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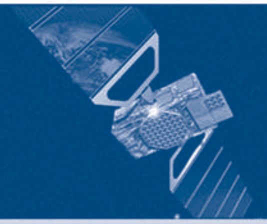
September 24-25, 2007 • Fort Worth, Texas



	TRACK 1	TRACK 2	TRACK 3	TRACK 4	TRACK 5
Monday AM 8:30-12:00	CN405: **Fundamentals of GNSS I with emphasis on GPS** Chris Bartone, Ohio University	CN425: **GNSS Signals & Systems with emphasis on Galileo** Tony Pratt, Orbstar Consultants	CN460: **Intro to Strapdown Inertial Navigation Systems I** Kevin Dutton, Honeywell International	CN414: **Fundamentals of Space-Based Augmentation System (SBAS) Design** Mohinder Grewal, California State Univ, Fullerton	CN407: **GNSS Signal Propagation: Theory & Practice** Richard Langley & Peter Dare, Univ of New Brunswick
Monday PM 1:00-5:00	CN406: **Fundamentals of GNSS II with Emphasis on GPS** Chris Bartone, Ohio University	CN426: **GNSS Signal Performance with emphasis on Galileo** Tony Pratt, Orbstar Consultants	CN461: **Intro to Strapdown Inertial Navigation Systems II** Kevin Dutton, Honeywell International	CN413: **GNSS Integrity** Christophe Macabiau, ENAC	CN473: **Autonomous Land Navigation using GPS/INS** David Bevly, Auburn University
Monday EVE 6:45-9:30	CN420: **GPS Modernization** Thomas Stansell, Stansell Consulting	CN430: **Basics on GNSS Signal Processing** Christophe Macabiau, ENAC	CN462 **Applications of Strapdown Inertial Navigation Systems** Andrey Soloviev, Ohio University, SEE WEB SITE	CN477: **Fundamentals of Enhanced Loran** Ben Peterson, Peterson Integrated Geopositioning	CN416: **Fundamentals of Pseudolites for GNSS** Stewart Cobb, Novariant Corporation
Tuesday AM 8:30-12:00	CN410: **Fundamentals of DGNSS** Hans-Jürgen Euler, inPosition gmbh, Switzerland	CN433: **Future GNSS Signal Processing I** Olivier Julien, ENAC	CN465: **MEMS Sensors for Navigation** Steve Becka, Honeywell International	CN441: **Fundamentals of Antennas for GNSS** Chris Bartone, Ohio University	CN436: **Open Source Software for COTS GPS Receivers** Andrew Greenberg, Portland State University
Tuesday PM 1:00- 5:00	CN415: **Fundamentals of DGNSS for Baseline & Network RTK applications** Hans-Jürgen Euler, inPosition gmbh, Switzerland	CN434: **Future GNSS Signal Processing II: Advanced Tracking Architectures** Olivier Julien, ENAC	CN480: **Fundamentals of Kalman Filtering for GPS/INS Integration** Mohinder Grewal, California State Univ, Fullerton	CN445: **Special Topics for GNSS Antennas** Rama Rao, Mitre Corporation	CN471: **Integrated Navigation Systems for Low-Cost Applications** Demoz Gebre-Egziabher, University of Minnesota

GNSS Solutions™ Instructors

Additional information on instructors can be found at:
www.GNSSsolutions.com/ION_GNSS_2007_Tutorial_Instructors.pdf

Dr. Chris G. Bartone, P.E. is an associate professor at Ohio University with over 24 years of professional experience. He received his Ph.D.EE from Ohio University in 1998, a MSEE from the Naval Post-graduate School in 1987, and BSEE from Penn State in 1983. He previously worked for the Naval Air Warfare Center. Chris received the RTCA William E. Jackson Award in 1998 for his outstanding contribution to aviation in the area of DGPS. At Ohio University, Dr. Bartone has developed and teaches a number of GPS, wave propagation, antennas, and radar classes; his research concentrates on all aspects of navigation.

Thomas A. Stansell is a pioneer of satellite navigation with over 47 years of experience, beginning in 1960 at the Johns Hopkins University Applied Physics Laboratory, later with Magnavox, Leica, and now an independent consultant. He has lead many firsts in Transit, GPS and Glonass receiver technology. He has played a key role and contributed crucial ideas to the design of all modernized GPS signals: L5, L2C, M-code, and L1C, including a lead role for L2C and L1C, receiving the GPS JPO 2002 GPS Navstar Award. Tom is an ION Fellow and has received the ION Kepler and IEEE PLANS Kershner Awards. Today, Tom is an influential GPS consultant advising the GPS Wing on modernization issues.

Dr. Hans-Jürgen Euler has over 22 years of experience with GPS and its applications including precise surveying in post-processing and real-time. In the late 80's, he pioneered the fast integer ambiguity resolution technique. He has worked with The Ohio State University, Terrasat, Germany, and Leica Geosystems developing GPS algorithms for real-time and post-processing software. In 2002 he became a Leica GNSS Research Fellow. For more than 10 years he worked in the RTCM Subcommittee 104, where he serves as Chair of the RTCM SC104 working groups for network RTK and Galileo. Today Hans-Jürgen works for his own company inPosition gmbh in Switzerland.

Dr Tony Pratt has over 40 year of experience. He graduated with a B.Sc. and Ph.D. in EE from Birmingham University, UK in 1967. He has held teaching positions at Loughborough University, UK, Yale University; IIT, New Delhi, University of Copenhagen, and University of Nottingham. He has worked for or consulted to industry for Navstar Ltd, Peek, Parthus, QinetiQ Ltd, UK, Cambridge Positioning Systems, now part of the CSR plc group. Dr. Pratt is a Consultant to the UK Government in the development of the Galileo Satellite System and has played key roles in the signal design and international negotiations. He runs two companies, OrbStar Consultants and OrbStar Ltd providing various services to the GNSS sector. Dr Pratt has published numerous papers on signal processing, sonar, and satellite navigation. He holds over 17 patents.

