304)

**Bold = Corporate Member** ★ = Event Partner

## Exhibit Hall Access

### Wednesday, August 25

10:00 a.m. - 7:00 p.m.

Exhibits Open

### Thursday, August 26

10:00 a.m. - 4:00 p.m.

Exhibits Open

## JNC Conference Events

### Tuesday, August 24

*Informal Lunch:*

12:00 p.m. - 1:30 p.m., Event Center I

This event is included in the price of a full or Tuesday single-day registration.

### Wednesday, August 25

*Informal Lunch:*

12:15 p.m. - 1:30 p.m., Event Center I

This event is included in the price of a full or Wednesday single-day registration.

*JNC Barbecue Dinner:*

7:00 p.m. - 8:00 p.m., Event Center I

Informal barbecue dinner and cash bar.

This event is included in the price of a full or Wednesday single-day registration.

### Thursday, August 26

*Informal Lunch:*

12:15 p.m. - 1:30 p.m., Event Center I

This event is included in the price of a full or Thursday single-day registration.

### Friday, August 27

*Informal Lunch:*

12:20 p.m. - 1:30 p.m., Event Center I

This event is included in the price of a full registration, or a Friday single-day registration.

Visit the JNC exhibitors online profiles at [ion.org/jnc/exhibits.cfm](http://ion.org/jnc/exhibits.cfm)

Tutorials will be held Tuesday, August 24, in a FEDCON U.S. ONLY environment. Tutorials are included in a Full Conference or Tuesday registration.

## Resilient & Robust Positioning, Navigation, and Timing (PNT) - Ballroom B

Diverse elements of international infrastructure are critically reliant on GNSS for precise location and time, often in ways that are not obvious. This tutorial will provide a high-level perspective on the effects of interference on GNSS receivers and offer possible threat mitigation approaches. The tutorial will start with a discussion of potential GNSS threats and vulnerabilities. Then, after a quick review of how GNSS receivers process incoming signals to determine position, the focus will be on the effects of various interference types. The unique vulnerability of GNSS receivers on cold start will be discussed. Mitigations such as extended coherent integration, adaptive antenna arrays, and IMU aiding will be discussed. Civil jamming examples and incidents will be covered, along with methods to detect, identify and mitigate against their effects. In particular, the importance of maintaining situational awareness for establishing environmental context will be examined. Techniques for detecting spoofing and authenticating signals will be discussed. Use of LEO satellites as a backup for traditional GNSS will be highlighted as a mitigation of and deterrent to intentional interference. This course will present a discussion on celestial navigation techniques and system implementations, in the modern context. The course will consider air, sea and land operations, and explore celestial navigation technology solutions that are available today or in the near future. This course will appeal to R&D and systems engineers, managers and executives, and is accessible to both experienced and novice practitioners.



**Dr. Todd E. Humphreys** is an associate professor in the department of Aerospace Engineering and Engineering Mechanics at the University of Texas at Austin, and Director of the UT Radionavigation Laboratory. He received a B.S. and M.S. in Electrical and Computer Engineering from Utah State University and a Ph.D. in Aerospace Engineering from Cornell University. He specializes in applying optimal estimation and signal processing techniques to problems in radionavigation. His recent focus is on radionavigation robustness and security. His awards include the NSF CAREER award, the ION Thurlow award, and the Presidential Early Career Award. He is an ION Fellow.

## GPS/GNSS 101 - Ballroom C

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 the Air Force Institute of Technology (AFIT). Dr Raquet has a PhD in Geomatics Engineering from the University of Calgary, an MS in Aero/Astro Engineering from the Massachusetts Institute of Technology, and a BS in Astronautical Engineering from the US Air Force Academy. He has published over 170 navigation-related conference and journal papers and taught 60 navigation-related short courses to over 3600 students in many different organizations. He is the immediate past president of the Institute of Navigation and is an ION Fellow.

## Introduction to SatNav SDRs using Python: Part 1 - Ballroom D

This two-part course aims to provide attendees with a solid understanding of the fundamentals of satellite timing and navigation (satnav) software receivers and associated signal processing. The course is divided into multiple modules, each comprised of a short lecture followed by a python code demonstration that reinforces the topics covered. By the end of this course, attendees will have an understanding of how the provided satnav software receiver works which includes capabilities such as processing of multiband live-sky sampled data files, acquisition and tracking of visible open GNSS signals, and outputting signal observables. This open-source receiver may be further developed to yield a functional satnav SDR that is ideal for research.

Part 1: Satnav signal bands, signal structures, and link budgets; anatomy of a satnav receiver; software-defined radio concepts; front-end architectures; signal processing overview; sampled data analysis; correlation.

Pre-requisites: Basic understanding of digital signal processing, object-oriented programming concepts and the Python programming language are required to understand the software projects provided. Participating in the code demonstration portion is optional. Attendees registered for the code demonstrations will be able to download the demo software project and sampled data files, via external USB3 hard drives and DVDs, from a secure link that will be provided during the course.



**Dr. Sanjeev Gunawardena** is a research assistant professor with the Air Force Institute of Technology (AFIT). He leads robust GNSS technology development - one of three R&D thrusts of the Autonomy and Navigation Technology Center at AFIT. Sanjeev has been an active member of ION since 2000. He served as a GNSS+ track chair and co-chaired numerous technical sessions at GNSS+, ITM, and PLANS conferences. He was Eastern Council Member-at-Large during 2014-2015 and Satellite Division Treasurer during 2016-2018. Dr. Gunawardena was also the instigator and co-chair of the ION GNSS SDR Metadata Standard Working Group (ratified in 2020). He earned his PhD in Electrical Engineering from Ohio University.



**Mark Carroll** is an Electronics Engineer at the Air Force Research Laboratory Sensors Directorate. He received his BS in Computer Engineering and MS in Computational Science and Engineering from Miami University. His research interests include GNSS, Software Defined Radios (SDRs), and machine learning.

## CTS-153 Software - Ballroom E

With procurement of ground based, handheld and embedded card variants of military GPS receivers, a need to have a reliable tool to facilitate testing and evaluation of these receivers was addressed with the Compliance Tester Software for the IS-GPS-153 Interface (CTS-153) test tool. CTS-153 was originally developed, at the request of the GPS Joint Program Office (now part of SMC's Production Corps), to provide a means for test organizations and program offices (representing platforms integrating GPS) to evaluate the interface characteristics, and/or facilitate integration of military GPS receivers compliant with the various revisions of the IS-GPS-153 Interface. The range of GPS receivers conforming to the IS-GPS-153 includes the Precise Positioning Service Security Module (PPS-SM) based PLGR, Selective Availability/Anti-Spoofing Module (SAASM) based DAGR and GB-GRAM, and the M-Code based GB-GRAM-M. The purpose of the CTS-153 tutorial is to provide prospective users and interested parties with an understanding of basic operation of the test tool and useful features available to aid in successful integration of an IS-GPS-153 compliant GPS receiver. With the increasing availability of Military GPS User Equipment (MGUE) Inc 1 M-Code cards, this tutorial provides M-Code integrators timely exposure to the free CTS-153 test tool.

This presentation will consist of a real-time demonstration of useful CTS-153 features, including GPS receiver emulator function, RSAM error test function, as well as the data transfer and Hot Start process. Additionally, the presentation will provide an overview of basic IS-GPS-153 concepts and structure, with an emphasis on best ways to optimize integration of M-Code ground-based receivers. A focus will be placed on newly introduced MSID defined messages, which take advantage of the enhanced capabilities/functions of M-Code signals.



**Terrance Nelson** works for Booz Allen Hamilton where he has supported the Army Product Manager (PM) Positioning, Navigation, and Timing (PNT) and SMC Production Corps organizations for over 15 years in the area of Interface Control document (ICD) and Interface Specification (IS) development, GPS receiver specification development, platform integration support, and risk mitigation assessment. He functions as the primary CTS-153 SME and ICD-GPS-153 serial interface compliance test engineer and has functional experience in the areas of hardware and software design and analysis, including techniques for solving problems involving complex electrical systems. He holds a BS in Electrical Engineering from California State and is a licensed Professional Engineer.

Tutorials will be held Tuesday, August 24, in a FEDCON U.S. ONLY environment. Tutorials are included in a Full Conference or Tuesday registration.

