The 27th International Technical Meeting of the Satellite Division of The Institute of Navigation

ION GNSS+ 2014
GNSS+ Other Sensors in Today’s Marketplace

Tutorials: September 8 - 9 • CGSIC Meeting: September 8 - 9

Registration Hours
Monday, September 8 8:00 a.m. - 7:00 p.m.
Tuesday, September 9 8:00 a.m. - 7:00 p.m.
Wednesday, September 10 8:00 a.m. - 12:15 p.m. and 1:45 p.m. - 5:00 p.m.
Thursday, September 11 8:00 a.m. - 12:15 p.m. and 1:45 p.m. - 5:00 p.m.
Friday, September 12 8:00 a.m. - 12:00 p.m.

Mobile Conference Site
Access the ION GNSS+ program and other conference information on your mobile device. Point your mobile browser to m.ion.org.

Connectivity
Complementary internet is being provided in all public lobby areas by ION GNSS+. Connect to the "ION 2014" wireless network closest to your location.

Customize Your Conference Schedule
Once you are registered for the conference, visit the ION website to build a customized schedule of conference papers you wish to attend. Visit the ION GNSS+ program at www.ion.org/gnss for details.

Technical Paper Copies Online
Registered attendees may download copies of technical papers online for FREE. Papers can be accessed by logging into your ION web account at www.ion.org/gnss. Only papers provided to the ION by the presenting author will be available. If a desired paper is not available, we recommend you contact the author directly.

Conference Proceedings
Official conference proceedings are scheduled for distribution in November to all eligible conference participants.

Self-Service Business Area
The use of computers, a printer and a copier is being provided on a self-service basis in the ION registration lobby. Internet access is not available on these computers. For Internet access, please use the computers in the Internet Access Center. As a courtesy to others, please limit your time when others are waiting.

Important Safety Information
The Tampa Convention Center is a public building. Attendees are encouraged to keep their personal property in their possession at all times and not assume that their personal belongings will be safe if left unattended.

Photographs/Video Recording
Your presence at ION GNSS+ constitutes your agreement to be photographed, filmed, videotaped or otherwise recorded in connection with the conference and your agreement that your name, voice and likeness may be broadcast, distributed or displayed in connection with any program created from the conference without any compensation being paid to you.

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www.ion.org

Flash photography, personal video and audio taping of the sessions are prohibited. As a courtesy to others, please set your cell phones to vibrate.
THANK YOU TO OUR EVENT SUPPORTERS:

Internet Access Center

Self-Service Business Center

ION GNSS+ Mobile Application

Tampa Convention Center
Parking: $1.60 per hour.
Details on page 30.
## Monday Morning Concurrent Subcommittees, September 8, 2014

**Room 24**

**International Information Session**

John Wilde, DW International, Chair

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<tr>
<td>09:00</td>
<td>Introduction – John Wilde, CEO DW International, UK</td>
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<td>09:05</td>
<td>International Committee on GNSS Activities – Sharafat Gadimova, Programme Officer, Office for Outer Space Affairs, United Nations</td>
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<tr>
<td>09:30</td>
<td>Offshore GPS Requirements and Utilization for the Gulf of Mexico – Stephen M. Browne, Executive Vice President – Commercial, Veripos (US) Inc.</td>
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<tr>
<td>10:00</td>
<td>GNSS applications in Sweden and on-going developments of the national CORS network SWEPoS – Dan Norin, Geodesist, Lantmäteriet, Geodetic Department (Swedish Mapping, Cadastral and Land Registration Authority)</td>
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<tr>
<td>10:30</td>
<td>Break</td>
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<tr>
<td>11:00</td>
<td>Pre-announcement of Kyoto GPS/GNSS Symposium, 2015 fall – Mr. Seiji Anai, Secretary of JGPSC</td>
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<tr>
<td>11:20</td>
<td>Detecting GPS Jammers “Gone in 20 Seconds” – Prof. Charles Curry, Managing Director, Chronos Technology Ltd</td>
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<tr>
<td>11:40</td>
<td>Authorization and Operation of GNSS Aviation Services in Non-Core-Constellation States - Gerhard Berz, EUROCONTROL</td>
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<tr>
<td>12:00</td>
<td>Discussion Q&amp;A</td>
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<td>12:30</td>
<td>Session End</td>
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**Room 25**

**U.S. States and Local Government Session**

James Arnold, U.S. Department of Transportation, Chair

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>09:00</td>
<td>Introductions</td>
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<tr>
<td>09:05</td>
<td>Vulnerability Assessment to Determine Potential Impacts of Sea Level Rise on Transportation Infrastructure and Associated Assets – Joseph White, Maryland State Highway Administration</td>
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<tr>
<td>09:30</td>
<td>Connected Vehicles – Mike Lukuc, National Highway Traffic Safety Administration</td>
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<tr>
<td>10:00</td>
<td>The Automotive Sector: Extending State Networks to Support Vehicle Safety Requirements – David Kelley, Subcarrier Systems Corporation</td>
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<td>10:30</td>
<td>Break</td>
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<tr>
<td>11:00</td>
<td>Briefing from Tampa Bay Pilots Association</td>
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<td>11:30</td>
<td>States and Local Government Reports</td>
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<td>12:00</td>
<td>Discussion Q &amp; A</td>
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## Monday Afternoon Concurrent Sessions, September 8, 2014

**Room 24**

**Timing Session**

Dr. Wlodzimierz Lewandowski, ESA Navigation Program Board, Chair

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<tr>
<td>14:00</td>
<td>Introduction – Wlodzimierz Lewandowski, ESA Navigation Program Board</td>
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<td>14:20</td>
<td>Report from NIST – Victor Zhang, NIST</td>
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<td>14:40</td>
<td>Report from USNO – Demetrios Matsakis, USNO</td>
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<tr>
<td>15:00</td>
<td>Report from APL – Mihran Miranian, APL</td>
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<tr>
<td>15:20</td>
<td>Coffee Break</td>
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<tr>
<td>15:40</td>
<td>The NTSC contribution to BeiDou System Time – LU Xiaochun, WU Haitao, NTSC</td>
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<tr>
<td>16:00</td>
<td>Modelling the GPS+Galileo+Egnos Constellation – Mathias Suess, DLR</td>
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<td>16:20</td>
<td>A Common Clock Reference For All GNSS – Tom Stansell, Stansell Consulting</td>
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<tr>
<td>16:40</td>
<td>Discussion</td>
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<td>17:30</td>
<td>Session End</td>
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**Room 25**

**Surveying, Mapping, and Geosciences Session**

Giovanni Sella, NOAA-National Geodetic Survey, Chair

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<tr>
<td>14:00</td>
<td>CORS Status – Francine Coloma and Giovanni Sella, NOAA-NGS</td>
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<td>14:15</td>
<td>OPUS Updates and Future Geometric Datum – Joe Evjen, NOAA, National Geodetic Survey</td>
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<td>14:35</td>
<td>The eGPS RTN History and Lessons Learned – Lonnie Sears – eGPS</td>
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<td>14:55</td>
<td>Florida Permanent Reference Network (FPRN): State of the Network – Ron Hanson, Florida Department of Transportation</td>
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<tr>
<td>15:20</td>
<td>Break</td>
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<tr>
<td>15:40</td>
<td>Gulf Coast Subsidence and Greenland Melting: The Role of Satellite Geodesy – Tim Dixon, University of South Florida in Sea Level Rise Studies</td>
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<tr>
<td>16:00</td>
<td>Earthquake Cycle in Nicoya Peninsula Costa Rica – Nich Voss and Rocco Maiservisi, University of South Florida</td>
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<td>16:20</td>
<td>NRCAN Precise Point Positioning (PPP) Service – Ken MacLeod, Natural Resources Canada</td>
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<td>17:00</td>
<td>General Questions</td>
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<td>17:30</td>
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54th Meeting of the
Civil GPS Service Interface Committee
at the ION GNSS+ 2014 Conference
Tampa Convention Center • Tampa, Florida
September 8 - 9, 2014
The CGSIC is open and free to all ION GNSS+ registrants

Tuesday, September 9, 2014

Room 24/25
09:00-12:00
CGSIC Plenary Session A

09:00 Welcome/ Opening – Karen Van Dyke, U.S. Department of Transportation, Chair, CGSIC
09:05 Meeting Overview – Captain William Burns, Commanding Officer U.S. Coast Guard Navigation Center (NAVCEN), Deputy Chair
09:10 Key Note Address – Brigadier General Ronald Huntley, Director of Plans, Programs & Analyses, U.S. Air Force Space Command
09:30 U.S. National Space-Based PNT Update – Jason Kim, Senior Advisor, National Coordination Office for Space-Based Positioning, Navigation, and Timing
09:50 GPS Program Update – Colonel Matthew Smitham, Deputy Director, U.S. Air Force GPS Directorate
10:10 GPS Constellation Status and Performance – Lieutenant Colonel Todd Benson, Commander, U.S. Air Force Second Space Operations Squadron
10:30 Break
10:45 GPS International Activities – Ray Clore, GNSS Senior Advisor, U.S. Department of State, Office of Space and Advanced Technology
11:35 Q/A Panel

12:00 – 13:30 Lunch

Room 24/25
13:30-17:30
CGSIC Plenary Session B

13:30 Subcommittee Reports
   Report from International Information Subcommittee - John Wilde, DW International
   Report from Timing Subcommittee - Dr. Wlodzimierz Lewandowski, ESA Navigation Program Board
   Report from U.S. States and Local Government Subcommittee – James Arnold, DOT
   Report from Surveying, Mapping, and Geosciences Subcommittee – Giovanni Sella, NGS
14:10 WAAS and LAAS Program Status – Deborah Lawrence, Navigation Programs Manager, Federal Aviation Administration, U.S. Department of Transportation
14:40 NDGPS Program Update – James Arnold, U.S. Department of Transportation
14:50 Supporting GNSS Users With Products to Help Identify and Mitigate the Impacts of Space Weather – Mr. Rodney Viereck, Director, Space Weather Prediction Test-bed, NOAA, Space Weather Prediction Center
15:10 GPS Adjacent Band Compatibility Assessment – Karen Van Dyke, Director of PNT, U.S. Department of Transportation
15:30 Break
15:50 User Support Forum – Hank Skalski, Civil GPS Liaison to Air Force Space Command
16:10 GPS User Perspectives
17:00 Q/A Panel (Presenters)
17:30 Adjourn
The ION GNSS+ pre-conference tutorials have been organized to provide in-depth learning of specific GNSS related disciplines prior to the start of the technical program. All courses will be taught in a classroom setting at the Tampa Convention Center by some of the world’s leading GNSS educators.