Dr. Christophe Macabiau graduated as an electronics engineer in 1992 from the ENAC (Ecole Nationale de l'Aviation Civile) in Toulouse, France. Since 1994, he has been working on the application of satellite navigation techniques to civil aviation. He received his Ph.D. in 1997 and has been in charge of the signal processing lab of the ENAC since 2000. His research now also applies to vehicular, pedestrian and space applications, and includes advanced GNSS signal processing techniques for acquisition, tracking, interference and multipath mitigation, GNSS integrity, as well as integrated GNSS-inertial systems and indoor GNSS techniques.

Dr. Olivier Julien is an assistant professor at the ENAC, Toulouse, France, where he is part of the signal processing and telecommunications laboratory. He graduated as an electrical engineer from the ENAC and received his PhD from the Department of Geomatics Engineering at the University of Calgary, Canada. He is involved in many R&D projects including advanced GNSS receiver design, multipath and interference mitigation techniques, and GNSS interoperability, with an emphasis on future signals. Olivier is the recipient of the 2006 Bradford W. Parkinson award.

Dr. Kevin Dutton received his BS in Aeronautical Engineering from Rensselaer Polytechnic Institute in 1988 and his MS degree in Astronautics from the George Washington University in 1993. In the late 80's he worked at NASA Langley Research Center on advanced spacecraft trajectory. In 1993 he worked in the area of GPS to obtain his PhD in EE from Ohio University in 2003, studying various aspects of the GPS and INS, including attitude determination, relative navigation, and tightly coupled GPS/INS Kalman filter design. Since 2004 Dr. Dutton works for Honeywell International in Clearwater, Florida as lead designer of the Sea-Based JPALS GPS/INS relative navigation Kalman filter.

Stephen F. Becka is an Engineering Fellow for Honeywell International Inc. Steve has over 25 years experience in design, manufacture and evaluation of inertial sensors used in navigation, gravimetry, energy exploration, and automotive stability control. Since 1995, he has led design teams developing MEMS force-balance accelerometers, MEMS vibrating beam accelerometers and MEMS coriolis rate sensors. Steve has a BSME from Rensselaer Polytechnic Institute. As a member of the IEEE Gyro and Accelerometer Panel, he has been a significant contributor to numerous inertial component standards and authored several papers on MEMS inertial sensors.

Mohinder S. Grewal, Ph.D., P.E., is a Professor of EE at California State University, Fullerton (CSUF) and has over 35 years experience in systems identification, guidance, navigation, and control. He was an architect of the GEO Uplink Subsystem (GUS) for WAAS, including the GUS clock steering algorithm. He co-authored "Kalman Filtering Theory & Practice Using MATLAB," Second Edition, Wiley & Sons, 2001. Dr. Grewal also co-authored "Global Positioning Systems, Inertial Navigation, & Integration," Second Edition, Wiley & Sons, 2007. Grewal has published over 50 papers in IEEE and ION refereed journals and proceedings, including the ION "Redbook," (Volume VI), and over 250 technical reports.

Dr. Ben Peterson co-chaired the FAA's Loran Integrity and Accuracy Performance Panels (LORIPP and LORAPP) and as such is one of the principal architects of Enhanced Loran (eLoran) in the US. He developed the Loran Data Channel for transmitting time of day and differential Loran corrections. Prior to his retirement from the US Coast Guard (USCG) in 2000, he was a Captain and Engineering Department Head at the USCG Academy. He is an USCG Academy graduate and earned a Ph.D.EE from Yale University. He is a former president of the US ION, an ION Fellow, and an associate editor of ION Navigation Journal.

Dr. Rama Rao is a Principal Engineer at the MITRE Corporation where he works in areas related to antenna technology for GNSS, EHF military satellite communications systems and terrestrial communications. He received his Ph. D from Harvard University where he also served as an Assistant Professor of Applied Physics. Prior to joining MITRE he was at M. I. T. Lincoln Laboratory; the Sperry Research Center; a Research Associate at M.I.T.; and an Adjunct Professor at Northeastern University. Dr. Rao holds nine U.S. patents; two related to GPS antennas.

Prof. Richard B. Langley has been teaching and conducting research at the University of New Brunswick (UNB) since 1981. He has a B.Sc. in applied physics from the University of Waterloo and a Ph.D. in experimental space science from York University, Toronto. He is a co-author of the best-selling "Guide to GPS Positioning" published by Canadian GPS Associates and has been a columnist and contributing editor of GPS World magazine since its inception. His research team concentrates on atmospheric effects on GNSS and space-based augmentation systems as well as other error sources. Prof. Langley is an ION fellow and a co-recipient of the ION Burka Award.

Dr Peter Dare joined the Department of Geodesy and Geomatics Engineering at UNB in August 2000 and is the current chair of the department. Before joining UNB he worked in the School of Surveying, University of East London, England. He gained a BSc in Land Surveying Sciences from North East London Polytechnic in 1980, a MASc in Civil Engineering from the University of Toronto in 1983 and a PhD from the School of Surveying, University of East London in 1995. He has significant expertise in Geodesy, GPS, Operational Research, and Geomatics.

Dr. David Bevly received his B.S. from Texas A&M University in 1995, M.S from MIT in 1997, and Ph.D. from Stanford University in 2001 in mechanical engineering. He joined the faculty of the Department of Mechanical Engineering at Auburn University in 2001 as an assistant professor. Dr. Bevly's research focuses on vehicle dynamics as well as modeling, control, and navigation of ground vehicle systems. Specifically, Dr. Bevly has developed methods for identifying critical vehicle parameters using GPS and inertial sensors as well as algorithms for control of off-road vehicles including participation in the past DARPA Grand Challenges.