## Integrity/Assurance of Navigation Systems - Ballroom E

In critical navigation systems that involve large risks to financial or human life, the design process of such systems needs to be at high levels of reliability in order to limit such risks. This course introduces the concept of integrity and assurance of navigation systems. The course will start by defining assurance and integrity and how system requirements are derived. The concept of integrity risk tree will then be introduced by using the derived requirements, identifying the system components, fault nodes and fault modes, and allocating the risks among these system components and faults. The tutorial will also present different methods and techniques to address the requirements and allocations, and how to evaluate the system performance during the design process. In addition, validation and verification techniques will be discussed. The course will use different examples from aviation and ground applications for illustration purposes at each step of the navigation system design process.



**Dr. Samer Khanafseh** is currently a research assistant professor at the Illinois Institute of Technology and the cofounder and manager of TruNav LLC. Dr. Khanafseh is an associate editor of IEEE Transactions on Aerospace and Electronic Systems and was the recipient of ION's Early Achievement Award (2011) for his outstanding contributions to the integrity of carrier phase navigation systems. He has served ION as a session chair several times and as a reviewer for NAVIGATION and conference papers. Dr. Khanafseh received his PhD degree in Aerospace Engineering at IIT in 2008. Technical expertise and interests include high accuracy and high integrity navigation systems, cycle ambiguity resolution, fault monitoring and robust estimation techniques, high precision aviation applications such as Autonomous Airborne Refueling (AAR) of unmanned air vehicles, autonomous shipboard landing for the UCAS and JPALS programs, and Ground Based Augmentation System (GBAS).

## An Introduction to Cryptography with Attention to Navigation - Ballroom C

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 on GPS. Additionally, 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. Technical expertise and interests include signal design (especially binary sequences and spreading code generation), cryptography, signal authentication, and innovative methods to secure PNT. His latest research is in applying inference methods to reasoning about PNT assurance.

## Introduction to SatNav SDRs using Python: Part 2 - Ballroom D

This two-part course aims to provide attendees with a solid understanding of the fundamentals of satellite timing and navigation (satnav) software receivers and associated signal processing. The course is divided into multiple modules, each comprised of a short lecture followed by a python code demonstration that reinforces the topics covered. By the end of this course, attendees will have an understanding of how the provided satnav software receiver works which includes capabilities such as processing of multiband live-sky sampled data files, acquisition and tracking of visible open GNSS signals, and outputting signal observables. This open-source receiver may be further developed to yield a functional satnav SDR that is ideal for research.

Part 2: Acquisition engines; signal tracking techniques and control state machines; inter-frequency aiding; measurement computation; introduction and demonstration of provided python SDR architecture and code.



**Dr. Sanjeev Gunawardena** is a research assistant professor with the Air Force Institute of Technology (AFIT). He leads robust GNSS technology development - one of three R&D thrusts of the Autonomy and Navigation Technology Center at AFIT. Sanjeev has been an active member of ION since 2000. He served as a GNSS+ track chair and co-chaired numerous technical sessions at GNSS+, ITM, and PLANS conferences. He was Eastern Council Member-at-Large during 2014-2015 and Satellite Division Treasurer during 2016-2018. Dr. Gunawardena was also the instigator and co-chair of the ION GNSS SDR Metadata Standard Working Group (ratified in 2020). He earned his PhD in Electrical Engineering from Ohio University.



**Mark Carroll** is an Electronics Engineer at the Air Force Research Laboratory Sensors Directorate. He received his BS in Computer Engineering and MS in Computational Science and Engineering from Miami University. His research interests include GNSS, Software Defined Radios (SDRs), and machine learning.

Lunch in Event Center I (First Floor): 12:00 p.m. - 1:00 p.m.

# Tuesday Technical Sessions 10:30 a.m. - 12:00 p.m.



Rod Earwood  
JNWC



Kevin Martin  
The MITRE Corporation

## Session D1a: NAVWAR: Counter PNT Ballroom B

- 10:35 Design of Optimal Jamming Spectra and Practical Waveforms to Deny Multi-GNSS Signals:** Jerome M. Shapiro, Jonathan T. Warneke, Cal P. Pechacek, Ryan Jobson and Justin K Htay, The MITRE Corporation
- 10:55 Jammer Airborne Wavefront Simulator (JAWS):** George Lee, Steven Fuller, Paul Osadchy, Dan Dresner, Northrop Grumman; William Deike, Dana Howell and Denice Jacobs, Air Force Research Laboratory/RWYN; Eddy Emile, SMC/GPUT
- 11:15 Blue Force Electronic Attack (BFEA) Jammer Aided Navigation - BFJAN:** Taehwan Kim, Khiem Cai, Jarret Perry, James Landon, Raytheon Intelligence and Space
- 11:35 The Future of GNSS Field Testing – Get it Done!:** Greg Gerten and Steve Billman, KBR

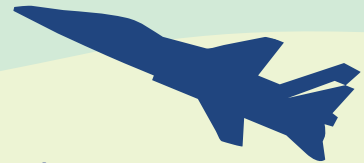
### Alternates

- 1. Countering Vision-based Navigation Systems: Theory, Modeling, and Simulation:** Emily Bates and Mark Page, The MITRE Corporation
- 2. Raytheon Modeling and Simulation in the Threat Environment and Associated Performance against Threat Characterization:** Ryan Jackson, Jarrett Perry, Matt Dusard, Raytheon Intelligence and Space

Lunch in Event Center I (First Floor): 12:00 - 1:00 p.m.



# JOINT NAVIGATION CONFERENCE 2022



June 6-9, 2022

Town and Country Hotel  
San Diego, California



## SAVE THE DATE

ion.org



Dr. Steven Lewis  
The Aerospace Corporation



Lt. Caleb Sapp  
US Space Force

## Session A1: Space and Satellite Applications, NTS-3 Overview

### Ballroom E

- 1:50 NTS-3 Signals Experiments – Overview:** Jon Anderson, Canyon Consulting; Philip Dafesh, James Gillis, The Aerospace Corporation; Joanna Hinks, Air Force Research Laboratory; Shawn Miller, Brady O'Hanlon, Joseph J. Rushanan, The MITRE Corporation; Logan Scott, LS Consulting; Steve Stoyanov, L3Harris; Greg Myer, Renee Yazdi, Canyon Consulting
- 2:10 NTS-3 Signals Assurance Experiments:** Joanna Hinks, Air Force Research Laboratory/RV, James T. Gillis, The Aerospace Corporation; Perry Loveridge, Qualcomm, Joseph J. Rushanan, The MITRE Corporation
- 2:30 NTS-3 Experiments with a New SatNav Payload Architecture:** Joanna Hinks, Air Force Research Labs; James Lake, Canyon Consulting; Val A. Loretto, MEI Company; Shah Nejad, Canyon Consulting; Gary Okerson, The MITRE Corporation; Nathan Pax, University of Dayton Research Institute; Stephen Stoyanov, L3Harris; Renee A. Yazdi, Canyon Consulting
- 2:50 Profiling Embedded Performance of Generating Chimera Authentication:** Jared Kresge, Samuel Wamsley, CAL Analytics; Sanjeev Gunawardena, Air Force Institute of Technology

#### Alternates

1. **Assessment of NTS-3 Acquisition Aiding Signals: Benefits to Military GPS Receiver Performance, Spectrum Compatibility, and use Cases:** Philip Dafesh and Alex Eapen, The Aerospace Corporation
2. **Experimental Plans for the Navigation Technology Satellite (NTS-3) with Regards to the Timekeeping System:** Kyle W. Martin, Applied Technology Associates; John Janis, L3Harris; Joanna Hinks, John Elgin, Gordon Lott, AFRL; Benjamin K. Stuhl, Space Dynamics Laboratory
3. **GNSSTA as a Receiver for NTS-3 Experimentation:** Shawn Miller, The MITRE Corporation



Dr. Victor O. panel  
Resonant Sciences



Dr. Mikel Miller  
IS4S

## Session B1: Collaborative Navigation Techniques

### Ballroom C

- 1:50 NATO Team Employing Cooperative Navigation Technologies and Techniques in GNSS Denied Environments:** Luke Rinard, T2S Solutions; Yoonkee Kim, C5ISR Center; Mikel Miller, IS4S
- 2:10 Collaborative Navigation with Warfighters Transitioning to and from Mounted Platforms:** Jordan Britt and Kevin Betts, Leidos
- 2:30 Raytheon HiPRNav-T and 2-Way Time Transfer:** Matthew Dusard, Jarrett Perry and Paul Quinn, Raytheon Intelligence and Space
- 2:50 Resilience for Multi-Filter All-source Navigation Framework:** Jonathon S. Gipson and Robert C. Leishman, ANT Center, AFIT