Paper course notes will be provided to attendees by the instructor on the day of the course. Electronic notes will be made available from the meeting website. Note that power will NOT be made available to course attendees for individual laptop computers; please come prepared with adequate battery power if required. It is also recommended that attendees dress in layers to accommodate varying temperatures in the facility.

### Tutorial Cost:
$375 per course unit if registered and paid by August 15; $425 per course payment received after August 15. Please reference the ION GNSS+ registration form for other registration policies.

### Registration:
Registration for the ION GNSS+ tutorials is accomplished online through the normal conference registration process. ION reserves the right to cancel a tutorial if adequate registration is not obtained. If a course is cancelled, the full cost of the course will be refunded via the original payment method.

### ION GNSS+ 2014 TUTORIALS SCHEDULE

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<td>Monday, September 8, 2014</td>
<td><strong>1:30 p.m. – 5:00 p.m.</strong> Select from:</td>
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<td></td>
<td>Fundamentals of GNSS 1 with Emphasis on GPS</td>
<td>Dr. Chris Bartone</td>
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<td>GNSS Receiver Design 1: RF Front-End Theory and Design</td>
<td>Dr. Sanjeev Gunawardena</td>
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<td>Kalman Filter Applications to Integrated Navigation 1</td>
<td>Dr. Frank van Graas and Dr. James L. Farrell</td>
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<td><strong>6:00 p.m. – 9:30 p.m.</strong> Select from:</td>
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<td>Fundamentals of GNSS 2 with Emphasis on GPS: User Functions, Solutions &amp; Performance</td>
<td>Dr. Chris Bartone</td>
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<td>GNSS Receiver Design 2: Baseband Signal Processing and Implementation</td>
<td>Dr. Sanjeev Gunawardena</td>
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<td>Kalman Filter Applications to Integrated Navigation 2</td>
<td>Dr. Frank van Graas and Dr. James L. Farrell</td>
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<tr>
<td>Tuesday, September 9, 2014</td>
<td><strong>9:00 a.m. – 12:30 p.m.</strong> Select from:</td>
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<td>Introduction to Multi-Constellation GNSS Signals</td>
<td>Dr. Christopher J. Hegarty</td>
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<td>RTK GNSS Positioning</td>
<td>Dr. Mark Petovello</td>
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<td>Introduction to GNSS Remote Sensing: Reflectometry and Radio Occultation</td>
<td>Dr. James Garrison</td>
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<td></td>
<td>Inertial Navigation – Sensors, Algorithms, and Performance</td>
<td>Dr. Mike Veth</td>
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<td><strong>1:30 p.m. – 5:00 p.m.</strong> Select from:</td>
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<td>GNSS Effects for Aviation</td>
<td>Dr. Todd Walter</td>
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<td>Precise Point Positioning</td>
<td>Dr. Sunil Bisnath</td>
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<td>Ubiquitous Positioning</td>
<td>Prof. Dorota Grejner-Brzezinska &amp; Prof. Terry Moore</td>
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<td>Image Aided Inertial Navigation – Design, Analysis, and Alternatives</td>
<td>Dr. Mike Veth</td>
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<td>The Ionosphere and its Effects on GNSS</td>
<td>Patricia Doherty</td>
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**Fundamentals of GNSS 1 with Emphasis on GPS**

Room 16

Dr. Sanjeev Gunawardena

This course emphasizes the fundamentals of GNSS with major emphasis on GPS. The course will begin with an overview of GNSS and GPS. Presentation of coordinate frames and spread spectrum techniques used in GNSS will be illustrated. GPS signal structure and navigation data formats (legacy and modernized) will be discussed. (Only a brief over of other GNSS such as Galileo, Glonass, BeiDou, and QZSS will be presented.) This course will conclude with an overview of GNSS antenna and receiver technologies. Topics to be covered include:

- Introduction to positioning systems
- A brief historical timeline of GNSS
- GPS Segments
- Space segment and SV blocks
- Ground control & improvement programs;
- User segment and applications
- GPS Link Budget
- Fundamental concept of GNSS position and time determination
- Coordinate frames and datum's used in the application of GNSS
- Earth Centered Inertial
- Earth Centered Earth Fixed
- Latitude, Longitude, Height
- Height: MSL/Orthometric height, Ellipsoidal height, Geoid Undulation
- WGS-84 and the International Terrestrial Reference Frame
- Local Level Tangent
- Coordinate Conversion
- GNSS signal structure formats; legacy and modernized signals
- Direct Sequence Spread Spectrum; auto and cross correlation;
- Legacy GPS: C/A, P(Y) code formats
- Motivation for modernized signal formats
- Modernized GPS
- L2C signal format, status
- L5 signal format, status
- L1C signal format, status
- Other GNSSs (Galileo, Glonass, BeiDou,QZSS)- brief overview
- GPS Navigation Message Data Format Descriptions
- NAV, CNAV, CNAV-2
- Overview of GNSS antenna technologies
- Antenna technologies vs. performance vs. application
- Applications in space, aviation, survey, consumer, automotive, general purpose
- Antenna Technologies: dipoles, helix, patches, multi-band GNSS
- Ground plane effects, choke rings, and the like
- Overview of GNSS receiver technologies
- Carrier tracking loops (frequency and phase lock loops)
- Code tracking loops (order and delay variations)

**GNSS Receiver Design 1: RF Front-End Theory and Design**

Room 15

Dr. Sanjeev Gunawardena

This is the first of a two-part sequence covering the design and practical implementation of GNSS receivers using the latest RF and digital signal processing technologies. Topics to be covered are applicable to a wide range of GNSS user equipment design. The course begins with reference receivers through aviation-grade, military and low-power consumer-grade single-chip devices. Material will be presented from both a theoretical and practical perspective, with case studies as well as overviews of the latest commercial GNSS chipsets. This course includes several software demos designed to enhance understanding of concepts. A demo toolbox is available through the instructor's blog for those wishing to follow along in class (min system requirements: Windows® XP and MATLAB® 2007b). This section (Part 1) covers the design of GNSS RF front-ends from LNA to ADC. Topics to be covered include:

- Overview of received GNSS signals: Link budget and system noise figure, signal structures, PSD, spreading codes and their auto and cross-correlation properties.
- Front-end architectures: Superheterodyne vs. direct conversion, analog vs. digital downconversion, baseband vs. IF sampling, and direct RF sampling.
- RF/IF component parameters important to GNSS signal processing including selection guidelines.
- Implementation intricacies: Factors affecting the performance of GNSS receivers such as passband group delay variation and component-induced multipath.
- Sampling subsystem: AGC, ADC specifications and dynamic range considerations.
- GNSS front-end implementation options including PCB-level design and commercial GNSS MMICs.
- Software signal simulation demos for: GPS (L1-C/A, L1C, L2C, and L5), GLONASS (L1, Galileo (E1B/C, E5a, and E5b) and BeiDou (B1I and B2I).

**Kalman Filter Applications to Integrated Navigation 1**

Room 14

Dr. Frank van Graas

Dr. James L. Farrell

The focus of this course is on the basic theory, an intuitive understanding as well as practical considerations, for the design and implementation of Kalman filters. Although many new types of filters are published in the literature, the Kalman filter is still the optimal and most efficient solution for the majority of integrated navigation systems. The course will start with a review of statistics and detailed insights into the most important noise processes, including random walk and Gaussian white noise processes. This will be followed by a review of state variables and an overview of Kalman filters, including linear, linearized and extended filters. Matlab®-based examples are provided to facilitate hands-on experience with Kalman filters for integrated navigation applications. For those having no previous experience with modern estimation, a review of fundamentals will be included. Linear systems are characterized in terms of (1) a vector containing the minimum number of independent quantities required to define its state at any instant of time and (2) a matrix expression capable of propagating that state from one time to another. In combination with expressions relating measurements to states, a standard cycle is formed whereby a system’s entire time history is continuously produced, with the best accuracies achievable from any combination of sensors, extravagant or austere, providing any sequence of measurements that can be incomplete, intermittent and indirect, as well as accurate. That already wide versatility is broadened further by straightforward extension to systems with nonlinearities (Extended Kalman Filter (EKF)) which has proved adequate for a host of applications (including some to be discussed in this tutorial). The relation between Kalman (sequential) and block (weighted least squares) estimation will be illustrated, and a number of important subtleties that often go unrecognized will be uncovered.

**Course Level: Beginner to Intermediate**

(The course is at the beginner-level and will enhance understanding of the principles of filtering at the beginner and intermediate levels.)

Dr. Frank van Graas is a Fritz J. and Dolores H. Russ Professor of Electrical Engineering at Ohio University, where he has been on the faculty since 1988. He is an Ion past president 1998-99 and currently serves as the Ion treasurer. He served as the Ion’s Executive Branch Science and Technology Policy Fellow in the Space Communication and Navigation Office at NASA Headquarters during the 2008-2009 academic year. At Ohio University, his research includes GNSS, inertial navigation, low-frequency signals, Ladar/EO/IR, and space communications system design. As president and technical director of VIGIL INC, he continued his teaching and consulting on inertial navigation and tracking for private industry, DOD, and university research.