Dr. Stewart Cobb earned his S.B, M.S. and Ph.D. degrees in Aeronautics and Astronautics from MIT and Stanford University. His doctoral research showed how pseudolites could augment conventional RTK positioning to reach the navigation performance levels necessary to land airliners on autopilot. He has led the design, fabrication, and testing of both C/A code and P/Wideband code based pseudolites at Stanford University and IntegriNautics (now Novariant). He is currently Chief Engineer at Novariant Corporation, where he designs GPS receivers and pseudolites for precise control of air and ground vehicles.

Andrew Greenberg is an Associate of the Electrical and Computer Engineering Department at Portland State University. He is the project manager for the Portland State Aerospace Society, that focuses on educational open source and open hardware educational aerospace project. He received his MSEE, BS in Physics and BSEE from Portland State University and Reed College. He has been an embedded systems consultant and the lead product development manager for a medical device company for over 10 years. He is one of the founding members of the open source GPS community and coordinates the open source software for the GPL-GPS project, which provides an open source software infrastructure for customizing the software on commercial, off-the-shelf GPS receivers.

Dr. Gebre-Egziabher is an assistant professor of Aerospace Engineering and Mechanics at the University of Minnesota, in Minneapolis, Minnesota. His research is in the areas of navigation, guidance and control with a particular emphasis on application of estimation theory to avionics sensor fusion and system integration issues. Dr. Gebre-Egziabher received a Bachelor of Science degree in Aerospace Engineering from the University of Arizona, a Master of Science degree in Mechanical Engineering from George Washington University and a Ph.D. in Aeronautics and Astronautics from Stanford University.

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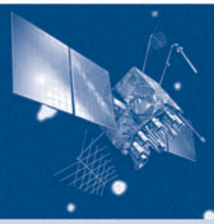

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TRACK 1 MONDAY AM & PM

Updated

MONDAY, 8:30am-12:00 pm, Crystal Ballroom A
CN405 Fundamentals of GNSS I with emphasis on GPS (3.0 CEU)
Dr. Chris Bartone, P.E., Ohio University

This course emphasizes the fundamentals of GNSS with emphasis on GPS. The core functions which need to be performed in obtaining a user solution using GPS in an error free environment will be covered. The course concludes with an illustration of a user state calculation, performance metrics (i.e., DOPS) and an error budget for GPS.

- Intro to positioning and satelite navigation.
- GPS Segments: Control, Space, User.
- Coordinate frames and datum's used in the application of GNSS.
  - ECI, ECEF, LLH, MSL, WGS-84, ITRF, conversions, etc.
- GPS signal structure formats for current and future signals.
  - Basic GPS: C/A, P(Y) code formats
  - Modernized GPS, Galileo, Glonass (Overview)
- GPS Link Budget
- GPS Receiver Architecture (Overview)
- GPS Navigation Message Data Format Descriptions
- Calculation of the GPS space vehicle (SV) position using the broadcast Kepler parameters (ephemeris and almanac)
- GPS Time Considerations
- Calculation of user state (i.e., position and time)
- Associated performance parameters (i.e., dilution of position terms)
- GPS error budget (overview)

Updated

MONDAY, 1:30pm-5:00 pm, Crystal Ballroom A
CN406 Fundamentals of GNSS II with emphasis on GPS (3.0 CEU)
Dr. Chris Bartone, P.E., Ohio University

This course emphasizes the fundamentals of GNSS with emphasis on GPS in the presence of various error sources. The course provides details on the source and nature of various error sources in satellite navigation systems, their impact, and methods for mitigation. The course concludes with an illustration of an error mitigated user state calculation and provides an introduction to differential GNSS.

- GPS error budget (review)
- Overview of receiver types and receiver technologies
- Overview of various GNSS antenna types and antenna technologies
- Satellite orbit errors and mitigation methods
- Satellite clock errors
- Error mitigation by smoothing
- Signal Multipath Error characterization and mitigation techniques
  - Code phase multipath
  - Carrier phase multipath
- Atmosphere Errors:
  - Troposphere error sources, characterization, models, and mitigation (simple)
  - Ionosphere error sources, characterization, models, and mitigation (simple)
    - GPS Broadcast model (Klobuchar Model)
- GNSS Receiver Autonomous Integrity Monitoring (RAIM)-overview
- Precise Point Positioning (PPP)
- Introduction to Differential GNSS (DGNSS) and different ways to implement it.

TRACK 2 MONDAY AM & PM

NEW

MONDAY 8:30am-12:00pm, Crystal Ballroom B
CN425: GNSS Signals and Systems with emphasis on Galileo (3.0 CEU)
Dr. Tony Pratt, Orbstar Consultants

This course provides a solid foundation of GNSS Signal formats and emphasizes the new signals and services for Galileo. Details on GNSS signal formats, spreading codes, and their characteristics are provided.