#### Alternates

1. **Decentralized Cooperative Navigation for GPS-Denied Conditions:** Cory Schutz, Noam Eshed, and Joel Douglas, Systems & Technology Research
2. **The PNT Chain: A Collaborative Navigation Architecture for Projecting Accurate PNT Information Across Vast GPS-denied Areas:** Samuel Shapero, Daniel Levy, Matthew Lashley, and Mark Smith, Georgia Tech Research Institute
3. **Cooperative PNT in a Relative Reference Frame using two-way Time and Range, Barometric Pressure and Inertial Measurements:** William Kirchner, Ramachandra Sattigeri, Vladislav Gavrillets, and James Doty, Collins Aerospace
4. **Collaborative Development of PNT Systems:** Douglas Burch, Collins Aerospace



Peter Lewis  
Draper



Dr. John Raquet  
IS4S

## Session C1: Complementary PNT 1: Vision Aided Air

### Ballroom D

- 1:50 Image Positioning System for PNT AgilePod:** Donald Venable, Michael Veth, Veth Research Associates; Mark Smearcheck, AFRL
- 2:10 Flight Test Results for a Vision Navigation System Integrated onto an Army UAV Platform:** Greg Reynolds, Army CCDC AvMC; Rory Alston, Kevin Betts, Clayton Graves, Tom Grieve, Patrick O'Leary, Jonathan Ryan, and Velislav Stamenov, Leidos, Inc.
- 2:30 Honeywell Vision-Aided Navigation for GPS-Denied Environments:** Kevin Sweeney, Justin Syrstad, Annis Nusseibeh, Tim Kukowski, Sally Ann Keyes, Honeywell International
- 2:50 Open Architecture Vision-aided Navigation Updates Using the MISB Unmanned Air System (UAS) DataLink:** Alison Brown, Dien Nguyen, Tom Silva, Jarrett Redd, and Sergio Huerta, NAVSYS Corporation; Stephen B. Brown, NAVAIR PMA-263; John Unger, Mike Walton, Sechan Electronics, Inc.

#### Alternates

1. **Boeing Vision Based Navigation Design & Flight Demo Results:** R. (Ken) Li, Boeing Research & Technology; Tom Tsao, BDS; Andrey Tolstov, Kevin Davis, Paul Haug, Boeing Research & Technology
2. **Using Motion Capture and Augmented Reality to Test AAR with Boom Occlusion:** Xiaoyang Wu, Vincent Bownes, and Scott Nykl, AFIT
3. **Airborne APNT for the Warfighter: Lessons Learned in Fielding Vision-Based Navigation on Various Operational Airborne Platforms:** Jonathan Ryan, Kevin Betts, Clayton Graves, Tom Grieve, Patrick O'Leary, and Velislav Stamenov, Leidos, Inc.



Amelia Fortmayer  
Army CCDC C5ISR



Amanda Humphrey  
JNWC

## Session D1b: NAVWAR: Situational Awareness

### Ballroom B

- 1:50 NAVWAR Situation Awareness Framework:** Luke Rinard, T2S Solutions; Robert Beckinger, Fritz Newcomer, C5ISR Center; William Travis, Josh Starling, Travis Keller, Jeremy Shepherd, IS4S; Scott Parsons, Andy Keckler, SRC Inc.
- 2:10 Spoofing Detection in NovAtel's OEM7 Receivers:** Sandy Kennedy, Ali Broumandan, Thomas Taylor, NovAtel America, Inc.
- 2:30 Improved Jamming Situational Awareness Using Array Data:** John Weger, BAE Systems/NSS
- 2:50 NAVWAR Emitter Warning Tactical (NEWT) Display for Aircrew Situational Awareness in GPS-denied Operations (ASiAGO):** William Deike, Michael Corey, AFRL/RYYWN; Tim Bartlett, Peter Heinig, The Perduco Group

#### Alternates

1. **Situationally Aware PNT – The Next Step in Emerging Threat Detection, Protection, and Mitigation:** Brent Abbott, Orolia Defense and Security
2. **Orienting the Warfighting OODA Loop:** Renee A. Yazdi, Canyon Consulting; Joseph P. Lortie, Jr, Defense Aerospace Consultant; L. Kevin Slimak, Brian Zufelt, COSMIAC UNM; Madeleine Naudeau, Air Force Research Labs



Joe Page  
Joint Navigation  
Warfare Center



Doug Taggart  
Overlook Systems  
Technologies

## Session A2: Space and Satellite Applications

### Ballroom E

- 4:05 **An Experiment in Interstellar Navigation:** Gregory S. Hennessy and George H. Kaplan, US Naval Observatory
- 4:25 **Analysis of GPS III Concentric Array Based Antenna (CABA) Satellite Payload Configuration for Enhanced PNT Performance:** Erik Lier, Mark Crews, Chuck Frey, Lockheed Martin Space; Madeleine Naudeau, AFRL
- 4:45 **Options for Expanded Space Service Volume:** James Lake, Laura Duffy, Canyon Consulting, LLC, and Jason Guarnieri, AFRL/RV
- 5:05 **Space-based GPS Interference Monitoring and Detection with Proliferated LEO:** Steven W. Lewis, Blair F. Thompson, Tanner Stevens, Rebecca Bishop, The Aerospace Corporation

#### Alternate

1. **Resilient Cislunar Positioning, Navigation, and Timing:** David William Allen, Steven W. Lewis, Blair S. Thompson, and Andrew T. Takano, The Aerospace Corporation



Dr. Thomas Powell  
The Aerospace  
Corporation

## Session B2: PANEL: MGUE Integration



### Ballroom B

This panel will feature representatives from weapon systems conducting some of the initial integration of MGUE receivers. Panelists will share experience and lessons learned working with the first generation of M-Code receivers.

#### Panel Members:

1. Terrance Nelson, Systems Engineer, Booz Allen Hamilton
2. Glen Collins, GPNTS Technical Lead, Booz Allen Hamilton
3. Dr. John Janeski, The Aerospace Corporation
4. Eric Hillen, TBS
5. Paul White, Engineer, U.S. Army DEVCOM Aviation & Missile Center
6. Dr. Sultan Mahmood, WBB Inc.



Mark Smearcheck  
AFRL Sensors  
Directorate



Ann Adams Witt  
Honeywell

## Session C2: Complementary PNT 2: LiDAR and Vision Aided Ground

### Ballroom D

- 4:05 **Ground Vehicle Vision-Aided Navigation Demonstration at the Positioning, Navigation, and Timing Assessment Exercise 19:** Gary Katulka, Paul Olson, Steve Huie, US Army CCDC C5ISR Center; Troy Mitchell, Ben Brink, Steven Gambino, Tom Grieve, Jordan Britt, and Kevin Betts, Leidos, Inc.; Scott Rutter, Valor Tactics, Inc.
- 4:25 **Vision-Aided Navigation for Dismounted Operations in GPS-Denied Environments:** Aneesa Sonawalla, Kimberly J. Ryan, Eric Jones, Tristan C. Endsley, Ted J. Steiner, Draper
- 4:45 **LiDAR-Aided INS System for GPS-Denied Navigation in Dense Forestry Area:** Andrey Soloviev, Ananth Vadlamani, JD Sharon, QuNav; Michael Caporellie, US Army C5ISR
- 5:05 **Sensor-fused Doppler Lidar/IMU for Terrestrial Navigation:** Jason Hull, Diego Pierrottet, Stephen Sandford, Donald Erbschloe, Kenneth Morrison, Psionic LLC

#### Alternate

1. **Assured Position, Navigation, and Timing for Ground Vehicle Using the Leonardo DRS Production Data Distribution Unit expandable (DDUx) and DVE Wide Thermal Camera System:** Troy Mitchell, Ben Brink, Steven Gambino, Kevin Betts, Leidos, Inc., Bart Blanchard, John Schwaller, Leonardo DRS