Dr. James L. Farrell is an Ion Fellow and author of over 80 journal and conference manuscripts. He authored *Integrated Navigation* (Academic Press, 1976) and *GNSS Aided Navigation and Tracking* (2007). His technical experience includes teaching appointments at Marquette and UCLA, two years each at Minneapolis Honeywell and Bendix-Pacific, and 31 years at Westinghouse in design, simulation, and validation/test for modern estimation algorithms in navigation and tracking applications, and digital communications system design. As president and technical director of VIGIL INC, he continued his teaching and consulting on inertial navigation and tracking for private industry, DOD, and university research.
Fundamentals of GNSS 2 with Emphasis on GPS: User Functions, Solutions and Performance

Room 16

This course emphasizes the fundamentals of GNSS user function solutions, error characterization, and mitigation with major emphasis on GPS. The core functions that need to be performed in obtaining a user solution using GPS in an error free environment will be initially be explained. Atmospheric effects from the ionosphere and troposphere as well as error mitigation techniques from a stand-alone GNSS user perspective will be covered. Additional error mitigation techniques will be covered including differential techniques. A case study using real GPS data will be used throughout the course to illustrate user solution with-instrument performance metrics (i.e., error, DOPs) for stand-alone (without atmospheric corrections), with atmospheric corrections, and differential positioning. Topics to be covered include:

- GNSS Observables: code, carrier, and date formats
- RINEX formats
- NMEA formats and messages
- Manufacture unique file formats
- Calculation of the GPS space vehicle (SV) position using the broadcast ephemeris parameters (ephemeris and almanac) with GPS NAV message data.
- SV clock, relativistic, and single-frequency corrections
- Transit time (i.e., Earth rotation) correction
- GPS Time Considerations: GPS week number, time of week, local time, UTC, and the leap second
- Calculation of user state (i.e., position, velocity, and time)
- Ordinary-least squares solution (un-weighted and weighted)
- Associated user solution performance parameters (i.e., dilution of precision terms)
- Case Study: Stand-alone performance illustration (no atmospheric corrections)
- Atmospheric Errors ("stand-alone" perspective)
- Ionosphere error sources and characterization, models and mitigation using dual-frequency and single-frequency techniques.
- Troposphere error sources and characterization, models and mitigation;
- Case Study: Stand-alone performance illustration (with atmospheric corrections)
- GPS error budget
- Error characterization for a "stand-alone" user
- Satellite orbit and clock errors
- Signal multipath error characterization, analysis, and mitigation techniques
- Code-minus-Carrier and Code-Carrier-Divergence Analysis
- Smoothing (single- & dual-frequency methods)
- General types of augmentation; (PPP, A-GPS, DGNS)
- Differential GNSS and different ways to implement it
- Correction-based methods
- Illustrated DGPS examples
- Measurement-based methods
- Single, double, and triple differencing techniques
- Case Study: DGPS performance illustration

Course Level: Beginner to Intermediate

This course is more advanced than a simple user’s introductory course; but not too detailed for the beginner.

Dr. Chris Barton

Dr. Frank van Graas

Dr. James L. Farrell

GNSS Receiver Design 2: Baseband Signal Processing and Implementation

Room 15

This is the second of a two-part sequence covering the design and practical implementation of GNSS receivers using the latest RF and digital signal processing technologies. Topics to be covered are applicable to a wide range of GNSS user equipment. Design from reference receivers through aviation-grade, military, and low-power consumer-grade single-chip devices. Material presented from both a theoretical and practical perspective with case studies as well as overviews of the latest commercial GNSS chipsets. This course includes several software demos designed to enhance understanding of concepts. A demo toolbox is available through instructor’s blog for those wishing to follow along in class (min system requirements: Windows® XP and MATLAB® 2007b). This section (Part 2) covers digital signal processing significant implementation throughput of the formation of range measurements and the implementation of these techniques using hardware, software, or reconfigurable logic (i.e. FPGA) processors. Topics to be covered include:

- Overview of received GNSS signals: Signal structures of GPS, GLONASS, Galileo and Beidou.
- Signal correlation: Time, frequency and transform-domain techniques. Advanced correlator architectures for multi-path mitigation and signal deformation monitoring.
- Complexity reduction for realtime implementation and impacts thereof.
- Signal acquisition algorithms and statistics, fast acquisition techniques, transition to tracking, bit/symbol synchronization, and state machine-based low-level channel control.
- Tracking: FLL/PLL and DLL, loop tightening techniques, noise bandwidth, tracking performance, block (batch) processing and open-loop tracking techniques.
- Measurement computation: Navdata extraction/decoding, TOT/TOR registers, and formation of pseudorange and carrierphase.
- Implementation techniques and platforms from MATLAB® to dedicated hardware.
- Software signal acquisition and tracking demos for: GPS (L1-C/A, L1C, L2E, and L5), GLONASS (L1), Galileo (E1B/E5a, E5a, and E5b) and Beidou (B1I and B2I).

Course Level: Beginner to Intermediate

Dr. Sanjeev Gunawardena

In this course, integration of GPS with an Inertial Measurement Unit (IMU/INU) will be used to illustrate the application of Kalman Filtering to integrated navigation. The course will start with a brief summary of the Kalman Filter followed by the steps required to implement the filter, including the selection of the state variables, observability, error sources, sensor bandwidth, update rate, time synchronization, lever arm, and identification of the noise processes. At the conclusion of the course, participants should be able to understand the underlying principles that lead to the successful design and implementation of Kalman filters for integrated navigation applications.

The approach presented offers a major benefit enabled by a departure from IMU/INU integrations. Precise carrier phase observations one second apart provide streaming velocity for dead reckoning, yielding huge improvement in multiple aspects of performance (robustness, integrity, interoperability, insensitivity to below-mask ionospheric and tropospheric degradations, etc.). Flight-verified cm/sec velocity performance, including an instance of zero elevation above horizon, will be shown. Of crucial significance, integration with a low-cost IMU will be shown to be sufficiently dramatic to conclude that there is little reason not to use it.

The course is designed to follow Kalman Filter Applications to Integrated Navigation 1 and Inertial Navigation, and will also be beneficial to intermediate-level attendees who are familiar with filtering concepts and inertial navigation principles.

Kalman Filter Applications to Integrated Navigation 2

Room 14

Dr. Frank van Graas is a Fritz J. and Dolores H. Russ Professor of Electrical Engineering at Ohio University, where he has been on the faculty since 1988. He is an ION past president 1998-99’ and currently serves as the ION treasurer. He served as the ION’s Executive Branch Science and Technology Policy Fellow in the Space Communication and Navigation Office at NASA Headquarters during the 2008-2009 academic year. At Ohio University, his research includes GNSS, inertial navigation, low-frequency signals, LADAR/EO/IR, surveillance and flight test. He is an ION Fellow and has received the ION’s Johannes Kepler (1996), Distinguished Service (1999), Colonel Thomas L. Thurlow (2002), and Dr. Samuel M. Burka (2010) awards.

Dr. James L. Farrell is an ION Fellow and author of over 80 journal and conference manuscripts. He authored Integrated Aircraft Navigation (Academic Press, 1976) and GNSS Aided Navigation and Tracking (2007). His technical experience includes teaching appointments at Marquette IMU and UCLA, two years each at Minneapolis Honeywell and Bendix-Pacific, and 31 years at Westinghouse in design, simulation, and validation/test for modern estimation algorithms in navigation and tracking applications, and digital communications system design. As president and technical director of VIGIL INC. he has continued his teaching and consulting on inertial navigation and tracking for private industry, DOD, and university research.
TUTORIALS

Introduction to Multi-Constellation GNSS Signals
Room 15

This course provides an overview of multi-constellation GNSS signals. Digital modulation techniques used for satellite navigation systems are described, including direct sequence spread spectrum (DSSS), binary offset carrier (BOC), and variants. Important physical link characteristics are discussed such as pseudorandom noise codes, autocorrelation/cross-correlation properties, power levels, and polarization. Common features found in modern GNSS signal designs are introduced including dataless (pilot) components, square-wave subcarriers, secondary codes, forward error correction, and error detecting coding. An overview of multiplexing techniques, which enable the transmission of multiple GNSS signals from the same satellite, is provided. Such techniques include code division multiple access (CDMA), frequency division multiple access (FDMA), time division multiple access (TDMA), quadrature shift keying, interplexing, majority vote, and variants.

The present and future signals of the Global Positioning System (GPS), including C/A-code, P(Y)-code, L2 civil (L2C), L5, M-code, and L1 civil (L1C) are detailed, as are the signals for GLONASS, GALILEO, BeiDou, satellite-based augmentation systems (SBAS), and other emerging satellite navigation systems. Key factors that motivated the signal designs are identified. Guidance is provided on obtaining publicly available signal specifications for each GNSS constellation.

This class is intended for anyone with an interest in better understanding multi-constellation GNSS signals including researchers, design engineers, application developers, end-users, systems engineers, managers and executives. Attendees are assumed to have a familiarity with the basic concepts of satellite navigation.

Course Level: Beginner to Intermediate

Dr. Christopher J. Hegarty is the Director for CNS Engineering & Spectrum with The MITRE Corporation. He is the chair of RTCA’s Program Management Committee, co-chair of RTCA Special Committee 159, and associate editor of NAVIGATION. He was the recipient of the 2005 ION Johannes Kepler Award and served as ION President in 2008. He is a Fellow of the ION, the IEEE, and the co-author of Understanding GPS: Principles and Applications, 2nd Edition.
Tuesday Morning, September 9 – 9:00 a.m. – 12:30 p.m.

**RTK GNSS Positioning**

Room 14

This course will introduce the key principles associated with high accuracy real-time kinematic (RTK) GNSS positioning. After briefly reviewing the relevant concepts of GNSS positioning, the course will present the different measurements and error sources that limit positioning accuracy. The geographic and temporal variability of the errors will be addressed, as appropriate.

Once the GNSS errors are understood, focus will turn to mitigation of these errors through measurement differencing and linear measurement combinations. The motivation for these approaches will be explained in the context of trying to resolve the carrier phase ambiguities. To this end, ambiguity resolution strategies in the position and ambiguity domains will be discussed. Mathematical formulations for the various approaches are introduced. Geometry-free ambiguity resolution is discussed along with its advantages and disadvantages relative to geometry-based approaches. The benefit of using different linear phase combinations and/or ambiguity values will be presented.

The course will conclude with a look at how to predict the success of the ambiguity resolution process, the role of additional frequencies and systems in ambiguity resolution, and a brief look at multiple reference station approaches. Case studies will be included in electronic format only.

Users and programmers will gain knowledge in the wide range of aspects that need to be considered when trying to achieve high positioning accuracy with GNSS.

**Course Level: Beginner to Advanced**

Dr. Mark Petovello is a professor in the Department of Geomatics Engineering, University of Calgary. Since 1998, he has been involved in various navigation research areas including satellite-based navigation, inertial and dead-reckoning navigation, ambiguity resolution, reliability analysis and software-based GNSS receivers. He has extensive experience in navigation algorithm development, implementation and refinement, and is co-creator of several navigation-related software packages. Dr. Petovello has received several awards for his research and teaching.

**Introduction to GNSS Remote Sensing: Reflectometry and Radio Occultation**

CANCELLED

**Inertial Navigation – Sensors, Algorithms, and Performance**

Room 16

In this overview course, the student will learn the fundamentals of inertial navigation sensors and systems and strategies for integrating these sensors into multi-sensor navigation systems. The course will begin with an introduction to inertial navigation, and a discussion of accelerometer and gyroscope design, operation, and error sources. Next, the applicable coordinate frames will be presented and the WGS-84 Earth Model will be explained. Strapdown mechanization algorithms are developed along with applicable error models. Strategies for integrating inertial sensors with other sensors will be presented and compared including various position, velocity, and attitude update examples. Both feed-forward and feedback Kalman filters will be compared. Concepts are illustrated using multiple Matlab-based examples, which are provided to each student on CD. The course will conclude with a discussion of future technology developments and their impacts on the field.