GNSS System Overview:
- Necessary & Desirable GNSS signal characteristics
- GNSS Frequency Bands: Present, future, ITU regulations
- Galileo signals and relationship to GPS signals

Galileo Signals and Services:
- Galileo service:
  - Open Services (OS)
  - Commercial Services (CS)
  - Safety of Life (SOL)
  - Public Regulated Services (PRS)
  - Search and Rescue (SAR)

Galileo/GPS Signaling Waveforms:
- GNSS Spreading symbol waveforms (BPSK, Binary Offset Carrier (BOC), AltBOC, Linear Offset Carrier (LOC), DoubleBOC, Multiplexed BOC (MBOC), non-binary (i.e., tertiary)
- GNSS Spreading codes for Galileo and GPS in L1, L2, L5/E5, E6 bands

- Auto & Cross Correlation properties for GNSS Signals
- Power Spectral Densities (PSD) for GNSS Signals
- GNSS satellite signal multiplexing: orthogonal, interplex, and Coherent Adaptive Sub-carrier Modulations (CASM)

NEW

MONDAY 1:30pm-5:00pm, Crystal Ballroom B
CN426 GNSS Signal Performance with emphasis on Galileo (3.0 CEU)
Dr. Tony Pratt, Orbstar Consultants

This course provides a solid foundation for the performance of GNSS Signal formats and emphasizes the new signal and services for Galileo. Details on GNSS signal spreading codes and their performance in noise, multipath, and interference are provided. Additionally, the performances of the Galileo signals are characterized with respect to the GPS signal formats.

Interference Aspect for GNSS Signals:
- Interference consideration for GNSS spreading codes
  - Inter & Intra interference between Galileo & GPS
  - Galileo/GPS satellite power control
  - Spectral Separation Coefficients (SSC) with lists for SSC values

Signal generation effects at the satellite:
- GNSS satellite signal generation and filter effects
- GNSS satellite antenna effects

Link Performance Characterizations:
- Down link signal link budgets
- Signal-to-Noise ratio budgets
- User range error
  - Cramer-Rao lower bound on tracking performance
- Multipath consideration for Galileo & GPS signals
  - Relationship to transmitted & receiver bandwidth

TRACK 3 MONDAY AM & PM

NEW

MONDAY, 8:30am-12:00pm, Crystal Ballroom C
CN460 Introduction to Strapdown Inertial Navigation Systems I (3.0 CEU)
Dr. Kevin Dutton, Honeywell International

This course emphasizes the physics and mathematics of strapdown inertial navigation systems. It provides sufficient information for the user to construct their own free inertial navigation solution. Main topics include:

- Basic inertial navigation with two-dimensional examples
- Vector and matrix notation and mathematics
- Coordinate frames: Inertial, Earth-Centered, Earth-Fixed, Local-level (East/North/Up, North/East/Down, Wander), Body, transformations
- Attitude Fundamentals and Representations
  - Direction Cosine Matrix (DCM)
  - rotation vector and Euler angles
  - quaternions
- Earth geoid and gravity model
- Strapdown inertial navigation equations
- Vertical channel dynamics
  - inherent instability in vertical channel
  - stabilization of vertical channel using external information
- Coning and sculling
  - Definitions and compensation
- Integration of navigation equations
  - attitude update
  - velocity update
  - position update

NEW

MONDAY, 1:30pm-5:00pm, Crystal Ballroom C
CN461 Introduction to Strapdown Inertial Navigation Systems II (3.0 CEU)
Dr. Kevin Dutton, Honeywell International

This course emphasizes the fundamentals of strapdown inertial navigation sensors – the types of sensors and their errors and their behavior. The course also discusses sensor and system specifications. Main topics include:

- Strapdown inertial navigation error equations and performance
- Alignment techniques
  - gyro-compass alignment
  - in-flight alignment
  - at-sea alignment
  - transfer alignment
- Inertial sensors
  - gyroscopes
  - accelerometers
- Sensor errors and error models
  - Gauss-Markov random process
  - bias
  - scale factor
  - misalignment
  - non-orthogonality
  - size effects
- Sensor calibration techniques
- Sensor specifications
- Inertial navigation system performance and specifications

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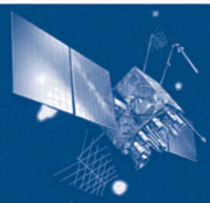

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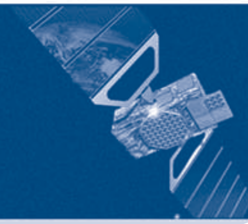

TRACK 1 TUESDAY AM & PM

Updated

TUESDAY, 8:30am-12:00 pm, Crystal Ballroom A
CN410 Fundamentals of Differential GNSS applications (3.0 CEU)
Dr. Hans-Jürgen Euler, inPosition gmbh, Switzerland

This course emphasizes the fundamentals of differential GNSS baseline techniques with focus on DGPS and an introduction to DGPS RTK applications. The course will explore the various error mitigation techniques and methods for improving navigation to sub-meter accuracy and higher precision positioning. Performance aspects with respect to accuracy, integrity, continuity, and availability will be presented. Main topics include:

- Introduction to DGPS techniques and different ways to implement (overview)
- Mitigation of error in GNSS applications: (SV, atmosphere, antenna)
- Differential pseudorange based navigation error mitigation techniques
- Overview of differential services available
  - Space Based Augmentation Systems (e.g., WAAS, EGNOS, etc.)
  - Local Area Augmentation Systems
  - Commercial services
- Date link: RTCM SC104 standard for DGNSS
  - Message outline and philosophy
  - The different messages for DGNSS
- Precise differential techniques
- Carrier phase ambiguity resolution
- Multi-frequency advantages
- Summary of standards for RTK applications: RTCM SC104 V2 & V3

NEW

TUESDAY, 1:30pm-5:00pm, Crystal Ballroom A
CN415 Fundamentals of DGNSS for Baseline and Network RTK applications (3.0 CEU)
Dr. Hans-Jürgen Euler, inPosition gmbh, Switzerland

This course emphasizes the fundamentals of GNSS Baseline RTK techniques with focus on GPS Baseline RTK applications, including GPS Network RTK applications. The course will explore the various methods for error mitigation. The shortcomings and merits of different approaches are analyzed. Main topics include:

