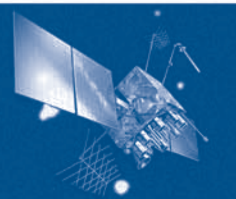

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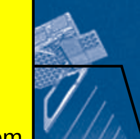


Track 6 Added:
Navigation Systems Integration Track by:
Dr. James L. Farrell
see web site:
www.GNSSsolutions.com

	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	CN413: **GNSS Integrity** Christophe Macabiau, ENAC	CN460: **Introduction to Strapdown Inertial Navigation Systems I** Kevin Dutton, Honeywell International	CN414: **Fundamentals of Space-Based Augmentation System (SBAS) Design** Mohinder S. Grewal, California State University, Fullerton
Monday PM 1:30-5:00	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	CN477: **Fundamentals of Enhanced Loran** Ben Peterson, Peterson Integrated Geopositioning	CN461: **Introduction to Strapdown Inertial Navigation Systems II** Kevin Dutton, Honeywell International	CN471: **Integrated Navigation Systems for Low Cost Applications** Demoz Gebre-Egziabher, P.E., Univ of Minnesota
Monday EVE 6:45-9:30	CN407 **GNSS Signal Propagation: Theory & Practice** Richard Langley & Peter Dare, Univ of New Brunswick	CN430: **GNSS Receiver Signal Processing I** Christophe Macabiau, ENAC	CN409: **Precise Timekeeping and GNSS** Demetrios Matsakis, U.S. Naval Observatory	CN462: **Applications of Strapdown Inertial Navigation Systems** Andrey Soloviev, Ohio University	CN473: **Autonomous Land Navigation using GPS/INS** David Bevly, Auburn Univ, See web site for description
Tuesday AM 8:30-12:00	CN410: **Fundamentals of DGNSS** Hans-Jürgen Euler, inPosition gmbh, Switzerland	CN433: **GNSS Receiver Signals Processing II - Future** Olivier Julien, ENAC	CN428: **Glonass Fundamentals & Modernization** Sergey Revnivykh, TsNIImash & Sergey Karutin, Russian Institute of Space Device Engineering (RISDE)	CN480: **Fundamentals of Kalman Filtering for GPS/INS Integration I** Mohinder S. Grewal, California State Univ, Fullerton	CN441: **GNSS Antennas I - Fundamentals** Chris G. Bartone, P.E., Ohio University
Tuesday PM 1:30- 5:00	CN415: **Fundamentals of GNSS for Baseline RTK & Network RTK applications** Hans-Jürgen Euler, inPosition gmbh, Switzerland	CN434: **GNSS Receiver Signal Processing III – Advanced** Olivier Julien, ENAC	CN420: **GPS Modernization & Relation to other GNSS** Thomas Stansell, Stansell Consulting	CN481: **Fundamentals of Kalman Filtering for GPS/INS Integration II** Mohinder S. Grewal, California State Univ, Fullerton	CN445: **GNSS Antennas II - Special Topics** Rama Rao, Mitre Corporation

GNSS Solutions® Instructors

Additional information on instructors can be found at:
www.GNSSsolutions.com/ION_GNSS_2008_Tutorial_Instructors.pdf

Dr. Chris G. Bartone, P.E. is an associate professor at Ohio University with over 25 years of professional experience. He received his Ph.D.EE from Ohio University in 1998, a MSEE from the Naval Postgraduate 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. Chris is Editor of the ION VNM and Chair of the ION Outreach Committee.

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 and recipient of the ION Kepler 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. Hans-Jürgen Euler has over 23 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 EE 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. 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 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. 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 eLoran in the US. He developed the Loran Data Channel for transmitting time of day and differential Loran corrections and currently works on eLoran receiver development. Prior to his retirement from the USCG in 2000, he was a Captain and Engineering Department Head at the Academy. He is an Academy graduate and earned a Ph.D. in 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. Demetrios Matsakis is Head of the U.S. Naval Observatory's Time Service Department and has been with USNO for almost 30 years. He received his Ph.D. in Physics at U.C. Berkeley and BS in Physics from MIT. Dr. Matsakis has published over 100 scientific papers, and is ex-President of the International Astronomical Union's Commission on Time. He teaches in a private capacity.