**Course Level:** This course will be presented at a conceptual level and is appropriate for engineers, managers, and executives in the navigation and military industries who are interested in inertial navigation techniques and strategies for implementing these methods into existing products.

Dr. Mike Veth is the co-founder of Veth Research Associates where he provides expert consultation on alternative navigation and control topics. His research focus is applying nonlinear estimation theory to optimally fuse inertial sensors with non-traditional navigation sources for truly robust non-GNSS navigation and control applications. He received his BS EE from Purdue University and a PhD EE from the Air Force Institute of Technology. Dr. Veth has authored over 40 technical articles and book chapters in areas relating to computer vision, navigation, and control theory. He is a member of the ION, a Senior Member of the IEEE, and a graduate of the US Air Force Test Pilot School.
This course will describe the use of Global Navigation Satellite Systems (GNSS) to support air navigation. Particular attention will be paid to challenges that can affect the availability and safety of GNSS based navigation. The currently operating systems that augment the Global Positioning System (GPS) will be described. These are Aircraft Based Augmentation Systems (ABAS), Ground Based Augmentation Systems (GBAS), and Satellite Based Augmentation Systems (SBAS). They support differing flight operations and different regions of operations. Each method is described in detail and how it overcomes the challenges to provide suitable guidance.

The main GNSS feared events that must be overcome are satellite faults, ionospheric effects, tropospheric effects, and local reflections of the signals at the aircraft. This course will describe each effect in detail and how they are addressed by each augmentation system. Aircraft navigation is judged by four criteria: accuracy, integrity, continuity, and availability. How well each system performs on these metrics will be described. Emphasis will be placed on describing the feared events and the integrity monitors that prevent them from affecting the aircraft. The course will conclude with a discussion on the future direction of these augmentation systems utilizing new signals and new GNSS constellations.

**Course Level: Beginner to Intermediate**

Dr. Todd Walter is a Senior Research Engineer in the Department of Aeronautics and Astronautics at Stanford University. His research focuses on implementing high-integrity air navigation systems. He is active in the international standards bodies coordinating the use of Global Navigation Satellite Systems to implement these systems. He was awarded the ION Thurlow and Kepler awards. He is also a fellow of the ION and has served as its president.
Ubiquitous Positioning

CANCELLED

Image Aided Inertial Navigation – Design, Analysis, and Alternatives

Room 16

Dr. Mike Veth

This course builds upon the concepts presented in Inertial Navigation: Sensors, Algorithms, and Performance and will focus on the rapidly growing area of image and video-based navigation techniques. The topics will include detailed descriptions of camera calibration and removal of image distortion, feature extraction techniques including: SIFT, SURF, FAST, and Shi-Tomasi, methods for solving the correspondence problem, and extracting navigation information including essential/fundamental matrix techniques as well as feature tracking techniques and the inherent strengths and weaknesses of various feature types (e.g., lines vs. corners). Finally, strategies for extracting navigation information will be presented including feature tracking, optical flow, and methods for coupling with inertial sensors. Strategies for implementing these algorithms using various software products including Matlab and OpenCV will be presented, as well as illustrations of real-time systems. Time will be provided for in-depth question and answer sessions as well as Matlab-based examples. Applicable references will be provided for further study.

Course Level: This course will be presented at an engineering level with the goal of understanding the various components and algorithms required to construct a multi-sensor image-aided navigation system. The course is appropriate for engineers with experience in the navigation field with an interest in developing or generating detailed requirements for alternative navigation systems.

Dr. Mike Veth is the Co-founder of Veth Research Associates where he provides expert consultation on alternative navigation and control topics. His research focus is applying nonlinear estimation theory to optimally fuse inertial sensors with non-traditional navigation sources for truly robust non-GNSS navigation and control applications. He received his BS EE from Purdue University, and a PhD EE from the Air Force Institute of Technology. Dr. Veth has authored over 40 technical articles and book chapters in areas relating to computer vision, navigation, and control theory. He is a member of the ION, a Senior Member of the IEEE, and a graduate of the US Air Force Test Pilot School.

The Ionosphere and its Effects on GNSS

Room 13

Ionospheric effects on radio wave propagation remain one of the largest sources of error for GNSS users. The ionosphere is a part of the upper atmosphere where free electrons exist in quantities large enough to affect the propagation of radio waves. The magnitude of these effects varies dramatically with respect to local time, season, geographic location, solar activity and magnetic activity. Although the ionosphere has been studied for many years, its effects on GNSS signals continue to be a source of concern and investigation.

This course will begin with a background on the physics of the ionosphere. It will continue with discussion on the ionospheric effects most important for GNSS users. These include range errors that are due to a change in the speed of the satellite signal as it encounters the free electrons along the path between a satellite and a receiver. Other major effects include amplitude and phase scintillations that are induced by fluctuations in the index of refraction along the propagation path. This course will illustrate the techniques used to estimate and mitigate these ionospheric effects for single and dual frequency users.

Worldwide ionospheric studies using GNSS will be presented. These studies reveal ionospheric features characteristic of the low, middle and high latitude regions. Space weather will be introduced as we view ionospheric features that occur in response to solar disturbances including solar flares, coronal mass ejections and solar radio bursts. Measurements from a network of GPS receivers over South America will be used to illustrate the dynamic geophysical environment of the near-equatorial region where the most significant sources of error for GNSS are found.

This course will conclude with a look to the future by examining the potential improvements to ionospheric estimation and mitigation when modernized signals, a second civil frequency and multiple satellite constellations are available.

Course Level: Beginner to Intermediate

Patricia Doherty is the Director of the Institute for Scientific Research at Boston College. Her research interests include the worldwide ionosphere, ionospheric effects on GNSS and on Satellite Based Augmentation Systems. She initiated and directs an African Outreach program to bring the use of GNSS for practical applications and scientific exploration to African universities. She is the current president of ION, an ION Fellow and a recipient of the ION Burk Award (1995).
3 constellation simulator

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- One touch record/replay of RF signals
- GPS, GLONASS, Galileo, BeiDou, QZSS and SBAS
- Signal simulation software available (GPS and GLONASS)
- Free library of worldwide recordings and simulations

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Plenary Session
Tuesday, September 9, 2014  6:30 p.m. — 8:30 p.m.
Tampa Convention Center, Ballroom A (First Floor)

Welcome, Meeting Highlights and Introduction of Technical Chairs

ION GNSS+ 2014 General Chair
Mr. Douglas Taggart,
Overlook Systems Technologies, Inc.

ION GNSS+ 2014 Programme Chair
Prof. Terry Moore,
University of Nottingham,
United Kingdom

Satellite Division Chair
Dr. Jade Morton,
Colorado State University

PLENARY SESSION:

The Wonderful World of Natural Navigation: Tristan Gooley
A talk that starts with solo crossings of the Atlantic in a light aircraft and then a small yacht, before plunging into the very rare art of natural navigation. Tristan describes how his love of the subject grew over time and explains how he learnt to find his way using the sun, moon, stars, weather, plants and animals. He has used natural navigation in the Sahara desert, in jungles, on ice, on oceans and in the English countryside. Tristan explains how these ancient techniques can be used by anyone willing to try something new and how natural navigation can enrich all journeys, large or small.

Tristan Gooley is a writer, navigator and explorer. Tristan set up his natural navigation school in 2008 and is the author of The Natural Navigator, one of the world’s only books on natural navigation. He is also the author of: The Natural Explorer (March 2012), How to Connect with Nature (January 2014), and The Walker’s Guide to Outdoor Clues & Signs (May 2014). He has written for the Sunday Times, the New York Times, the BBC, Geographical Magazine, Yachting Monthly, The Financial Times and many other periodicals.

Tristan Gooley has led expeditions in five continents, climbed mountains in Europe, Africa and Asia, sailed small boats across oceans and piloted small aircrafts to Africa and the Arctic. He has walked with and studied the methods of the Tuareg, Bedouin and Dayak in some of the remotest regions on Earth. He is the only living person to have both flown solo and sailed singlehanded across the Atlantic and is a Fellow of the Royal Institute of Navigation and the Royal Geographical Society. See http://www.naturalnavigator.com/ for more information.

Panel Discussion Lightning Talks
A series of presenters who will be given just five minutes each to highlight the key hot topics that will be discussed during the week’s panels; to entice you to attend their session. It will be fast and fun snapshot of what is happening in the world of GNSS+.

Moderator: Alan Cameron, GPS World

Presenters:
Dr. John Betz, The MITRE Corporation
Didier Faivre, European Space Agency, France
Dr. Frank van Diggelen, Broadcom
Glen Gibbons, Inside GNSS
Oscar Pozzobon, QASCOM S.R.L., Italy
Dr. Frank van Graas, Ohio University
Dr. Todd Humphreys, The University of Texas at Austin
Prof. Dorota Grejner-Brzezinska, The Ohio State University
Dr. Didier Flament, European Space Agency, France
Room 21
8:30 a.m. – 12:15 p.m.
D1: Advances in Positioning Using Radio and Other Signals

Dr. David De Lorenzo, Polaris Wireless
Dr. Ramsey Faragher, University of Cambridge, UK

1. A Low Overhead Receive Only Wi-Fi Based Location Mechanism: E. Lindskog, H. Wan, R. Banerjea, N. Kakani, D. Huntington, CSR

2. Collaborative Wi-Fi SLAM Towards Indoor Positioning: H. Jing, J. Pitchin, C. Hill, T. Moore, University of Nottingham, UK

3. Adaptive Estimation of Signals of Opportunity: Z.M. Kassas and T.E. Humphreys, The University of Texas at Austin

4. Multipath Assisted Positioning Using a Single Antenna with Angle of Arrival Estimations: C. Gentner, T. Jost and A. Dammann, German Aerospace Center (DLR), Germany

5. Tightly-Coupled GPS/UWB-Ranging for Cooperative Positioning for Low Energy: Y. Cho, M. J. Kim, Y. Lee, S. Park, Electronics and Telecommunications Research Institute, Republic of Korea; B. Shin, T. Lee, Korea Institute of Science and Technology, Republic of Korea

6. Cooperative Positioning for Low Energy Bluetooth Technology: B. Sheta, Military Technical College, Egypt; M. Youssef, Samsung Semiconductor Inc. and Royal Military College of Canada

7. A Reference Design for the Radionavigation of Femtosatellites: R.B. Harris, T. Perez, N. Kamte, J. Berry, The University of Texas at Arlington