- DGNSS techniques and their limits (overview)
- Algorithms for Integer Ambiguity Searches as the key for precise positioning
- Error sources of RTK and their mitigation
  - Antenna phase center variations (absolute & relative)
  - Tropospheric residual errors
  - Ionospheric residual errors
- Limitations of Baseline RTK
- General idea of Network RTK to overcome baseline length-dependent influences
- Analysis of different concepts (proprietary and non-proprietary)
  - Virtual Reference Stations (also called VRS, iMAX and similar)
  - Area Correction Parameters (FKP German abbreviation)
  - Master-Auxiliary Concept as used for RTCM SC1040301 standard
- Why is interoperability important when providing a Network RTK service
- The impact to Galileo of Network RTK
- New trends in Network RTK

TRACK 2 TUESDAY AM & PM

NEW

TUESDAY, 8:30am-12:00pm, Crystal Ballroom B
CN433 Future GNSS Signal Processing I (3.0 CEU)
Olivier Julien, ENAC

This course provides an excellent overview of future GNSS signal processing and the many aspects that affect GNSS receiver performance. The course starts with requirements on future GNSS signal structures, and then addresses the receiver architecture for future GNSS signals acquisition and tracking.

Receiver Requirements for Design:

- Review of future transmitted civil GNSS signal model: GPS L1 C/A, GPS L5, Galileo E1 OS (BOC and MBOC), Galileo E5 (E5a/E5b)
- Results on budget link for GPS L1, L5 and Galileo E1, E5a/E5b
- Application constraints : market, cost, environment, standards

Basic Signal Processing Architecture for future GNSS Signals:

- The GNSS signal processing essential brick: the Correlator output model
- Signal Acquisition in presence of noise:
  - Review of acquisition results for GPS L1 C/A
  - Acquisition detectors for GPS L5 and Galileo E5, Galileo E1
  - Acquisition performance for GPS L5 and Galileo E5, Galileo E1
- Signal Tracking in presence of noise:
  - Review of tracking loops for GPS L1 C/A: PLL, FLL, DLL
  - Carrier tracking loops for GPS L5 and Galileo E5 and E1
  - Code tracking loops for GPS L5 and Galileo E5 and E1

NEW

TUESDAY, 1:30pm-5:00pm, Crystal Ballroom B
CN434 Future GNSS Signal Processing II: Advanced Tracking Architectures (3.0 CEU)
Olivier Julien, ENAC

This course provides an excellent overview of future GNSS signal processing and the many aspects that affect GNSS receiver performance. The course starts with requirements, addresses advanced GNSS receiver architectures for future signals, and concludes with receiver performance characterizations in the presence of noise, multipath, and interference.

Reminder on transmitted civil GNSS signal model and budget link:

- GPS L1 C/A, GPS L5, Galileo E1 OS (BOC and MBOC), Galileo E5 (E5a/E5b)

Propagation channel model:

- Detailed budget link for GPS L1, L5 and Galileo E1, E5a/E5b
- Multipath model
- Detailed interference threats in L1 and E5 bands

Advanced Signal Tracking Architecture:

- Advanced receiver architecture for dedicated civil signals (BOC, MBOC, AltBOC, joint data/pilot channels, etc.)

Multipath effects:

- Review of traditional code and carrier multipath envelopes for GPS L1 C/A
- Advanced multipath mitigation techniques for code and carrier tracking on GPS L5 and Galileo E5, Galileo E1
  - Code multipath envelopes
  - Carrier multipath envelopes

Interference effects:

- Wide band interference effect on GPS L1, Galileo E1
- C/W interference effect and mitigation on GPS L1, Galileo E1
- Pulsed interference effect and mitigation on GPS L5, Galileo E5a/E5b

TRACK 3 TUESDAY AM & PM

NEW

TUESDAY, 8:30am-12:00pm, Crystal Ballroom C
CN465 MEMS Sensors for Navigation (3.0 CEU)
Steve Becka, Honeywell International

This course will present an overview of current MEMS inertial technology, with a focus on navigation applications. It will include material on sensing concepts related to navigation, MEMS manufacturing concepts, inertial sensor operating principles, and an overview of current MEMS inertial sensor characteristics.

Topic to include:

- Overview of Inertial Sensing Concepts and Application
- MEMS Navigation Applications and Requirements
- MEMS Processing Technology Concepts and Capabilities
  - Manufacturing Tools
- Theory and Design Concepts - MEMS Accelerometers
  - Displacement/Rebalance MEMS Accelerometers
  - Resonant MEMS Accelerometers
- Current MEMS Accelerometers And Performance
- Theory and Design Concepts – MEMS Gyroscopes
  - Vibratory MEMS Gyroscopes
  - MEMS Multi-Sensors (Gyro/Accel)
- Current MEMS Gyroscopes and Performance
- Future Direction of MEMS Inertial Technology

Updated

TUESDAY, 1:30pm-5:00pm, Crystal Ballroom C
CN 480: Fundamentals of Kalman Filtering for GPS/INS Integration I (3.0 CEU)
Dr. Mohinder S. Grewal, California State University, Fullerton

This course emphasizes the fundamentals of Kalman filtering with application to GPS/INS integration. It addresses subtleties, problems, and limitations of estimation theory as applied to real world situations encountered in GPS, INS, and navigation and provides application examples.