Marvin Fisher  
AFLCMC/EBDT



Tim DeLoache  
Booz Allen  
Hamilton

## Session D2: Weapon Applications

### Ballroom C

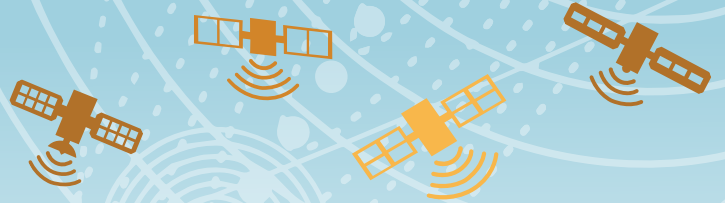
- 4:05 **Determining the 'Goodness' of AltNav for the Precision Weapon and Munitions Domain:** Paul C. Manz, Daniel R. Smith, and Thomas J. Blenk Jr., US Army Joint Program Executive Office Armaments and Ammunition
- 4:25 **Image-Based Navigation and Seeking in GPS Denied and Contested Environments:** Matthew Jamula, Draper
- 4:45 **MIM-104 Patriot Missile Launcher Incorporates M-Code based MAPS Gen1:** Paul White, U.S. Army DEVCOM - Missiles & Aviation; Greg Graham, NTA-INC; Dave Jones, Gentry Gardner, GPS Source
- 5:05 **eLoran Based Navigation System for GPS Denied Environments:** Christopher Zarowski, Jeffrey Anderson, Mayflower Communications Company, Inc.; Stephen Bartlett, UrsaNav, Inc.; Joseph Hewlett, Scott Salazar, Naval Air Warfare Center Weapons Division, US Navy

#### Alternates

1. **Modernized GPS for Precision Guidance Kit (PGK):** Steve Phillips, Justin Miller, Randall Jaffe, and Justin Yakura, L3Harris
2. **Stellar Aiding to Improve Long Range Missile Performance:** Kyle Miller, John Mastrangelo, Joseph Ho, Thomas Vaughan, James Hardaway, Ball Aerospace & Technology Corp.; Scott David, Michael Payne, NTA-Inc.; Patrick Renfro, US Army CCDC/AVMC



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SYSTEMS AND APPLICATIONS MEETING



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and a Commercial Exhibit

**ABSTRACTS DUE OCTOBER 7, 2021**



Dr. Michael Coleman  
Naval Research  
Laboratory



Ryan Dupuis  
Excelitas  
Technologies

## Session A3: Applications of Atomic Standards in DoD Time Transfer and Dissemination



### Ballroom E

- 8:35 Exploring the Chip Scale Atomic Clock (CSAC) for On Demand Position Navigation & Time (OD-PNT) Applications: Luke Littleton-Strand, Jade A. Babcock-Chi, Penina Axelrad, Dennis M. Akos, University of Colorado at Boulder
- 8:55 Higher Throughput, Greater Range Military Communication Systems and Improved Electronic Warfare Systems Performance Leveraging the Latest State of the art Miniature Rubidium Atomic Clock Technology: David Garigen, Orolia Defense & Security
- 9:15 Position Determination and Timing with Laser Pulses: Nathan Barnwell, Kari Moran, Jonathan Itschner, Kevin Stanzione, and LaChelle McMahan, NIWC Pacific
- 9:35 Realizing Satellite Time Transfer Through S&T: McLaina Oum, William Joo, and Joe Schneckner, NIWC Pacific

#### Alternate

1. Wireless Time and Frequency Clock Synchronization Technology for Software Defined Radios: Wilbur Myrick, Brian Sexton, W. Todd Faulkner, Daniel T. Goff, ENSCO, Inc.; Olukayode K. Okusaga, JHU APL



Col. Clifford Sulham  
SMC PCU



Michael Stanitis  
The Aerospace  
Corporation

## Session B3: Military GPS User Equipment

### Ballroom C

- 8:35 BAE Systems MGUE Status, M-Code is Here: Charles A. Popeck and Shawn Ryan, BAE Systems/NSS
- 8:55 L3Harris Military GPS User Equipment (MGUE): Rick Bieniak, L3Harris
- 9:15 Raytheon MGUE Program Status: Mike Delanty, Mark Martinez, and Jarrett Perry, Raytheon Intelligence and Space
- 9:35 First Flight Test of EGL with M-Code: Scott Leavy, Paisley Rowe, Michael Nelson, Honeywell

#### Alternates

1. Improvements to MAPS Gen 1 and Fielding Status: David Jones and Gentry Gardner, GPS Source
2. Data-Focused Methods for GPS Spoofing Detection: Mark Demore II, Patrick Sweeney, Joseph Curro, Brett Borghetti, AFIT
3. M-Code Receivers for SWAP-Constrained Platforms: Greg Farley, BAE Systems/NSS



Dr. Michael Veth  
Veth Research  
Associates



Dr. Gary Katulka  
CCDC/CSISR

## Session C3: Complementary PNT 3: Vision Aided Optical and RF/Stellar

### Ballroom D

- 8:35 All-Weather Absolute Visual Navigation with Advanced Radar: Scott Jenkins, Tim Bielek, Doug Bickel, R. Derek West, Tucker Haydon, Sandia National Laboratories
- 8:55 Boeing Modern Celestial Navigation Design: R. (Ken) Li, Tom Tsao, C.J. Yoo, Paul Haug, Boeing Research & Technology
- 9:15 Celestial-Based Position Algorithm for GPS-Denied Environments with SkyPASS Gen3 Simulation and Implementation Test Results: Laura Eshelman, Adam Smith, Art Lompado, Katie McCann, and David Chenault, Polaris Sensor Technologies, Inc.
- 9:35 Honeywell Celestial-Aided Navigation Performance in GPS-Denied Ground Testing at PNTAX 2020: Trevor Stephens, Ross Merritt, Brian Schipper, Paul Samanant, Honeywell International



Roger Fuller  
USCG HQ Office of  
CSIT Capability



Connor Brashar  
Sandia National  
Laboratories

## Session D3: Navigating in Challenged Environments (e.g., Urban, Indoor and Sub-Surface Navigation)

### Ballroom B

- 8:35 Feasibility Analysis of Low SWAP-C Gravitational Anomaly-Aided Navigation: Sally Ann Keyes, Trevor Stephens, Honeywell Aerospace, Larry Vallot, EXB Solutions Inc.
- 8:55 Multi-source Absolute Positioning for Dismounted Warfighters in Denied Environments Using the ENCORE Handheld Navigation Device: Kevin Betts, Ben Brink, Steven Gambino, Troy Mitchell, and Kyung-Min Su, Leidos, Inc.
- 9:15 RoDAR: Robust Dual Antenna Receiver for Jamming and Spoofing Detection and Mitigation in NovAtel's OEM7 Receivers: Sandy Kennedy, Ali Broumandan, Thomas Taylor, NovAtel America, Inc.
- 9:35 Direction of Motion Pedestrian Dead Reckoning Efficacy in a Non-Foot-Mounted, Body Worn Measurement Unit: George Hsu, PNI Sensor Corporation

#### Alternates

1. A Survey of Alt-PNT Technologies to Inform the Development of a Novel PNT Framework for Tactical End-Users: David Castello and Landon Tomcho, Air Force Research Laboratory, Information Directorate
2. The Performance of a Multi-GNSS/INS Receiver for Land Vehicle Systems During GNSS Denial: Mike Bobye, Ryan Dixon, Thomas Taylor, NovAtel America, Inc.