Alternates

1. Image Aided Inertial Navigation with Known Features: Observability Analysis and Performance Evaluation: L. Wang, X. Niu, Q. Zhang, H. Zhang, W. Jiang, GNSS Research Centre, Wuhan University, China

2. A Long Endurance Wi-Fi/PDR Hybrid Positioning for Scalable Indoor Localization: Y. Cho, M. J. Kim, J. Lee, S. Park, Electronics and Telecommunications Research Institute, Republic of Korea; B. Shin, T. Lee, Korea Institute of Science and Technology, Republic of Korea

Room 22
8:30 a.m. – 12:15 p.m.
E1: GNSS Vulnerabilities 1: Interference

Prof. Andrew Dempster, University of New South Wales, Australia
Dr. Todd Humphreys, University of Texas at Austin


2. Single Antenna GPS Spoof Detection that is Simple, Static, Instantaneous and Backward Compatible: E. McLimlin, D. De Lorenzo, T. Walter, T. Lee, and P. Enge, Stanford University


4. Overview of Weak Interference Detection and Localization Techniques for the GNSS Environmental Monitoring System (GEMS): E. Cetin, University of New South Wales, Australia; M. Trinkle, The University of Adelaide, Australia; A. Bours, ENSTA ParisTech, France; G. Gabelli, University of Bologna, Italy; R.J.R. Thompson, A.G. Dempster, University of New South Wales, Australia; G.E. Corazza, University of Bologna, Italy

5. Off-Grid High Resolution DOA Estimation for GNSS Circular Array Receivers: X. Wang, E. Aboutanios, University of New South Wales, Australia; M. Amin, Villanova University, USA; C.Y. Pui, University of Adelaide, Australia

6. A Hybrid Approach for DME Interference Suppression in GNSS: R. Wu, W. Wang, L. Li, D. Lu, L. Wang, Q. Jia, Civil Aviation University of China, China

7. Two Stage Beamformer for GNSS Receiver Antenna Arrays: Y. C. Chuang and I. Gupta, The Ohio State University


Alternates


2. GNSS Vulnerability Assessment Based on Application Suitability: S. Jing, X. Zhan, X. Liu, Shanghai Jiao Tong University, China


Room 24/25
8:30 a.m. – 12:15 p.m.
F1 PANEL:
Status of GPS, GLONASS, Galileo, BeiDou, and QZSS

Dr. John W. Betz, The MITRE Corporation

This session provides an update on satellite-based navigation systems in operation or under development. A representative for each system will provide a system overview, summarize current or planned characteristics and performance, report recent programmatic events, update schedule and plans, and summarize ongoing interactions with other service providers. Questions from the audience are encouraged.

Panel Topics:

GPS:
Col. Matthew Smitham, Deputy Director, GPS Directorate

GLONASS:
Dr. Sergey Karutin, Head of PNT Information and Analysis Center of Central Research Institute for Machine Building, Federal Space Agency (Roscosmos), Russia

Galileo:
Galileo Program Status: Mr. Marco Falcone, European Space Agency Galileo System Manager, The Netherlands

Galileo Evolution: Prof. Guenter W. Hein, European Space Agency, Head of EGNOS and GNSS Evolution Program Department, The Netherlands

BeiDou:
Mr. Qiao Hua Huang, Deputy Director of China Satellite Navigation Office, China

QZSS:
Mr. Yoshiyuki Murai, Executive Director, Promotion of QZSS Utilization, Quasi-Zenith Satellite System Services Inc., Japan

Informal Luncheon, Exhibit Hall, 12:15 p.m. – 1:15 p.m.
A panel discussion covering issues of standardization and certification from key organizations involved in indoor location. Invited representatives from 3GPP for cellular technologies, WiFi Alliance and IEEE 802.11 for WiFi, Bluetooth SIG, MEMS Industry Group for Inertial Sensors, OGC for mapping and the Indoor Location Alliance as well as other industry groups covering both E-911 regulatory issues as well as commercial LBS.

Discussion will focus on the progress and issues for bringing indoor location to a level of standardization to allow penetration into all mobile devices.

With representatives from:
1. 3GPP: Kirk Burroughs, Qualcomm
2. WiFi Alliance/IEEE: Marc Linsner, Cisco
4. FCC/CSRIC: Chris Gates, Nextnav
5. Multiple: Steve Malkos, Broadcom
6. OGC: Hongwei Liu, MappedIn, Canada
7. MEMS Industry Group: Mahesh Chowdhary, ST Microelectronics
8. In-Location Alliance (ILA): Jounni Kämäräinen, Nokia, Finland

Panel and demonstrations including:

1. Resolving Indoor Location on Three Axes Using A-GNSS/Wi-Fi/and Barometric Pressure: Ryan Kelly, Rnx Networks
2. Enhanced WiFi Ranging with Round Trip Time Measurements: Steve Malkos, Broadcom
3. Indoor Positioning with MEMS, GNSS, WiFi, Signals of Opportunity and Cloud-based Learning: Dave Huntingford, CSIR
5. Indoor Location Demonstration: Markus Krainz, Indoors
7. Indoor and Local Positioning with BT Low Energy and Easy Installation: Dr. Jani Ollikainen and Hannu Laine, Nokia, Finland
8. In-Location Alliance (ILA): Jounni Kämäräinen, Nokia, Finland

Demo areas will be set up around the edge of the conference room. Each presenter will have their demo running. In turn, each will talk about their demo from the stage – at the same time there will be live video of the demo feeding to the big screen on stage.

Panel and demonstrations including:

1. Resolving Indoor Location on Three Axes Using A-GNSS/Wi-Fi/and Barometric Pressure: Ryan Kelly, Rnx Networks
2. Enhanced WiFi Ranging with Round Trip Time Measurements: Steve Malkos, Broadcom
3. Indoor Positioning with MEMS, GNSS, WiFi, Signals of Opportunity and Cloud-based Learning: Dave Huntingford, CSIR
5. Indoor Location Demonstration: Markus Krainz, Indoors
7. Indoor and Local Positioning with BT Low Energy and Easy Installation: Dr. Jani Ollikainen and Hannu Laine, Nokia, Finland
8. In-Location Alliance (ILA): Jounni Kämäräinen, Nokia, Finland
1. Inertial Sensor Error Model Selection Based

2. Quadrotor Inertial Navigation Aided by

3. Broad Motion Mode Recognition for Portable

4. A New Method in Modelling the IMU Stochastic

5. Continuous Motion Recognition for Natural

6. Fast Generation and Tracking of GNSS

7. Analysis of DME Ranging Error Fluctuation

8. Comparison Multi-constellation and Multi-

9. Modelling the Networked GNSS Constellation:

10. Improving Availability and Accuracy

11. Fast Generation and Tracking of GNSS

12. Toward a New Definition of a PNT Trust Level in

13. Comparing Multi-constellation and Multi-Frequency

14. An Alternate Approach for M-Code ISCs

15. From L-Band Measurements to a Preliminary

16. Continuous Motion Recognition for Natural

17. An Inertial Sensor Error Model Selection Based

18. Vehicle Dynamics Model with In-Flight

19. Continuous Motion Recognition for Natural

20. Temporal-Spatial Smoothing for Vision

21. Estimation of Galileo Uncalibrated

22. Real-Time PPP with GALILEO, Paving the

23. Solution for Inter-Satellite Linked Space-

24. Modelling the Networked GNSS Constellation:

25. A Novel Method of GNSS PVT Computation

26. Precise Orbit Determination of Next

27. From L-Band Measurements to a Preliminary

28. An Alternative Application of the

29. Fast Generation and Tracking of GNSS

30. Toward a New Definition of a PNT Trust Level in

31. Improving Availability and Accuracy

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36. A Novel Method of GNSS PVT Computation

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38. From L-Band Measurements to a Preliminary

39. An Alternative Application of the

40. Fast Generation and Tracking of GNSS

41. Toward a New Definition of a PNT Trust Level in

42. Improving Availability and Accuracy

43. Estimation of Galileo Uncalibrated

44. Real-Time PPP with GALILEO, Paving the

45. Solution for Inter-Satellite Linked Space-

46. Modelling the Networked GNSS Constellation:

47. A Novel Method of GNSS PVT Computation

48. Precise Orbit Determination of Next

49. From L-Band Measurements to a Preliminary

50. An Alternative Application of the
### Room 21
8:30 a.m. – 12:15 p.m.
**D3: Enhancing GNSS with Sensors, Mapping and Cooperation**

<table>
<thead>
<tr>
<th>Panelists</th>
<th>University/Location</th>
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<tbody>
<tr>
<td>Prof. Mark Petovello</td>
<td>University of Calgary, Canada</td>
</tr>
<tr>
<td>Prof. Nobuaki Kubo</td>
<td>Tokyo University of Marine Science and Technology, Japan</td>
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</table>

8:35
1. **Coarse Based Optimum Geometries for DOA Estimation with Multiple CRPAs GPS Arrays:**
   - X. Wang, University of New South Wales, Australia
   - M. Amin, K. Ahmad, Villanova University, USA
   - E. A. Aboaloukhi, University of New South Wales, Australia

8:57
2. **A Map Aided Localization System for Safety-relevant Automotive Assistance Systems:**
   - T. Scheide and P. Hecker, Institute of Flight Guidance, TU-B, Germany

9:20
3. **Tightly Coupled INS/DGPS System for Collaborative Navigation in Mobile Ad Hoc Networks:**
   - G. Pages, A. Guerreiro, B. Priot, T. Peremou, and V. Calmettes, ISAE University, France

9:43
4. **Development of a Positioning Tool for the Navigation of Visually Impaired People:**
   - P. Hafner, K. Huber, T. Moder, M. Wieser, Graz University of Technology, Austria
   - G. Hollinger, C. Strauß, Strauß & Hollinger, GeoIT OGE

10:05 - 10:35 Break, Refreshments in Exhibit Hall

### Room 22
8:30 a.m. – 12:15 p.m.
**E3: GNSS Error Models**

<table>
<thead>
<tr>
<th>Panelists</th>
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<tbody>
<tr>
<td>Prof. Kefei Zhang</td>
<td>RMIT University, Australia</td>
</tr>
<tr>
<td>Dr. Ismael Colomina</td>
<td>Centre Tecnològic de Telecomunicacions de Catalunya, Spain</td>
</tr>
</tbody>
</table>

8:35
1. **Analyzing Scintillation Using Ionospheric Asymmetry Index:**
   - M. M. Shalih, R. Notarpietro, Politecnico di Torino, Italy
   - P. Yin, Civil Aviation University of China and University of Bath, UK