Main topics include:

- Linear discrete Kalman filter
- Extended Kalman filter (for nonlinear plant and observation models)
- Unscented Kalman filter (for nonlinear plant and observation models)
- Square root Kalman filter (UDU^T)
- Kalman filter engineering
- Strapdown and gimbal IMU
- Loosely and tightly coupled INS/GPS
- Ultra tightly coupled INS/GPS
- Example: 8, 11, 17 states, with pseudoranges and delta pseudoranges
- Examples and demos with MATLAB®

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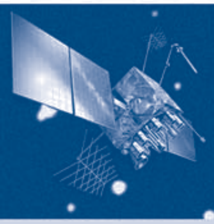

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TRACK 4 MONDAY AM & PM

Updated

MONDAY, 8:30am-12:00pm, Texas Ballroom A/B
CN 414: Fundamentals of Space-Based Augmentation System (SBAS) Design (3.0 CEU)
Dr. Mohinder S. Grewal, California State University, Fullerton

This course emphasizes the Space-Based Augmentation System design with descriptions of corrections and verification processor algorithms, GEO uplink subsystem algorithms, and integrity design. It provides application examples. Main topics include:

- Description of Space-Based Augmentation System
- GNSS data errors
- L1/L2 (L1/L5) bias and ionospheric estimation
- Multipath estimation and mitigation
- GPS and GEO orbit determination
- SBAS and GEO signal integrity design
- Description of GEO Uplink Subsystem (GUS)
- GUS clock steering description and algorithms
- Examples from WAAS
- Demos with MATLAB®

NEW

MONDAY, 1:30pm-5:00pm, Texas Ballroom A/B
CN413 GNSS Integrity (3.0 CEU)
Christophe Macabiau, ENAC

This course provides information on obtaining integrity in GNSS applications. An overview of the different ways to obtain GNSS integrity for various applications will be discussed followed by details on GNSS integrity in civil aviation applications, and particularly on receiver autonomous integrity monitoring (RAIM) approach. The course concludes with several practical examples.

GNSS integrity overview:

- Definition for applications
- Integrity and continuity trees
- Integrity monitoring
- Requirements on integrity monitoring performance
- Overview on integrity monitoring techniques

GNSS Integrity for civil aviation:

- Integrity requirements & monitoring for civil aviation applications
- Augmentations proposed and implemented: ABAS, GBAS, SBAS RAIM:
- Algorithm specifications from high level requirements
- Detection criterion
  - fault detection
  - fault exclusion
- Horizontal, Vertical, and other Protection Level (PL) computation
- Practical examples

TRACK 5 MONDAY AM & PM

Updated

MONDAY, 8:30am-12:00pm, Texas Ballroom C/D
CN407 GNSS Signal Propagation: Theory and Practice (3.0 CEU)
Prof. Richard Langley and Prof Peter Dare, University of New Brunswick

This course provides details of atmospheric refraction effects on GNSS signals and how they can be minimized in positioning, navigation, and time transfer. Also discussed is the use of GNSS signals for studying atmospheric phenomena. The main topics to be covered by this course are:

- Electromagnetic waves
- Refractive index
- Phase and group delay
- Ionospheric effects
  - Complex refraction
  - Corrections and models
  - Scintillation and storms
- Neutral atmosphere effects
  - Refractivity of air
  - Corrections and models
  - The water vapor problem
- Studying the atmosphere with GNSS GPS

NEW

MONDAY, 1:30pm-5:00pm, Texas Ballroom C/D
CN473 Autonomous Land Navigation using GPS/INS (3.0 CEU)
Dr. David M. Bevly, Auburn University

This course emphasizes the fundamentals of GPS/INS navigation for ground vehicles. The course also introduces other sensors such as vision and Lidar, for navigation in GPS denied environments. The course includes examples of work on a variety of vehicles with illustrations of navigation and estimation results. Main topics include:

- GPS/INS Integration for Vehicle dynamics
  - Brief overview of GPS and its errors
  - IMU modeling and ground vehicle dead-reckoning errors
  - Introduction of the Kalman Filter
- Ground Vehicle Dynamics
  - Ground vehicle models
  - Estimation of vehicle navigation states
  - Estimation of vehicle parameters
- Integration of additional navigational signals
  - Vision
  - Lidar
  - Doppler Radar
  - Odometer
- Application Examples
  - DARPA Grand Challenge
  - John Deere Auto Steer Tractor
  - Other UGVs

TRACK 1 MONDAY EXTENDED EVENING

Updated

MONDAY, 6:45pm-9:30pm, Crystal Ballroom A
CN420: GPS Modernization; (2.5 CEU)
Thomas Stansell, Stansell Consulting

This course provides information on many aspects of GNSS modernization; the course covers topics on GPS modernization, including signals and satellite capabilities, interoperability with Galileo signal formats and services, QZSS and other GNSS concepts including:

- Motivations for the current modernization
- GPS Modernization:
- Clock and orbit accuracy improvements
- L2C, L5, M-code, and L1C signals ab availability time frame
  - BPSK, BOC, and MBOC modulations
  - Code generation methods and performance differences
  - Time multiplexed and quad-phase pilot carriers
  - CNAV and CNAV-2 message formats
  - Forward error correction and interleaving differences
- Interoperability with Galileo and QZSS
  - Benefits of interoperability
  - Common and unique center frequencies
  - Impact of different GPS and Galileo performance objectives
- Decimeter tri-lane phase navigation
  - Comparison with differential code navigation
  - Code and phase measurement error characteristics
  - Factors affecting sub decimeter phase navigation accuracy
  - Application opportunities and considerations
- Other GNSS
  - Chinese Compass with Beidou-2
  - Indian Regional Satellite System

TRACK 2 MONDAY EXTENDED EVENING

NEW

MONDAY, 6:45pm-9:30pm, Crystal Ballroom B
CN430 Basics on GNSS Signal Processing (2.5 CEU)
Christophe Macabiau, ENAC

This course provides an excellent basic presentation of GNSS receiver design. The course starts with requirements on signal structure and propagation channel effects, then addresses the receiver signal processing techniques required for acquisition and tracking.