Sergey Revnivykh is Deputy Director General of the Central Research Institute of Machine Building, leading institute of Federal Space Agency, head of PNT Analysis and Information Center. He is a member of the management of the Federal GLONASS Program. Graduated Moscow Aviation Institute, flight dynamic engineer in 1978. Received Ph.D. degree in Moscow Aviation Institute in 2006.

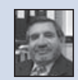
Sergey Karutin earned his M.S and Ph. D. degree in Electronics from Bauman Moscow State Technical University. He started as a software engineer in Russian Institute of Space Device Engineering (RISDE) and his first project was GLONASS/GPS attitude determination receiver. He is currently deputy head in RISDE of the satellite navigation division and mainly responsible for GLONASS and augmentation development, as well as new indoor applications.

Thomas A. Stansell is a pioneer of satellite navigation with over 49 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.

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

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.

Dr. Andrey Soloviev is a Senior Research Engineer at the Ohio University AEC. He holds B.S. and M.S. in Applied Mathematics and Physics from Moscow University of Physics and Technology and a Ph.D. EE from Ohio University. His current research focuses on multi-sensor integration including deep GPS/inertial integration. Andrey currently serves as the ION Land Representative. He received the RTCA William E. Jackson Award in 2002 and the ION Early Achievement Award in 2006 for outstanding contributions to deeply integrated Inertial/GPS.

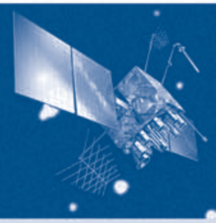


Mohinder S. Grewal, Ph.D., P.E., is a Professor of EE at California State University, Fullerton (CSUF) and has over 35 years experience in systems identification, guidance, navigation, and control. He was an architect of the GEO Uplink Subsystem (GUS) for WAAS, including the GUS clock steering algorithm. 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. 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.

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. 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.



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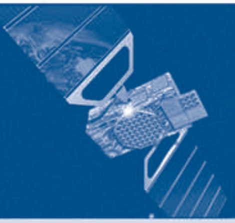


TRACK 1 MONDAY AM & PM

Updated

MONDAY, 8:30am-12:00 pm, Room 1
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 needed 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 in GPS.

- Introduction to Positioning and Satellite Navigation
- GPS Segments: Control, Space, User
- Coordinate frames and datum's used in GNSS
  - ECI, ECEF, LLH, MSL, WGS-84, ITRF, conversions, etc.
- GPS signal structure formats for current and future signals.
  - Basic/Legacy GPS: C/A, P(Y) code formats
- Modernized GPS, Galileo, Glonass (Overview)
- GPS Link Budget
- 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 precision)
- GPS error budget (overview)

Updated

MONDAY, 1:30pm-5:00 pm, Room 1
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 source in satellite navigation systems, their impact, and methods for mitigation. The course concludes with an illustration of an error-state calculation, and provides an introduction to differential GNSS.

- GPS • GPS error budget (review)
- Overview of receiver technologies and tracking loops
- Overview of antenna technologies
- Satellite orbit errors and clock errors
- Signal Multipath Error characterization and mitigation techniques
  - Code phase multipath
  - Carrier phase multipath
- Error mitigation by smoothing
- Atmosphere Errors:
  - Troposphere error sources
    - Characterization and mitigation (simple)
  - Ionosphere error sources
    - Characterization and mitigation (simple)
- GNSS Receiver Autonomous Integrity Monitoring (RAIM)-overview
- Precise Point Positioning (PPP)
  - Concept, implementation, limitations
- Introduction to differential GNSS (DGNSS) and different ways to implement it.