8:57
2. **Assessment of Single-difference Ionospheric Residuals in a Regional Network for GBAS:**
   - K. Wang, M. Meindl, A. Geiger, M. Roether, Institute of Geodesy and Photogrammetry, Switzerland
   - M. Scaramuzza, M. Toller, P. Truffer, Skyguide - Swiss Air Navigation Services Ltd., Switzerland

9:20
3. **GPS Scintillation Modeling and Receiver Design Strategies for Low-Latitude Regions:**
   - F. Ghafoori and S. Skone, University of Calgary, Canada

9:43
4. **SBAS Performance Analysis in Equatorial Regions:**
   - A. Cezón, M. Cueto and E. Sardón, GMV, Spain

10:05 - 10:35 Break, Refreshments in Exhibit Hall

### Room 25
8:30 a.m. – 12:15 p.m.
**F3a: Modernization of GNSS Systems, Compatibility, Interoperability, Service Performance**

<table>
<thead>
<tr>
<th>Panelists</th>
<th>University/Location</th>
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<tbody>
<tr>
<td>Dr. Chris Hegarty</td>
<td>The MITRE Corporation</td>
</tr>
<tr>
<td>Dr. Xiancheng Ding</td>
<td>China Electronics Technology Group, China</td>
</tr>
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</table>

8:35
1. **GALILEO User Performance During the In-Orbit Validation Campaign and Early Service Preparation:**
   - M. Eleuteri, S. Rinaldi, D. Cretoni, A. Guarnieri, R. Barca, Thales Alenia Space Italy, Italy
   - M. Kirchner, J. Krueger, T. Bey, D. Fernandez-Prim, J.J. Floch, EADS Astrium, Germany

9:20
2. **GALILEO in Orbit Validation Open Service and Search and Rescue Positioning Performance:**
   - M. Gasbarra, M. Eleuteri, F. Pagli, Thales Alenia Space Italy
   - A. Nuckelt, D. Oskam, Airbus Defence and Space

9:43
3. **Update on the GALILEO Timing Performance:**
   - S. Bindia, E. Breeuwer, M. Falcone, J. Hahn, A. Mudrak, Galileo Project Office, ESA, The Netherlands
   - D. Cretoni, Thales Alenia Space
   - M. Mink, Airbus Defence and Space

10:05 - 10:35 Break, Refreshments in Exhibit Hall

### Room 26
8:30 a.m. – 12:15 p.m.
**F3b: Alternatives and Backups to GNSS for Navigation**

<table>
<thead>
<tr>
<th>Panelists</th>
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<tbody>
<tr>
<td>Prof. Dr. Ismael Colomina</td>
<td>Centre Tecnològic de Telecomunicacions de Catalunya, Spain</td>
</tr>
<tr>
<td>Dr. Marco Petovello</td>
<td>University of Calgary, Canada</td>
</tr>
</tbody>
</table>

Blue text indicates student award winner.

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See Page 26 for Session F3b: Alternatives and Backups to GNSS for Navigation 2

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Informal Luncheon, Exhibit Hall, 12:15 p.m. – 1:15 p.m.
EXHIBITOR DEMO: Thursday, September 11 2:00 p.m. - 2:45 p.m.

**Room 18**
1:45 p.m. – 5:30 p.m.

**A4: New Consumer Products and Applications: Phones, Tablets, Wearables, Automotive**

Scott Burgett, Garmin
Andrew Hazlett, Broadcom

1:50 1. Ultra Low Power - High Accuracy Location for Wearables: S. Malkoš and M. del Castillo, Broadcom Corporation
2:35 3. Commercial GNSS at High Altitudes: Smartphone Receiver Performance on a Multi-Week Stratospheric Balloon Mission: T. Reid, B. Chan, Stanford University; F. van Diggelen, S. Podshivalov, Broadcom Corporation
3:25-3:55 Break, Refreshments in Exhibit Hall

**Room 19**
1:45 p.m. – 5:30 p.m.

**B4: Aviation and Marine Applications**

1:50 1. Architectures for Advanced RAIM: Offline and Online: J. Blanch, T. Walter, P. Enge, Stanford University; S. Wallner, F. Amarillo Fernandez, ESA/ESTEC, The Netherlands; J. Burns, K. Alexander, Federal Aviation Administration; J.P. Boyero, European Commission, Belgium; Y. Lee, MITRE/CAASB; B. Pervan, M. Joergers, S. Khanafesh, Illinois Institute of Technology; I. Martini, M. Rippl, German Aerospace Center (DLR), Germany; V. Kropp, University of Munich, Germany; C. Milner, C. Macabiau, ENAC, France; N. Saund, CNES, France; G. Berz, EUROCONTROL, Belgium
2:12 2. Analysis of the use of GPS + GLONASS for Aviation Applications: A. Joseph, B. Schnauffer and J. Kazimierczak, Rockwell Collins Inc.
4:00 4. GBAS CAT II/III Business Aircraft Flight Trials and Validation: J. Dvorska, L. Podivin, M. Musil, L. Zaviralova, M. Kren, Honeywell International
3:25-3:55 Break, Refreshments in Exhibit Hall

**Room 20**
1:45 p.m. – 5:30 p.m.

**C4: Software Receivers**

2:35 3. Fastening GPS and Galileo Tight with a Software Receiver: J. Arribas, CTTIC, Spain; M. Branzanti, Università di Roma La Sapienza, Italy; C. Fernández-Prades, P. Closas, CTTIC, Spain
2:58 4. Combination of Multicorrelator-based Maximum Likelihood Discriminator with Vector Tracking to Improve Receiver Sensitivity: D. Kubrak, D. Serant, G. Carrié, Thales Aénros Space, France
3:25-3:55 Break, Refreshments in Exhibit Hall

**elenium DEMO: Thursday, September 11**

2:00 p.m. - 2:45 p.m.

**Room 17**

“Inside Spoofing”

- 1. Synchronization of GPS Enabled Wi-Fi Access Points: T. Khan, R. Kukas, University of British Columbia, Canada
- 2. BDS Application on Unmanned Aerial Vehicle Air Traffic Management: J. Fang, Y. Zhu, Aviation Data Communication Corporation, China; Z. Wang, Beihang University, China

2. Intent-based Dynamic Model Estimation for Airborne GNSS Positioning: L. Fu, and J. Zhang, R. Li, Beihang University, China

**Alternates**

1. Fronted Imperfections in Multi-Antenna GNSS Receivers – A Guideline for Receiver Design for Safety Critical Applications: M. Cuntz, A. Konovalev, German Aerospace Center (DLR), Germany; M. Meurer German Aerospace Center (DLR), and RWTH Aachen University, Germany
2. Implementation Details and Performance Results of an SoC-Based Vector Tracking GPS Receiver: B. Keyser, Auburn University; D. Hodo, JS4S; S. Martin and D. Bevly, Auburn University
3. Universal GNSS SDR Toolbox for MATLAB®: Architecture, Applications and Performance: S. Gunawardena, ChameleonChips.com
This panel will ask: What will navigation systems look like in 20 years’ time? Which will be the dominant technologies? What performance can we expect? What will the new applications be?

Panel Members:
1. Prof. Per Enge, Stanford University
2. Dr. Logan Scott, The MITRE Corporation
3. Dr. Christoph Guenther, German Aerospace Center (DLR), Germany
4. Logan Scott, LS Consulting
5. Dr. Mark Psiaki, Cornell University

Unintentional and intentional interference, ranging from random noise to structured signals, can disrupt or distort the positioning and timing information provided by GNSS receivers. This session will discuss techniques for enhancing the ability of receivers to detect, disregard, and operate through such interference. The session focuses on solutions and their performance rather than on the methods underpinning specific interference tactics.

Panel Members:
1. Prof. Per Enge, Stanford University
2. Dr. Chris Hegarty, The MITRE Corporation
3. Dr. Christoph Guenther, German Aerospace Center (DLR), Germany
4. Logan Scott, LS Consulting
5. Dr. Mark Psiaki, Cornell University

Dr. Sunil Bisnath, York University, Canada
Dr. Xiaolin Meng, University of Nottingham, UK

1:50
Transmission of Augmentation Messages for Precise Point Positioning Utilizing Japanese QZSS LEX Signal: K. Harima, S. Choy, RMIT University, Australia; Y. Wakabayashi, S. Kogure, Japan Aerospace Exploration Agency, Japan; C. Rizos, University of New South Wales, Australia

2:12
PPP for Advanced Precise Positioning Applications, Including Reliability Bound: M.D. Lainez Samper and M.M. Romay Merino, GMV, Spain

2:35
A Novel Ambiguity Acceptance Test Threshold Determination Method with Controllable Failure Rate: L. Wang, Queensland University of Technology, Australia; S. Verhaegen, Delft University of Technology, The Netherlands; Y. Feng, Queensland University of Technology, Australia

2:58
Precise Cooperative Positioning: A Case Study in Canada: S. Banville, P. Collins, P. Tétartault, F. Lahaye, and P. Héraux, Natural Resources Canada

3:25-3:55 Break, Refreshments in Exhibit Hall

4:00
Analysis and Modelling of Pseudorange and Carrier-phase Biases in GNSS Precise Positioning: J. Aggrey and S. Bisnath, York University, Canada

4:23
Array-aided Single-Differenced Satellite Phase Bias Determination: Methodology and Results: A. Khodabandeh, Curtin University of Technology, Australia

4:46
A Real-time World-wide Ionospheric Model for Single and Multi-frequency Precise Navigation: A. Rovira-Garcia, J. M. Juan, J. Sanz, Technical University of Catalonia (UPC), Spain

5:08
The Performance of Long Baseline Troposphere Decorrelation for Subcentimetre RTK PPPs: S. Li, D. Xiang, Tongji University, China; Y. Feng, Queensland University of Technology, Australia

4:00
Improving WAAS Availability Along the Coast of California: E. Sparks, Jet Propulsion Laboratory California Institute of Technology: E. Altschuler, Sequoia Research

4:23
Detection Performances of Evil Waveform Monitors for the GPS L5 Signal: P. Thevenon, O. Julien, O. Tessier, ENAC, France; D. Maillard, M. Cabantous, Capgemini, France; F. Amarillo-Fernández, F. De Oliveira Salgueiro, ESA

4:46
Robust EGNOS GEO Ranging with Electric Propulsion Satellite: H. Secretan, F. Mercier, CNES, France; S. Trilles, J. Mancuso, X. Berenguer, Thales Alenia Space France, France

5:08
The Ionospheric Delay Correction Method in SBAS of BeiDou: S. Wang and B. Zhu, Peking University, China