Receiver Requirements for Design:

- Transmitted GPS L1 signal model
- Propagation channel model
  - Main receiver signal processing blocks: antenna, RF front-end, local oscillator, signal processing
  - Budget link for GPS L1
  - General multipath and interference model
  - General model for signal output by ADC
- Application constraints : market, cost, environment, standards

Basic GPS L1 C/A Signal Processing Architecture:

- Correlator
  - Definition and general structure
  - Signal characteristics at correlator output: signal, noise, multipath, interference
- Basic Signal Acquisition for GPS L1 C/A in presence of noise:
  - Acquisition detectors
  - Acquisition strategy
  - Acquisition performance
- Basic Signal Tracking for GPS L1 C/A in presence of noise
  - Carrier tracking loops for GPS L1 C/A: PLL, FLL
  - Code tracking loop for GPS L1 C/A

Images: GPS SV image courtesy Lockheed Martin. Galileo satellite image courtesy ESA - P. Carril

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TRACK 4 TUESDAY AM & PM

Updated

TUESDAY, 8:30am-12:00pm, Texas Ballroom A/B
CN441 Fundamentals of Antennas for GNSS (CEU: 3.0)
Dr. Chris G. Bartone, P.E., Ohio University

This course emphasizes the fundamentals of antenna for GNSS. A solid basis for understanding fundamentals of antennas, antenna types, design, development, tests, and implementation aspects of GNSS antennas will be covered including:

- Fundamentals of Antennas:
  - Antenna pattern and field descriptions
  - Mismatch losses (Γ, SWR, polarization)
  - Wave and antenna polarization
  - Antenna and receiver noise figure considerations
  - Antenna aperture
  - The Friis transmission equation
- Antenna Types: linear, helix, patches, arrays
- Common GNSS Antennas
- Antenna Specifications
- Antenna Siting Issues: Mask angle, multipath, etc.
- Antenna Multipath considerations: design, metrics, and technology comparison (patch, survey, integrated multipath limiting antenna (IMLA))
- Test and Evaluation:
  - Computer simulation tools
  - Component level evaluations
  - Antenna test range options
  - Field test characterization
  - Phase and group delay calibration (overview)

NEW

TUESDAY, 1:30pm-5:00pm, Texas Ballroom A/B
CN445 Special Topics for GNSS Antennas (CEU: 3.0)
Dr. Rama Rao, Mitre Corporation

This course explores select specific topics for GNSS antennas which is important to many users, especially for specific applications. Topics include:

Antenna Effects on GNSS Observables:
- Phase Center vs look-angle, phase wrap-up, and measurement techniques
- Group delay and bandwidth effects

Ground Plane Effects
- Mitigating Methods (rolled edge, photonic band, resistivity tapered)
- Aircraft Fuselage Effects Investigations Using Scale Models;

Active GPS Antennas:
- G/T Ratio and measurement

Interference Issues for GPS Antennas
- Impact of Radiation from Interference Sources in the ARNS band

Special GNSS Antennas:
- Turnstile Antenna (Counselman),
- Spiral Antennas (NovAtel)
- Inverted and planar inverted F Antennas
- Multi-band GNSS Antennas
- Multi –System Antennas (combine GPS, PCS, Bluetooth, Wireless, etc)
- Very Compact Ceramic Antenna for Hand-sets, Automobiles, etc.

Adaptive Antenna Arrays:
- Multiple Element Antenna Arrays for Reducing Interference and Jamming,
- Brief introduction to Space Time Adaptive Processing and Space Frequency Adaptive Processing

TRACK 5 TUESDAY AM & PM

Updated

TUESDAY, 8:30am-12:00pm, Texas Ballroom C/D
CN436 Open Source Software for COTS GPS Receivers (CEU: 3.0)
Andrew Greenberg, Portland State University

This course introduces GPL-GPS, an open source software infrastructure for creating your own customizable receiver software for commercial, off-the-shelf GPS receivers. This course assumes familiarity with the basics of GPS operation. Main topics include:

- Introduction to COTS Receivers:
  - Embedded System Fundamentals
  - GPS Receiver Fundamentals
- GPL-GPS Hardware:
  - Zarlink GP4020 and future chipsets
  - GP4020-based & other receiver boards
- GPL-GPS Software Infrastructure:
  - eCos real time operating system
  - OpenSource GPS code
  - GPL-GPS code: threads & data flow
- Nuts and Bolts
  - Operating Systems considerations and build
  - Debug tools

NEW

TUESDAY, 1:30pm-5:00pm, Texas Ballroom C/D
CN471 Integrated Navigation Systems for Low-Cost Applications (CEU: 3.0)
Dr. Demoz Gebre-Egziabher, P.E., University of Minnesota

This course emphasizes the fundamentals of multi-sensor system design and performance analysis with emphasis on low cost systems. The design of algorithms with Kalman Filters or Extended Kalman Filters for mechanizing an integrated navigator or attitude determination system will be presented. Main topics include:

- Overview of multi-sensor systems
- Applications of low cost multi-sensor systems
- Sensors:
  - GPS for position and velocity
  - GPS as an attitude sensors
  - Inertial sensors
  - Magnetometers
  - Air data sensors
- Modeling and calibrating low cost sensors
- Overview of the Kalman Filter
- Design of integrated navigation systems.
  - GPS/INS Systems
  - Heading and velocity dead reckoning systems
- Design of integrated attitude determination systems
  - Single GPS antenna/INS attitude determination
  - Multi-antenna GPS attitude determination
  - Air data, Magnetometer and rate gyro attitude determination systems
  - Magnetometer, GPS and accelerometer attitude determination systems.