Dr. John Elgin  
AFRL Space Vehicle Directorate



Francine Vannicola  
Naval Research Laboratory



Jason Pontious  
AFRL Sensors Directorate



Alinn Herrera  
The Aerospace Corporation



Dr. Benjamin Lane  
STR



Dr. Gregory Hennessy  
US Naval Observatory



Dr. Adam Schofield  
Army CCDC C5ISR

## Session A4: Novel Timing Technologies and Applications

### Ballroom E

- 10:50 **Clock Resiliency Test Results with GPS Prototype Hardware:** Michael R. Jones, John P. Janis, Nicholas Quackenbush, Amy Caproni, Robert Montana, L3 Harris Technologies
- 11:10 **Current Status of the Optical Rubidium Atomic Frequency Standard:** Kyle W. Martin, Applied Technology Associates; John Elgin, Air Force Research Laboratory Space Vehicles Directorate; Benjamin K. Stuhl, Space Dynamics Laboratory
- 11:30 **Militarized Chip-Scale Atomic Clock:** Peter Cash, Igor Kosvin, Paul Machado, Michael Silveira, and Gary Wernsing, Microchip Technologies
- 11:50 **Distributed Network Time Synchronization: Social Learning versus Consensus:** Hyuck M. Kwon and Ian Ellis L. Hulede, Wichita State University, EECS

#### Alternate

- 1. **Novel Algorithm for Precision Time Synchronization of Distributed Defense Systems:** James P. Vogel, Evan D. Walsh, and David A. Friedman, Systems & Technology Research

## Session B4: Multi-GNSS Receivers for Military Applications

### Ballroom C

- 10:50 **Establishing Integrity for GNSS Signals from Assured GPS Signals: User Equipment Techniques in the Measurement Domain:** Tenny Sharpe, Thomas Powell, The Aerospace Corporation
- 11:10 **A Software Defined implementation of Time-differenced Carrier Phase Solution with Random Sample Consensus:** Zhen Zhu and Sanjeev Gunawardena, East Carolina University
- 11:30 **Multi-GNSS Applications of Codeless Processing of Binary Offset Carrier Signals:** Alan Choy, John Langer, Andrew Lin, Mark Kubiak, Herwin Chan, John Janeski, The Aerospace Corporation
- 11:50 **TerraStar X: RTK from the Sky – Global High Accuracy Positioning:** Sara Masterson, Paul Alves, Todd Richert, Thomas Taylor, Miguel Amor, NovAtel America, Inc.

#### Alternates

- 1. **Multi-GNSS Risks and Rewards – Applying RMF and Cyber Hygiene to GNSS:** Greg Gerten and Steven Billman, KBR; Ray Hitt, AFRL/RWYE
- 2. **Analysis of Direct Conversion Front-End Distortion on Satnav Signal Deformation Monitoring Applications:** Mark Carroll, Air Force Research Labs, RYWN; Sanjeev Gunawardena, Air Force Institute of Technology; Eric Vinande, Air Force Research Labs, RYWN
- 3. **Defending PNT & Frequency Stability: Layered Defenses of RF Monitoring, Military GPS Receivers and Clock Validation Algorithms:** Paul Myers, Orolia Government Systems, Inc.

## Session C4: Complementary PNT 4: Naturally Occurring Measurement Sources – Including Gravity, Magnetic Fields, Lightning

### Ballroom D

- 10:50 **Advancing the State of the Art for Magnetometer Calibration on an F16 Magnetic Navigation System:** Aaron Canciani, AFIT
- 11:10 **Magnetic Anomaly Navigation Flight Testing on an F-16:** Daniel J. Clarke, Justin T. Soeder, Raina L. Duncan, Bryce M. Turner, Casey V. Horgan, and Christopher L. Ames, U.S. Air Force
- 11:30 **Magnetic Anomaly Aided Navigation Results from Airborne Flight Test Including Edwards AFB and PNTAX 2020:** Paul Samanant, Trevor Stephens, Rob Compton, Blaise Morton, Honeywell; Aaron Canciani, NRO; Aaron Nielson, AFIT
- 11:50 **Boeing Modern Terrain Referenced Navigation Design Including Navigation Whisker:** R. (Ken) Li, C.J. Yoo, Cody Gruebele, Paul Haug, Andrey Tolstov, Boeing Research & Technology; Tom Tsao, BDS

#### Alternates

- 1. **Magnetic Velocity and Position (MVP) Sensing for APNT:** Rick Vosburgh, Archaius LLC
- 2. **Shipboard Calibration of a Strapdown Vector Magnetometer:** Paul Frontera, US Naval Academy; Stephen M. Alessandrini, Lockheed Martin Corp.
- 3. **Operationalizing MagNav:** Aaron Nielsen, Jeremy Gray, Joseph Curro, AFIT/ANT Center; Evelyn Boettcher, DiDacTex, LLC.; Robert C. Leishman, AFIT/ANT Center

## Session D4: PANEL: Rapid Agile Development and Manufacturing

### Ballroom B



Representatives from all three services will address their plans to respond to urgent PNT requirements from the field in a rapid manner. Panelists will present current plans to quickly allocate requirements to an open system architecture (OSA), cooperate with industry to demonstrate prototypes, where OSA promotes the ability to plug and play new sensors with flexible interfaces from a diverse set of providers, adaptive software development to support the fusion of PNT sensor information, iterative prototyping in a cooperative manner with industry conducting demonstrations/test in government laboratories, and move forward to conduct operational tests to ensure all requirements have been satisfied. Using this methodology manufacturing can begin in a very quick turnaround in comparison to current DoD acquisition.

#### Panel Members:

- 1. Mr. Chris Garrett, Senior Leader (SL) for System Engineering, USAF
- 2. CAPT Andrew Gibbons, Program Manager, Communications and GPS Navigation Program Office, USN
- 3. COL Nick Kioutas, Program Manager for Positioning, Navigation and Timing, US Army
- 4. Dr. Mikel Miller, Industry Perspective, IS4S

Lunch Served in Event Center I: 12:15 p.m. – 1:30 p.m.



Joseph Schnecker  
NIWC Pacific



**Mr. William B. Nelson**  
*Director, Assured Positioning  
Navigation & Timing (APNT) Cross  
Functional Team (CFT), U.S. Army  
Futures Command*



**Dr. Nikki Markiel**  
*Senior GEOINT Authority  
for Geomatics, National  
Geospatial Intelligence Agency*

Free Time in Exhibit Hall/Hosted Break in Event Center I: 3:15 p.m. – 4:00 p.m., Sponsored by LinQuest

## Wednesday Technical Sessions

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



Tracey Young  
Army CCDC C5ISR



Dr. Samer Khanafseh  
ITT/TruNav



Brian Louie  
SMC/PCU



Renee A. Yazdi  
Canyon Consulting



Chad Nash  
PM PNT



Dr. Alex Cerruti  
The MITRE Corporation



Chad Pinkelman  
NIWC Pacific



LCDR Joseph Haynsworth  
CSISC

### Session A5: Integrity and Assurance



Ballroom E

- 4:05 **A Modular Machine Learning Software Application for GPS Integrity Monitoring:** Wilbur Myrick, Brian Sexton, W. Todd Faulkner, Daniel T. Goff and Stanley Radzevicius, ENSCO, Inc.; and Joseph Stevanak, US Army CCDC C5ISR
- 4:25 **A Novel Fault Correlator Architecture for GNSS Spoofers Survivability:** Charles A. Givhan, Auburn University; Michael R. Walker and Connor L. Brashar, Sandia National Laboratories
- 4:45 **Detection and Localization of Adversarial GPS Interference Source Based on Clock Signatures:** Joseph B. Smith, Joshua M. Wood, Scott M. Martin, Auburn University; Connor Brashar, Sandia Nation Laboratories
- 5:05 **Testing of Low SWAP-C Dismount GNSS Threat Detection:** John Karvounis, Benjamin Funk, Jeff Kunst, Carole Teolis, Carol Politi, TRX Systems; Nhut Vo, C5ISR Center CP&ID PNT DIV

#### Alternate

1. A Bit Sequential Method for Proof of Life over Low-Rate Channels: Peter Hokanson and Johnathan York, ARL, Univ. of Texas at Austin

### Session B5: GPS Modernization

Ballroom C

- 4:05 **Evaluating Interference from GPS Regional Military Protection to Reception of GPS Signals:** John W. Betz, The MITRE Corporation
- 4:25 **GPS Next Generation Operational Control Segment (OCX) Performance Analyses of Key Navigation Metrics:** Michael Vilaboy, Qun Shi, L3Harris Corporation; Yoaz Bar-Sever, Willy Bertiger, Bela Szilagyi, Jet Propulsion Laboratory; Michael Coleman, Naval Research Laboratory
- 4:45 **An Exchange Format for M-code Navigation Message Data:** Brent Renfro, John Knutson, Emery Reed, ARL, The University of Texas at Austin; Cliff Harris, The Aerospace Corporation; Trevor Garner, National Geospatial-Intelligence Agency
- 5:05 **GPS III, IIRF, and Operational Control Segment Modernization:** Tonya Ladwig, Dave Hatch, and Mark Crews, Lockheed Martin Space