Alternates
1. SBAS Satellite Selection and Performance Monitoring at the Region Where Multiple SBAS are Available: T. Sakai, K. Hoshino, and K. Ito, Electronic Navigation Research Institute, Japan

2. Integrity and Overbounding of Biased Error Distributions. Concepts and Validation: M. Cohen, F. Rialert, E. Senant, D. Serant, M. van den Bosche, Thales Alenia Space France; N. Saund, Centre National d’Études Spatiales, France; I. Nikiforov, Université de Technologie de Troyes, France; M. Mabilleau, EGIS-Avia, France

3. Challenges and Opportunities of EGNOS/EDAS Augmentation and Integrity Computation in the Cloud: A. Favenza, Istituto Superiore Mario Boella, Italy; M. Pasin, Microsoft Innovation Center Torino, Italy; G. Marucco, J. Huang, Istituto Superiore Mario Boella, Italy; F. Scullino, Microsoft Innovation Center Torino, Italy

See Page 26 for Session F4b: Modernization of GNSS Systems, Compatibility, Interoperability, Service Performance 2
3. Generation of and Evaluation of the Track Map

4. Combined GPS-Locata Positioning for Machine Control in Mining Applications:

5. A Galileo Hardware Receiver for the Multi-Constellation Mass Market:

6. A Quadr Constellation Monolithic GNSS Receiver:

7. A Family of Solutions Based on the srx-platform

8. Locata Positioning Used for World’s First Full-autonomous Robotic Testing in Vehicle Collision Avoidance Systems:

9. Improving Extended Precise Orbit Quality

10. Deriving Bearing Measurements from Video Images using Haar-like Features for Vehicle-to-Vehicle Navigation:

11. A Family of Solutions Based on the srx-platform

12. Optimal Search Strategy in a Multi-Constellation Environment:

13. Innovative GNSS-based Core Technologies in a Multi-GNSS Hybridized Receiver:

14. Combined GPS-Locata Positioning for Machine Control in Mining Applications:

15. A Galileo Hardware Receiver for the Multi-Constellation Mass Market:

16. A Quadr Constellation Monolithic GNSS Receiver:

17. A Family of Solutions Based on the srx-platform

18. Locata Positioning Used for World’s First Full-autonomous Robotic Testing in Vehicle Collision Avoidance Systems:

19. Deriving Bearing Measurements from Video Images using Haar-like Features for Vehicle-to-Vehicle Navigation:

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98. A Family of Solutions Based on the srx-platform


100. Deriving Bearing Measurements from Video Images using Haar-like Features for Vehicle-to-Vehicle Navigation:

2. Inter-Sensor Validation for Improved Reliability of Multi-Sensor Systems: A. Dhillon, G. Lachapelle, J. Bancroft, University of Calgary, Canada


10:05 - 10:35 Break, Refreshments in the Lobby


6. Computing Integrity Bounds for Integrated INS/GNSS Solution: D. Gebrer Egziabher and Z. Xing, University of Minnesota, Twin Cities

7. GNSS-Aided INS Integrity Concept: O. Garcia Crespillo, A. Grosch, B. Belababs and M. Ripli, German Aerospace Center (DLR), Germany


10:05 - 10:35 Break, Refreshments in the Lobby

9. Use of the Signal Polarization for Interference Detection and Localization within the GNSS Environmental Monitoring System (GEMS) – System Update and Latest Field Test Results: E. Cetin, R.J.R. Thompson, University of New South Wales, Australia; M. Trinkle, The University of Adelaide, Australia; A.G. Dempster, University of New South Wales, Australia

10:40 - 10:50 5. SVD-based RF Interference Detection and Mitigation for GNSS: M. Sgammini, F. Antreich, M. Meurer, German Aerospace Center (DLR), Germany


11:49 - 12:15 8. A Spatial-Temporal Adaptive Filter for Interference Mitigation in GNSS Receivers: E. Tesdemir, L. Kurz and T.G. Noll, RWTH Aachen University, Germany

Blue text indicates student award winner.

Room 24
10:35 a.m. – 12:15 p.m.
E5b PANEL: GNSS – Our Strongest Asset or Weakest Link?

What are the key weaknesses for GNSS and how do we/do we need to prioritize them? What is the level of urgency in addressing these weaknesses? Are GNSS challenges only technical; are the real challenges even technical at all? What are the consequences for GNSS applications in the near future if we ignore these challenges?

Panel Members:
1. Prof. Dorota Grejner-Brzezinska, The Ohio State University

See Page 26 for Session
F5b: GNSS Augmentation Systems and Integrity 2


3:20 4. Galileo Commercial Service from the Early Definition to the Early Proof-of-Concept: D. Calle, E. Carbonell, I. Rodriguez, G. Tobías, GMV, Spain; E. Gehlter, Ifen, Germany; O. Pozobon, M. Cannale, Qascom, Italy.


5:05 7. The Importance of Human Motion for Simulation Testing of GNSS: K. Voutsis, P. Groves, University College London, UK; C. Ford, M. Holbrook, Spirient Communications plc, UK.


11:50 1. Features and Applications of the Adaptable Flexiband USBl.0 Front-end: A. Rügamer, F. Förster, M. Stahl, G. Rohmer; Fraunhofer IIS, Germany.

12:12 2. A Method for Improving Ambiguity Resolution – Determination and Application of Uncalibrated Phase Delays: K. Huber, Graz University of Technology, Institute of Navigation, Austria; F. Hinterberger, Vienna University of Technology, Austria; R. Lesjak, Graz University of Technology, Institute of Navigation, Austria; R. Weber, Vienna University of Technology, Austria.

12:35 3. Estimation of Triple-frequency Satellite Clocks and its Application for Precise Point Positioning: H. Li and B. Li, Tongji University, China.

1:12 4. Real-time Fast PPP Ambiguity Resolution Based on Regional Reference Network with Satellite FCBS Considering Orbit and Clock Errors: Y. Li, Y. Gao, University of Calgary, Canada; J. Shi, Wuhan University, China.


3:06 8. magicGNSS®: Real-Time POD and PPP Multi-GNSS Service: G. Tobías, D. Calle, P. Navarro, I. Rodríguez and D. Rodríguez, GMV, Spain.


4:12 10. Integrity Monitoring for Precise Point Positioning: S. Feng, A. Jokinen and W. Ochieng, Imperial College London, UK


7:05 17. A Novel Multi Image Based Navigation System to Aid Outdoor – Indoor Transition Flights of Micro Aerial Vehicles: M. Popp, P. Croccoli, J. Ruppelt and G.F. Trommer, Karlsruhe Institute of Technology, ITE, Germany.

7:25 18. The Potential of Electromyography to Aid Personal Navigation: T. Moore, C. Hill, J. Pinchin, G. Smith, University of Nottingham, UK; I. Loram, MMU Institute for Biomedical Research into Human Movement and Health, UK.

7:45 19. A Floor Classification Algorithm Based on Stair Awareness using MEMS IMU: S.Y. Park, M.S. Lee, H.J. Ju and C.G. Park, Seoul National University, South Korea.


8:25 21. Locata’s VRay Antenna Technology – Multipath Mitigation for Indoor Positioning: C. Rizos, University of New South Wales, Australia; A. Kealy, University of Melbourne, Australia; Y. Feng, Queensland University of Technology, Australia; S. Choy, RMIT University, Australia; M. Choudhury, J. LaManche, Locata Corporation, Australia


Room 21
1:45 p.m. – 4:55 p.m.
D6: Navigation Using Environmental Features

Dr. John Raquet, Air Force Institute of Technology
Prof. Patrick Oominch, Netherlands Defense Academy, Netherlands

1:50
1. The DG Performance Verifications of UAV Borne MMS Payload with Two Tactical Grade Low Cost MEMS IMUs Using New Calibration Method: C-H. Chu, M-L. Tsai, National Cheng Kung University, Taiwan

2:12

2:35
3. A Parallax Based Robust Image Matching for Improving Multi-sensor Navigation in GNSS-denied Environments: E. Angelats, P. Molina, M.E. Parés, I. Colomina, Centre Tecnològic de Telecomunicacions de Catalunya (CTTC), Spain

2:58
4. A Novel GNSS Positioning Technique for Improved Accuracy in Urban Canyon Scenarios Using 3D City Model: R. Kumar and M.G. Petovello, University of Calgary, Canada

3:20

3:47
6. Assured Vision Aided Inertial Localization: A. Soloviev, QuNav; C. Yang, Sigtem Technologies; M. Veth, QuNav; C. Taylor, AFRL

4:04

4:28
8. Terrain Aided Flight Solution: TerraFli:te: G. Soysal, Ankara University, Electrical Electronics Engineering, Turkey; Y. Ersoy, STM’s, Turkey; M. Efe, Ankara University, Electrical Electronics Engineering, Turkey; H. Kurtoglu and S. Cak, STM’s, Turkey

Alternates


2. Development of a Tightly Coupled Vision/GNSS System: B. M. Aumayer, M. G. Petovello, G. Lachapelle, Department of Geomatics Engineering, University of Calgary, Canada


Room 22
1:45 p.m. – 4:55 p.m.
E6a: GNSS Receiver Technology - Software and Algorithms 2

Dr. Olivier Julien, ENAC, France
Dr. Stuart Duncan, Surrey Satellite Technology Limited,

1:50
1. Measurement Quality Assessment in Urban Environments Using Correlation Function Distortion Metrics: P. Brocard, P. Thevieron, D. Salois, QuNav, ENAC, France; M. Mahibulla, Egis Avia, France

2:12
2. Characterization of Tracking and Position Errors in GNSS Receivers with Interdependent Tracking: V. Beltad, M.G. Petovello, and G. Lachapelle, University of Calgary, Canada

2:35
3. Adaptive Multithreaded Mitigation in Urban GNSS Positioning: I-W. Chu and J-C. Juan, Nati Cheng Kung University, Taiwan

2:58

3:20
5. Multi GNSS RAIM Module in a Software Defined Receiver for High-Reliability Terrestrial Applications: K. Frankl, V. Kropf, Benjamin, E. Eusfeldt, University FAF Munich/ESTA, Germany

3:42

4:04
7. Implementation and Testing for a Multi-frequency GPS Vector Tracking Loop: H. Yin, Y. Morton, M. Carroll, Miami University (Ohio)

4:26
8. Modeling and Analysis of Composite Multithread Characteristics for a Bayesian-Based Dense Multithread Mitigation Algorithm: N.I. Ziedan, Zayed University, Egypt

Alternates

1. Performance of Multicorrelator-based Maximum Likelihood Discriminator: G. Carne, D. Kubrak, M. Monnerat, Thales Alenia Space France