TRACK 4 MONDAY EXTENDED EVENING

NEW

MONDAY, 6:45pm-9:30pm, Texas Ballroom A/B
CN477 Fundamentals of Enhanced Loran (2.5 CEU)
Dr. Ben Peterson, Peterson Integrated Geopositioning

This course emphasizes the fundamentals of Loran with emphasis on the enhancements currently being made to the system and the impacts of those enhancements on receiver design. Main topics include:

- Current policy on the future of Loran in the US and the rest of the world
- Basic Loran Signal Structure
- Loran propagation: Primary, Secondary, and Additional Secondary Phase Factors, Envelope to Cycle Difference (ECD), Skywaves
- Loran Receiver Architecture Overview
- Acquisition/Cycle Integrity/Noise
- Hyperbolic navigation for position, velocity, and time.
- Electric field and magnetic field antennas
- Loran Data Channel
  - Modulation, demodulation and coding
  - Message Data Format & Integrity Descriptions
  - Differential Loran
- Loran for frequency and timing applications
  - Traceability to UTC & Independence of GPS
  - Calibration & differential corrections
  - Indoor applications
- GPS Vulnerability and Integration of Loran and GPS
  - Type of integration as function of threat being addressed

TRACK 5 MONDAY EXTENDED EVENING

Updated

MONDAY, 6:45pm-9:30pm, Texas Ballroom C/D
CN416 Fundamentals of Pseudolites for GNSS (2.5 CEU)
Dr. Stewart Cobb, Novariant Corporation

This course presents the many aspects of pseudolites in GNSS applications. System trade-offs and implementations considerations for high performance applications will be presented. Main topics include:

- Implementation of pseudolite systems
  - Benefits and limitations of pseudolites
  - Stand-alone pseudolite-only navigation systems
  - Differential pseudolite systems; integrity
  - Design trade-off issues and requirements
- Pseudolite signal structure considerations
  - PRN code and data selection
  - Dynamic range, near-far; pulsing format
  - Trade-offs; timing criteria and acquisition
  - Error sources; troposphere, multipath, etc.
- Pseudolite signal generation
  - C/A code and P/Wideband generators
  - RF power and pulsing
  - Clock steering and timing
- Pseudolite receiver considerations
- Off-frequency augmentatuion systems
- Case Study: airborne DGPS/DAPL application.

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	TRACK 1	TRACK 2	TRACK 3	TRACK 4	TRACK 5
Monday AM 8:30-12:00	☐ CN405: **Fundamentals of GNSS I** (Chris Bartone)	☐ CN425: **GNSS Signals & Systems with emphasis on Galileo** (Tony Pratt)	☐ CN460 : **Intro to Strapdown Inertial Navigation Systems I** (Kevin Dutton)	☐ CN414: **Fundamentals of SBAS Design** (Mohinder Grewal)	☐ CN407: **GNSS Signal Propagation: Theory & Practice** (Richard Langley & Peter Dare)
Monday PM 1:30-5:00	☐ CN406: **Fundamentals of GNSS II** (Chris Bartone)	☐ CN426: **GNSS Signal Performance with emphasis on Galileo** (Tony Pratt)	☐ CN461: **Intro to Strapdown Inertial Navigation Systems II** (Kevin Dutton)	☐ CN413: **GNSS Integrity** (Christophe Macabiau)	☐ CN473: **Autonomous Land Navigation using GPS/INS** (David Bevly)
Monday EVE 6:45-9:30	☐ CN420: **GPS Modernization** (Thomas Stansell)	☐ CN430: **Basics on GNSS Signal Processing** (Christophe Macabiau)	☐ CN462 **Applications of Strapdown Inertial Navigation Systems** (Andrey Soloviev) SEE WEB SITE	☐ CN477: **Fundamentals of Enhanced Loran** (Ben Peterson)	☐ CN416: **Fundamentals of Pseudolites for GNSS** (Stewart Cobb)
Tuesday AM 8:30- 12:00	☐ CN410: **Fundamentals of DGNSS** (Hans-Jürgen Euler)	☐ CN433: **Future GNSS Signal Processing I** (Olivier Julien)	☐ CN465: **MEMS Sensors for Navigation** (Steve Becka)	☐ CN441: **Fundamentals of Antennas for GNSS** (Chris Bartone)	☐ CN436: **Open Source Software for COTS GPS Receivers** (Andrew Greenberg)
Tuesday PM 1:00- 5:00	☐ CN415 : **Fund. of GNSS Baseline RTK & Network RTK applications** (Hans-Jürgen Euler)	☐ CN434: **Future GNSS Signal Processing II: Adv. Tracking & Architectures** (Olivier Julien)	☐ CN480: **Fundamentals of Kalman Filtering for GPS/INS Integration** (Mohinder Grewal)	☐ CN445: **Special Topics for GNSS Antennas** (Rama Rao)	☐ CN471: **Integrated Nav. Systems for Low-Cost Applications** (Demoz Gebre-Egziabher)

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Walk-in Registrations on-Site: Welcome at any time; if we run out of notes, we'll mail them to you.

Location: ION Headquarters Hotel, Hilton Fort Worth, Texas, 815 Main Street, Fort Worth, Texas 76102. See: http://www.ion.org/meetings/gnss2007hotel.cfm

Times:
7:00 am Continental Breakfast/Sign-in begins
8:30 am-12:00 pm Morning Sessions
1:30 pm-5:00 pm Afternoon Sessions
6:45 pm-9:30 pm Extended Evening Sessions

Continental Breakfast, Coffee/drinks/snacks through out the day

Register to win: Every paid tutorial attendee will be entered to win a handheld Garmin eTrax GPS Receiver; one entry for each tutorial.

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1	$369	$289	$399	$319
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