#### Alternate

1. GPS Satellite Autonomous Operations Accuracy: Charles H. Frey, Lockheed Martin Corporation/ Space Systems

### Session C5: Complementary PNT 5: RF Aided/SDR (Non-GPS)

Ballroom D

- 4:05 **SDR-Based PNT Solution Using Signals of Opportunity:** John Carlson, Martin Alles, Joe Kennedy, Echo Ridge, LLC; Mark Smearcheck, Air Force Research Laboratory; Luke Steelman, Naval Surface Warfare Center
- 4:25 **Using Signals of Opportunity for Navigation with Networked Sensors:** Andrew Joplin, Scott Jones, Johnathan York, ARL, The University of Texas at Austin
- 4:45 **An Agile RF Broadcast & SDR-enabled Closed Loop PNT System:** Gary Green, KBR; Joe Kennedy, Echo Ridge; Zac Hester, Braxton
- 5:05 **One Satellite Receiver for Localization of Radio Emitter:** Hyuck M. Kwon, Andrew Rankin, Ian Ellis L. Hulede, Wichita State University

#### Alternates

1. Accurate Global Navigation using VLF Signals and Ionosphere Photochemistry Modeling: Michael Turbe, Jordan Britt, Douglas Strangoener, Kevin Betts, Leidos; Chia-lie Chang, Tom Wallace, Vesperix Corporation
2. Correlation-agnostic Fusion for More Accurate Covariance Estimation: Clark Taylor, Aryan Naveen, ANT Center, AFIT; Zhen Zhu, East Carolina Univ.
3. Geometric Invariants for Radar Motion Estimation: Samuel Pine and Matthew Ferrara, Matrix Research Inc.

### Session D5: NAVWAR: User Technologies

Ballroom B

- 4:05 **Modernized GPS and Digital Anti-Jam Contributions to the Range and Lethality Challenge of Multi-Domain / Maritime Distributed Operations (MDO):** Justin R. Wymore Sr., BAE Systems/NSS
- 4:25 **Raytheon Alternate Navigation & Sensor Fusion Approach:** Kristin Makowski, Jarrett Perry, and Shubha Kadambe, Raytheon
- 4:45 **Optimal Filtering for Jamming Suppression:** John W. Betz, The MITRE Corporation
- 5:05 **Consumer Reports - NAVWAR Battery Side by Side Scoring and Assessment:** Mitchel Kromer, KBR; Ray Hitt, AFRL/RYWE

#### Alternates

1. Eroding the Jamming Threat to Military GPS: Alex Cerruti, Daniel Shultz, John W. Betz, The MITRE Corporation
2. Protected RF Mode for M-Code Receiver Interoperability with Anti-Jam Electronics: Greg Farley, BAE Systems/NSS



Dr. Madeleine Naudeau  
AFRL Space Vehicles Directorate



Mark Crews  
Lockheed Martin

## Session A6: Reconfigurable SatNav



### Ballroom E

- 8:35 **On Demand PNT (OD-PNT):** P. Axelrad, D. Akos, J. Morton, S. Palo, R. Kingsbury, University of Colorado Boulder; L. Scott, Logan Scott Consulting
- 8:55 **Adaptive and Learned Transmit Techniques to Defeat Jamming:** Michael Tinston, Enrico Mattei, Afsayh Saquib, Michael Person, Brent Marin, Dan Weigand, Expedition Technology, Inc.
- 9:15 **Noise Reduction Technique in Radio Astronomy Band for GPS Satellite Payload Applications:** J. Johana Yan, Donald E. Cowles III, Houman Ghajari, MaXentric Technologies LLC; Aly E. Fathy, University of Tennessee Knoxville
- 9:35 **Very Inexpensive Navigation Enhancement Layer:** Alberto Arredondo, Ron Trerotola, James Bardeen, Tiange Fan, Alexander Utter, Richard Welle, David Allen, The Aerospace Corporation

#### Alternates

1. **Developing the GNSS Waveform Prototyping Platform (GWPP) for End-to-End CHIMERA Tests:** Andrew Cochrane, Jim Aarestad, COSMIAC Research Center, The University of New Mexico; Greg Myer, Canyon Consulting; Luis Hernandez, COSMIAC Research Center, The University of New Mexico; Sanjeev Gunawardena, Air Force Institute of Technology
2. **Rapid-OODA with GNSS Machine Learning Toolset (MLT):** Brian Zufelt, COSMIAC University of New Mexico; Renee A. Yazdi, Canyon Consulting; Andrew Cochrane, Jim Aarestad, COSMIAC University of New Mexico; David Choi, Caleb Sapp, Madeleine Naudeau, Air Force Research Laboratory

## Session B6: PNT Open Systems Architecture 1

### Ballroom C



Morgan Raymond  
AFLCMC/WNY



Dr. Adam Schofield  
Army CCDC C5ISR

- 8:35 **ASPN Upgrade: Progress and Way Forward:** Adam Schofield, Meghan Bentz, CCDC C5ISR; Ken Fisher, Kyle Kauffman, and John Raquet, IS4S
- 8:55 **Department of the Air Force PNT Reference Architecture Development:** Delbert Champ, Headquarters Air Force A5/7; Matthew Kascak, Justin Malek, Armen Kurdian, Booz Allen Hamilton
- 9:15 **pntOS: Modular Open Software Approach for Real-time Sensor Fusion:** Michael Caporellie, Adam Schofield, US Army CCDC C5ISR Center; John Raquet, Kyle Kauffman, Integrated Solutions for Systems (IS4S)
- 9:35 **Challenges to Creating a Resilient-EGI (R-EGI):** Jacob Campbell, Morgan Raymond, AFLCMC/WNY; Barb Frantom, AFRL/RWYN; John Bowling, AFLCMC/EZ; Geneva West, Ray Simons, AFLCMC/WNY

#### Alternates

1. **PNT Open System Architecture:** David Selim, Honeywell Engineering & Technology
2. **Continuous Competition Design Agent (CCDA) for Acquisition of Resilient-EGI (R-EGI) Design:** Mikel M. Miller, John Larson, D. Bruce Simpson, James Moore, IS4S; Raymond Morgan, Jacob Campbell, Barb Frantom, John Rohde, USAF

## Session C6: Modeling and Simulation

### Ballroom D



Matthew Oliver  
LinQuest



Denice Jacobs  
AFRL Sensors Directorate

- 8:35 **Closing the Loop on Model Based Design: The Baro-Inertial Vertical Channel as a Case Study:** N. Datta, M. Braasch, Ohio University; C. P. Bruner, L. Murphy, M. Moelich, Northrop Grumman Mission Systems
- 8:55 **Modeling Tightly-coupled Receivers with GIANT:** Jacob Jost and Jim Fitch, LinQuest Corporation
- 9:15 **Tracking Phase Through the Polarization Efficiency Factor with Application to Precision Guided Munitions:** A. Tetewsky, J. Lozow, Draper; R. Scott Boughton, The Aerospace Corporation; G. Panas, D. Smith, Army; J. Fitch, LinQuest
- 9:35 **Navigation Warfare M&S Geolocation Algorithm Evaluation:** Robert Beckinger, Nora Lenhardt, Song Huang, and Liam Dobbins, C5ISR PNT

#### Alternates

1. **Performance Analysis of an Attitude-Based GPS Vector Tracking Loop:** Tanner Watts, Scott Martin, and David Bevely, Auburn University
2. **Real-world Performance of a GPS Interference Environment Inference Technique:** Dominic Antonacci, Walter Kuklinski, Chris Lathrop, Kevin Martin, and Robert Reynolds, The MITRE Corporation
3. **Real-Time Phase Alignment Enables Next Generation GNSS Wavefront Simulation:** Tim Erbes, Orolia Defense and Security

## Session D6: Application/Impact of PNT Technologies in the Homeland Critical Infrastructure

### Ballroom B



Jeremy Brown  
OSD R-E



John Edwards  
USCG CSISC

- 8:35 **AA Resilient National Timing Architecture:** Marc Weiss, Consultant; Patrick Diamond, RNT Foundation; Dana A. Goward, RNT Foundation
- 8:55 **A Multi-Level Approach for Integrating GNSS Integrity into Critical Timing Applications:** Josh Clanton, David Hodo, IS4S; John David Sprunger, and Scott Martin, Auburn University
- 9:15 **Out-of-Band Global Positioning Systems (GPS) Navigation Message Authentication (NMA):** Michael H. Cole, Ranwa Haddad and Karl L. Kovach, The Aerospace Corporation
- 9:35 **Resilient PNT Reference Architecture for Critical Infrastructure:** Patricia Larkoski, William Young, Bradley Moran, Fei Sun, Arthur Scholz, DHS HSEDI FFRDC, operated by The MITRE Corporation; Ernest Wong, DHS Science and Technology Directorate