Room 23
1:45 p.m. – 4:55 p.m.
E6b: GNSS Vulnerabilities 2: Spoofing and Authentication

Prof. Andrew Dempster, University of New South Wales, Australia
Dr. Todd Humphreys, University of Texas at Austin

1:50

2:12
2. Cooperative GPS Signal Authentication from Unreliable Peers: L. Heng, D. Chou, and G.K. Gao, University of Illinois at Urbana-Champaign

2:35

2:58

3:20
5. Autonomous Spoofing Detection and Mitigation with a Miniaturized Adaptive Antenna Array: A. Konovalov, S. Cassone, M. Luntz, SGG Germany; M. Neuer, DLR and RWTH Aachen University, Germany

3:42
6. Supersonic GNSS Authentication Codes: D. Pozzobon, G. Gamba, M. Canale, Qascom S.r.l., Italy

4:04
7. Civilian Unmanned Aerial Vehicle Vulnerability to GPS Spoofing Attacks: L. He, W. Li, L. Gao, University of Electronic Science and Technology of China, China

Alternates

1. GNSS Authentication Enabled the Galileo Public Regular Service (PRS): M. Turner, A. Chambers, J. Haddon, Airbus Defence and Space, UK; E. Aguado, B. Wales, M. Dumville, NSL, UK; N. Davies, R. Bowden, P. Tegnert, QinetiQ, UK

Friday Afternoon – September 12

1. Status of Operational SBAS (WAAS, EGNOS, MSAS) and History over the Past Years: WAAS, FAA Representative, EGNOS, ESA Representative, MSAS, Japan Representative

2. Update Recent Initiatives and Plans: GAGAN, Airport Authority India; K-SBAS, Project Manager Korean SBAS; SNAS, China Representative; SDCM: Dr. Grigory Stupak, Deputy Director General of Russian Space System, Russia; ASECNA, West African Association of Civil Aviation Agencies

3. First Dual Frequency and Bi-constellation Augmentation Experimental Results: Preparing for the Future Second Generation DFMC SBAS: Recent European GPS/Galileo/EGNOS Experimentations, ESA Representative, Japanese (ENRI), ENRI Representative, WAAS DF Trials


25
Thursday Morning: Room 23
8:30 a.m. – 12:15 p.m.
F3b: Alternatives and Backups to GNSS for Navigation

1. Using Indoor Maps to Enhance Real-time Unconstrained Portable Navigation: T. Li and J. Georgiou, Trusted Positioning Inc., Canada
2. A Fast LiDAR-based Features Extraction/Tracking Using Hough Transforms and Fuzzy C-means Clustering for LiDAR-aided Multi-sensor Navigation Systems: H. Nematallah, Queens University; S. Liu, Harbin Engineering University, China; M.M. Atia, S. Givigi, A. Noureldin, Royal Military College of Canada at Kingston, Canada
3. Collaborative LTE Femtocell Synchronization and Receiver Location for Improved Capacity and Indoor Positioning: D. Serant, F. Jambou, Thales Alenia Space France; A. Garcia-Peña, ENAC, France; L. Ries, CNES, France
4. Joint Semi-supervised RSS Dimensionality Reduction and Fingerprints Based Algorithm for Indoor Localization: C.F. Zhou, L. Ma, X. Z. Tan, Harbin Institute of Technology Communication Research Center, & Ministry of Public Security, China

Informal Luncheon
Exhibit Hall
12:15 p.m. – 1:15 p.m.

Thursday Afternoon: Room 25
1:45 p.m. – 5:30 p.m.
F4b: Modernization of GNSS Systems, Compatibility, Interoperability, Service Performance

1. GPS III Accuracy and Integrity Improvements Using ARAIM with Shorter Age of Data (AoD): S. Pullen and P. Enge, Stanford University; S. Shaw, C. Frey, J. Frye, M. Souder, Lockheed Martin
2. GPS Civil Signal Monitoring – Advancing Toward Implementation: A. Hansen, K. Van Dyke, DOT/OST-R; C. Miles, DOT/FAA; J. Lavrakas, Advanced Research Corporation
3. Inter-Satellite Links Study for GEO/MEO Satellite Network: D. Wang, J. Zhao, C. Liu, Beijing Satellite Navigation Center, China
4. GNSS Time Offset Monitoring & Time Synchronization Testing and Assessment: B. Yu, J. Li and C. Wu, China Electronics Technology Group, China
6. Satellite Navigation Regional Augmentation System Performance Analysis Based on BDS: Z. Wang, Y. Zhu, R. Xue, J. Fang, Beihang University, China
7. Preparing for the Galileo Commercial Service – Proof of Concept and Demonstrator Development: I. Rodríguez, G. Tobias, D. Calle, P.D. Tejera, GMV, Spain; O. Pozzobon, M. Canale, Qascom, Italy; D. Maharaj, P. Walker, CGI; E. Göhler, IFEN GmbH, Germany; P. Toor, Veripos; I. Fernández, European Commission
8. Demodulation Performance Assessment of New GNSS Signals in Urban Environments: M. Roudier, CNES, France; A. Garcia-Peña, O. Julien, ENAC, France; C. Poulihat, ENSEEIHT, France; T. Grelier, CNES, France; M-L. Boucheret, ENSEEIHT, France; L. Ries, CNES, France; D. Kubrak, Thales Alenia Space, France

Informal Luncheon
Exhibit Hall
12:15 p.m. – 1:15 p.m.

Friday Morning: Room 23
8:30 a.m. – 12:15 p.m.
F5b: GNSS Augmentation Systems and Integrity

1. Detection and Isolation of Ionospheric Fronts for GBAS: J. Jing, S. Khanafeh, S. Langel and B. Pervan, Illinois Institute of Technology
4. Architectures for High Integrity Multi-Carrier Constellation Solution Separation: Z. Kana, M. Grejas, J. Dunik and M. Sotak, Honeywell, Czech Republic

10:00-10:35 Break, Refreshments in the Lobby

Informal Luncheon
Exhibit Hall
12:15 p.m. – 1:15 p.m.

Awards Luncheon
Ballroom B (First Floor)
12:15 p.m. – 1:45 p.m.

Dr. Sherman Lo, Stanford University
Dr. Michael Veth, Veth Research Associates

Dr. Chris Hegarty, The MITRE Corporation
Dr. Xiancheng Ding, China Electronics Technology Group, China

Dr. Todd Walter, Stanford University
Michel Tossaint, European Space Agency, The Netherlands

Dr. Y. Balazadeh Gao, Beihang University, China; Y. Zhang, The 27th Research Institute of China Electronic Technology Group Corporation, China
Wednesday, September 10

12:15 p.m. – 1:15 p.m., Exhibit Hall
Informal Luncheon
This event is included with all full conference, exhibit only, and Wednesday single day registrations. See registration desk on-site to purchase tickets for guests.

6:00 p.m. – 8:00 p.m., Exhibit Hall
Exhibitor Hosted Reception
Join this year’s exhibitors as they host a social evening of information and cuisine. All exhibit booths will be open. Take this opportunity to review developments in GNSS technology, talk shop, get the specifics directly from the vendors, and learn about what has been happening in the GNSS marketplace during the past year. This event is included with any type of registration. Spouses and traveling companions 21 and older are welcome.

Thursday, September 11

12:15 p.m. – 1:15 p.m., Exhibit Hall
Informal Luncheon
This event is included with all full conference, exhibit only and Thursday single day registrations. See registration desk on-site to purchase tickets for guests.

Friday, September 12

12:15 p.m. – 1:45 p.m., Ballroom B, First Floor
Johannes Kepler and Bradford W. Parkinson Awards Luncheon
The purpose of the Kepler Award is to honor an individual for sustained and significant contributions to the development of satellite navigation.

The Bradford Parkinson Award, which honors Dr. Parkinson for his leadership in establishing both the U.S. Global Positioning Systems and the Satellite Division of The Institute of Navigation, is given to an outstanding graduate student in the field of Global Navigation Satellite Systems. The award includes a personalization plaque and a $2,500 honorarium.

This event is included with a full, or Friday single day, conference registration. Tickets for exhibitors and/or guests may be purchased using the registration form in this program or by visiting the ION registration desk onsite.
The world’s largest GNSS showcase!
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Conference Lounge

EXHIBIT HALL HOURS
Wednesday, September 10
Show Hours: 10:00 a.m. - 6:00 p.m.
Exhibitor Hosted Reception: 6:00 p.m. - 8:00 p.m.

Thursday: September 11
Show Hours: 9:00 a.m. – 6:00 p.m.
ACUTRONIC USA, Inc.
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Booth: 620

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Booth: 116

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DG Enterprise and Industry
EU Satellite Navigation Programmes - Legal, Financial and Institutional Aspects | H2
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Web: www.inlocationalliance.org
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Web: www.autosnowplow.com
Email: sheikh@asterlabs.com
Booth: 605

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Manassas, VA 20109 United States
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Email: kesthus@ion.org
Web: www.ion.org
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<td><a href="http://www.microsemi.com">www.microsemi.com</a></td>
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<td>Munich Satellite Navigation Summit</td>
<td>Werner-Heisenberg-Weg No. 39, Neubiberg, 85577 Germany</td>
<td>+49 89 6004 3425</td>
<td><a href="mailto:antje.tucci@unibw.de">antje.tucci@unibw.de</a></td>
<td>munich-satellite-navigation-summit.org</td>
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<td><a href="mailto:fboynton@NavtechGPS.com">fboynton@NavtechGPS.com</a></td>
<td><a href="http://www.navtechgps.com">www.navtechgps.com</a></td>
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<td>Querweg 20, Berlin, 13597 Germany</td>
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<td><a href="mailto:dirk.kowalewski@navxperience.com">dirk.kowalewski@navxperience.com</a></td>
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<td>northropgrumman.com</td>
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<td><a href="mailto:lori.winkler@novatel.com">lori.winkler@novatel.com</a></td>
<td><a href="http://www.novatel.com">www.novatel.com</a></td>
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ION GNSS+ 2014 Exhibitors
As of August 18, 2014

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Please see the convention center’s visitor information center for more information.

The In-Town Trolley is a great way to travel between the convention center and downtown Tampa during the week. The trolley runs every 15 minutes, Monday through Friday, 6:00 a.m. - 8:30 a.m. and 3:30 p.m. - 6:00 p.m. Trolley fare is 25 cents and requires exact fare to ride. Trolley routes are indicated in blue, yellow, and green on the transportation map above. Please see the convention center’s visitor information center for a service map and more information.