#### Alternates

1. **How the West is Losing the Navigation and Timing War, and Risking Everything:** Dana A. Goward, Resilient Navigation and Timing Foundation
2. **How to (Easily) Ignore Geofencing of Protected Areas:** Threat, Demonstration, and Mitigation.: Jonathan Taylor, Orolia Defense & Security
3. **PNT Assessments of Critical Infrastructure – Find, Fix and Fortify:** Greg Gerten and Geoffrey Hella, KBR



Paul Olson  
Army CCDC CSISR



William Deike  
AFRL Sensors Directorate

## Session A7: Operational System Demonstrations 1

### Ballroom E

- 10:45 IS-1500® Motion Tracker for Dismounted, GPS-Optional PNT:** Richard Madison and Brian Haight, Thales Defense and Security, Inc.
- 11:30 Adaptive Detection and Mitigation of Evolving PNT Threats via Synchronized Threat Libraries, Open Architecture, and Real-time Measures of Trust and Risk:** Paul D'Angio, Jonathan Duntze, Randy Yamada, and Ibrahim Akbar, Booz Allen Hamilton



Jei Chen  
NIWC Pacific



Sean Memmen  
Booz Allen Hamilton

## Session B7: PNT Open Systems Architecture 2

### Ballroom C

- 10:50 PNT AgilePod Flight Test Experimentation:** Mark Smearcheck, Branden McNally, Andrew Cottle, Air Force Research Laboratory, Jacob Hoehler, Adriel Fillippini, University of Dayton Research Institute
- 11:10 Machine Learning based GPS Authentication for PNT Open Systems Architecture:** Stanley Radzevicius, Wilbur Myrick, and Brian Sexton, ENSCO, Inc.
- 11:30 Navy's Next Generation, GPNTS Hull Optimized System – Tactical (GHOST) for Smaller Maritime Platforms:** Eric Shuey, PEO C4I - PMW/A 170 GPS Navigation Division; Aaron Nascimento, NAVWAR; Chad Pinkelman, NIWC Pacific GPNTS; Glen Collins, Booz Allen Hamilton; Phong Bach, Hanh Nguyen, Brett Balazs, Steve Ouellette, Raytheon IDS
- 11:50 Open Architecture GPS Inertial Simulator for Assured-PNT Development and Testing:** Dien Nguyen and Alison Brown, NAVSYS Corporation

#### Alternates

1. Learning Sensor Models for Robust PNT: Clark Taylor, ANT Center, AFIT
2. R-EGI- A Peek Under the Hood of the DDPs (Detailed Design Prototypes): Jacob Campbell, Morgan Raymond, AFLCMC/ACS; Mikel Miller, John Larson, IS4S



Dr. Kari Moran  
NIWC Pacific



Dr. Ronald Polcawich  
DARPA

## Session C7: Inertial Measurement Unit (IMU)

### Ballroom D

- 10:50 Compact Short-Term Navigation Grade Quartz MEMS IMU:** Sergey Zotov and David Hoyh, EMCORE Corp. - Systron Donner Inertial
- 11:10 Dual-Use Navigation-Grade MEMS IMU:** Burgess R. Johnson, John Reinke, Markus Gnerlich, Curt Albrecht, Todd Braman, Patrick Duffy, Daniel Endean, Honeywell International
- 11:30 Fibernetics Inertial Measurement Unit:** Ralph Bergh, Fibernetics LLC
- 11:50 Miniature, Precision Inertial Navigator:** Zenon Melnyk and William J. Tortora, Collins Aerospace

#### Alternates

1. mHRG IMU for Improved Navigation in GPS Denied Environments: Phil Bruner, Albert Choi, Philip Clark, Michael Chavez, Farzin Dinyarian, Lawrence Linick, Daniel Rampacek, William Schellhorn, Alex Trusov, Cole Umemura, Northrop Grumman; Scott David, Michael Payne, Stephen Pethel, NTA; Patrick Renfro, US Army CCDC AvMC
2. Toward GPS Denied Inertial Navigation Using Hollow Core Fiber Based Resonator Fiber Optic Gyro (RFOG) Technology: Marc Smiciklas, Glen Sanders, Wes Williams Honeywell Inc.; Jeff Williams NTA Inc.; Patrick Renfro, US Army DEVCOM/AvMC
3. LN200HP (Compacted High Performance IMU) with High Gyro Bandwidth, Low Quantization Noise, ARW, and Gyro Bias Error: Steven Kim, Daniel Tazartes, Greg Zimmerman, Northrop Grumman
4. Benefits of Quadratically Tapered Flexures for Silicon MEMS Gyroscopes and Resonators: Brian E. Grantham, Technology Development Directorate; US Army CCDC, AMC; Redstone Arsenal; Jennifer M. English, University of Alabama in Huntsville



Karen Van Dyke  
US DOT/OST-R

## Session D7: PANEL: National Critical Infrastructure Threat

### Ballroom B



This 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. Mr. Ken Alexander, Chief Scientific and Technical Advisor for Satellite Navigation, Federal Aviation Administration
2. Dr. Andrew Hansen, Principal, Aviation Modeling & System Design, OST-R/Volpe Center, U.S. Department of Transportation
3. Mr. James Platt, Chief, Strategic Defense Initiatives, EMP/PNT/GMD Space Weather/Space Risks, CISA, U.S. Department of Homeland Security
4. Ms. Misty Finical, Deputy Principal Advisor, Enterprise Protection, National Aeronautics and Space Administration

Lunch in Event Center I: 12:15 p.m. - 1:30 p.m.



Joseph Schnecker  
NIWC Pacific



Brig. Gen. Steven Whitney  
Director, Space Programs  
– Assistant Secretary for  
Acquisitions, United States Air  
Force



Dr. Bradford Parkinson  
Stanford Center for PNT

Break in Exhibit Hall: 3:15 p.m. – 4:00 p.m., Sponsored by Raytheon

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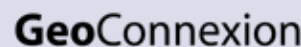
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## Session A8: Operational System Demonstrations 2

### Ballroom E

**4:00 GPS Jamming Training: SPACE JAM Update and Roadmap:** William Deike, Jeffrey Hebert, and Dan Drescher, AFRL/RYSW

**4:45 Using a GNSS Simulator to Output Inertial Sensor Data, via an Open-Source Plug-In Interface:** Jaemin Powell, Orolia Defense & Security



Dr. Jeff Hebert  
AFRL Sensors Directorate



Shawn Miller  
The MITRE Corporation

## Session B8: Software Defined Radios (SDRs) for PNT



### Room: Ballroom C

**4:05 Real-time SDR Implementation of a Deeply Coupled, High Integrity GNSS Receiver with pntOS Integration:** Luke Edwards, David Hodo, IS4S; Tanner Watts, Scott Martin, Auburn University; Greg Reynolds, Army DEVCOM AvMC

**4:25 Demonstration of Standalone Direct Acquisition of M-Code Capability:** Chun Yang, Andrey Soloviev, Ananth Vadlamani, QuNav; Joung C. Ha, AFRL/RYSW; Mathew Cosgrove, Taylor Schluter, Bo Halamandaris, Jeff Dickman, Northrop Grumman Mission Systems

**4:45 Performance Metrics and Advanced Capabilities of PyChips: An Easily Configurable Satnav SDR for Rapid Prototyping and Deployment:** Sanjeev Gunawardena, Air Force Institute of Technology

**5:05 Design and Test Results of a System-of-systems Open Architecture PNT (SOAP) Software Defined Radio:** Alison Brown, Jarrett Redd, Dien Nguyen, and Tom Silva, NAVSYS Corporation

#### Alternates

1. **Software Radio Prototype of a Frequency Hop Acquisition Using Secure Transec (FAST) Receiver:** Philip Dafesh and Eugene Grayver, The Aerospace Corporation
2. **Software Defined Radio Realization of Anti-jamming, Anti-spoofing and Situational Awareness:** Cedric Logan, Huan-Wan Tseng, Kyle Eaton, and Christopher Zarowski, Mayflower Communications Company, Inc.
3. **Plug and Play FPGA Implementation of a GPS Threat Detection, Mitigation, and Geolocating Unit:** Josh Starling, William Travis, IS4S; David M. Bevely, Auburn University; Greg Reynolds, DEVCOM Aviation & Missile Center

## Session C8: Autonomous Systems and PNT

### Ballroom D

**4:05 Intelligent Virtual Sensor Modeling for Assured PNT System:** Shahram Moafipoor, Brad Despres, Jeff A. Fayman, Lydia Bock, Bob Stadel Geodetics Inc., Geodetics Inc., An AEVEX Aerospace Company

**4:25 Accelerating Point Set Registration for Automated Aerial Refueling:** Ryan Raettig, Joel Miller, and Scott Nykl, AFIT

**4:45 Towards More Robust Vision-based Map Matching Through Machine Learning:** Tyler Hussey and Robert C. Leishman, AFIT/ANT Center

**5:05 Stereo Camera Calibrations with CNN-Based Optical Flow:** Joshua Larson, James Lynch, Scott Nykl, AFIT

#### Alternates

1. **Electromagnetic Interference Estimation via Conditional Neural Processing:** Edgar Gomez, KBR; Joseph Curro, US Air Force / AFIT
2. **Sensor Component Noise Parameter Extraction:** David Woodburn, Air Force Institute of Technology ANT Center
3. **Recurrent Neural Networks to Mitigate Visual Occlusion in Automated Aerial Refueling:** J. Isaac Nicholson and W. Blair Watkinson II, AFIT
4. **Protecting Drones from GPS Jamming: Enabling Robust BVLOS Operations:** Omer Sharar and Ben Sandford, InfiniDome



Dr. Robert Leishman  
Air Force Institute of Technology



Dr. J.P. Laine  
Draper

## Session D8: Antenna Technologies & Interference Mitigation for Robust PNT

### Room: Ballroom B

**4:05 Machine-learning Anti-Jam Interference Cancellation "MAJIC":** Phil Hess, Donna Branchevsky, Nathan Whitehair, Anson Lam, Adam Belhouchat, Alex Eapen, Terry Ferrett III, The Aerospace Corporation

**4:25 Miniature Multi-Band GNSS Antenna for SWaP-Constrained Applications and CRPAs:** Kathleen Fasenfest, Mike Taing, Edison Kuo, and Tam Nguyen, Antcom Corporation

**4:45 Multi-Array Panel Testing Results for a Dynamic Constellation Simulation System for Anechoic Chambers:** Josh Clanton and Josh Starling, IS4S; Lloyd Riggs, Auburn University

**5:05 Prototype and Demo of a GPS Interference Mitigation Module:** Chun Yang, Andrey Soloviev, QuNav; Mat Cosgrove, Nathan Duescher, Northrop Grumman; Gregory Reynolds, CCDC Aviation & Missile Center

#### Alternates

1. **Simultaneous Exploitation of Time, Spatial, and Polarization Domain Techniques to Mitigate Multipath and Inauthentic Signals for Civilian Satnav Applications:** Eric Hahn, Ohio University; Sanjeev Gunawardena, Air Force Institute of Technology; Chris Bartone, Ohio University
2. **Six Degrees of Freedom GPS Antenna Attitude Determination:** Robert Wellington, GPS6D; Jeremiah Shockley, The Perduco Group (a LinQuest owned company)
3. **Small SWaP 4-Channel GPS AJ System:** Cedric Logan and William LeComte, Mayflower Communications Company, Inc.



Dr. Manorama "Rama" Gollakota  
The Aerospace Corporation



Dr. Dontae Ryan  
DLR Technologies

Morning Coffee, 7:30 a.m. - 8:30 a.m., Sponsored by NAL Research

Morning Coffee, 7:30 a.m. - 8:30 a.m., Sponsored by NAL Research



Benjamin Wash  
Joint Navigation  
Warfare Center



Fay Spellerberg  
Joint Navigation  
Warfare Center



Fay Spellerberg  
Joint Navigation  
Warfare Center



Kevin Coggins  
Booz Allen  
Hamilton



Sean Memmen  
Booz Allen  
Hamilton



Benjamin Wash  
Joint Navigation  
Warfare Center



Fay Spellerberg  
Joint Navigation  
Warfare Center

## Session E9: JNWC FACILITATED PROGRAM (FEDCON U.S. ONLY):

8:30 a.m. – 10:10 a.m.  
8:30 a.m. Welcome

### Keynote:

8:45 a.m. - 9:30 a.m.



**Major General DeAnna M. Burt**

Commander, Combined Force Space Component Command, U.S. Space Command; and Deputy Commander, Space Operations Command, U.S. Space Force, Vandenberg Air Force Base, California

9:30 **JNWC Joint Assessment Program and Strategy:** Amanda Humphrey, DAF, JNWC

9:50 **Military Utility of a Reprogrammable SatNav Architecture:** Madeleine Naudeau, Air Force Research Lab; Logan Scott, LS Consulting; Jon Anderson, Renee Yazdi, Canyon Consulting; Jim Gillis, The Aerospace Corporation

Break, 10:10 a.m. - 10:50 a.m., Sponsored by Lockheed Martin

## Session E10: PANEL: Combatant Command Joint Urgent Operational Need (JUON): Warfighter Requirement and Solutions (FEDCON U.S. Only)



10:50 a.m. – 12:20 p.m.

This panel will present highlights of a current JUON to include requirements/funding, mission analysis, fielding, and effectiveness assessment. Discussion will also include use of modular capabilities to accommodate future expansion and modifications to address other combatant command needs and evolving threats.

### Panel Members:

1. Seth M. Anderson, MSgt, USAF, Manager, Jt SOF Threat Warning Sys Integration, USAF/645 AESS/361 ISRG OL-E
2. Brandon S. Shultz, SMSGT, USAF, Superintendent, Special Projects, USAF/645 AESS
3. Mark Phillips, Resonant Sciences
4. Benjamin Johnis, MSGT USAF USSOCOM SOCCENT

Lunch in Event Center 1 (First Floor), 12:20 p.m. - 1:30 p.m.

## Session E11: PANEL: Warfighters (FEDCON-U.S. Only)

1:50 p.m. – 3:20 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 who have had operational "in theater" experience in the past year will be solicited from all services.

### Panel Members:

- LCDR Harold J. Kiffer, NIS & GPS Division Chief, USCG Navigation Center
- CAPT Elizabeth Higgins, USN
- MAJ Gabe Wood, SF, Innovation Director, 7th Special Forces Group (Airborne)
- SGM Joshua Gendron, V Corps, US Army
- Lt Col Jonathan Ard, US Air Force
- Tech. Sgt. Jamie Ayinde, US Air Force

## Session E12: JNWC FACILITATED PROGRAM (FEDCON U.S. ONLY)

3:20 p.m. – 5:10 p.m.

3:20 **Civil Aviation Low Cost GPS Spoofer Threats:** Ken Alexander, Federal Aviation Administration

Break: 3:40 p.m. - 4:10 p.m., Sponsored by Northrop Grumman

4:10 **Advanced Anti-Access Area Denial Threats to US GPS Systems:** Connor L. Brashar, Brian Schaffer, Tucker Haydon, Prabodh Jhaveri, Sandia National Laboratories; Mark Page, Kevin Martin, The MITRE Corporation

4:30 **NAVWAR Sensor – Test Results, Maturation and Tech Transition:** Dana Howell and Denice Jacobs, Air Force Research Laboratory (AFRL/RYWN)

4:50 **Spectral Compression for Remote Signal Monitoring of GPS M-code:** Jordan Cameron, Russell Friesenhahn, Benjamin Glass, Peter Hokanson, Scott Jones, Andrew Joplin, Aaron Kerkhoff, Brian Mechler, Christopher Nail, Adam Williamson, and Johnathan York, ARL, The Univ. of Texas at Austin

## NOTICE:

**Friday Program to be Held at FEDCON Level. SECRET Materials Distributed via SIPRnet**

Due to capacity restrictions and time restraints as a result of the COVID environment, JNC's Friday technical program, previously planned to be held at the SECRET level, will now be held at FEDCON US-only at the Northern Kentucky Convention Center. Presentation briefing materials and oral remarks will be delivered in a FEDCON US-only environment.

The Joint Navigation Warfare Center (JNWC), the JNC's DOD sponsor, will be hosting the classified/SECRET materials associated with the briefings on the DOD's Secret Internet Protocol Router Network (SIPR Net) on the JNWC's home page for eligible attendees to access through authorized protocols.

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