TRACK 2 MONDAY AM & PM

Updated

MONDAY 8:30am-12:00pm, Room 2
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 signal and services for Galileo. Details on GNSS signal formats, spreading codes, and their characteristics are provided. Major topics include:

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, MilitaryBOC (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 Subcarrier Modulations (CASM)

Updated

MONDAY 1:30pm-5:00pm, Room 2
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. Major topics include:

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

Updated

MONDAY, 8:30am-12:00pm, Room 3
CN413 GNSS Integrity (3.0 CEU)
Dr. 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. Major topics include:

GNSS integrity overview:

- Definition for applications
- Integrity and continuity trees
- Integrity monitoring, performance, and 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 and exclusion
- Horizontal, Vertical, and other Protection Level (PL) computation
- Practical examples

Future of RAIM:

- GPS/Galileo RAIM for civil aviation
- RAIM for other applications

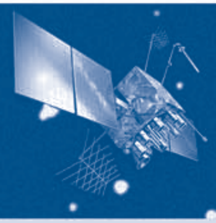
Updated

MONDAY, 1:30pm-5:00pm, Room 3
CN477 Fundamentals of Enhanced Loran (3.0 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, particularly in the United States, 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
- eLoran Receiver Performance Standards for RTCM and RTCA.
- 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

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



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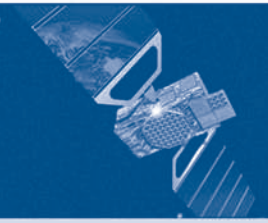


TRACK 1 TUESDAY AM & PM

Updated

TUESDAY, 8:30am-12:00 pm, Room 1
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 the navigation to sub-meter and high-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 it (overview)
- Mitigation of error in GNSS applications: (SV, atmosphere, antenna, multi-path)
- Differential pseudo-based navigation error mitigation techniques
- Overview of differential services available
  - Space Based Augmentation Systems (e.g., WAAS, EGNOS, etc.)
  - Commercial services
- Date link: RTCM SC104 standard for DGNSS
  - Message outline and philosophy
  - The different messages for DGNSS
- Precise differential techniques via carrier phase ambiguities
- Multi-frequency advantages
- Summary of standards for RTK applications:
  - RTCM SC104 V2
  - RTCM SC104 V3

Updated

TUESDAY, 1:30pm-5:00pm, Room 1
CN415 Fundamentals of GNSS Baseline RTK 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 Network RTK applications. The course will explore the various methods for error mitigation. The short-comings 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 in Network RTK
  - Virtual Reference Stations (also called VRS, iMAX and similar)
  - Area Correction Parameters (FKP German abbreviation)
  - Master-Auxiliary Concept
  - Computed Reference Stations
- Importance of interoperability when providing Network RTK services
- Aspects of other GNSS on Network RTK
- New trends in Network RTK

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

TRACK 2 TUESDAY AM & PM

Updated

TUESDAY, 8:30am-12:00pm, Room 2
CN433 GNSS Receiver Signals Processing II - Future (3.0 CEU)
Dr. Olivier Julien, Ecole Nationale de l'Aviation Civile (ENAC)

This course provides an excellent overview of future GNSS signal processing and the many aspects that affect GNSS receiver design and performance. The course starts with a reminder of future GNSS signal structures, and then addresses the important features to consider for future GNSS signals acquisition and tracking. Major topics include:

Review of civil GNSS signals
- Transmitted civil GNSS signals on L1/E1 and L5/E5 bands:
  - GPS: L1 C/A, L1C (TMBOC) and L5
  - Galileo: E1 OS (CBOC) and E5 (AltBOC)
- The correlation operation
  - Correlator output model,
  - GPS and Galileo main correlation functions,
  - Correlation losses

Acquisition of future GNSS signals
- Review of typical acquisition performance criteria
- Joint data/pilot acquisition detectors,
- Performance of MBOC signals acquisition and extension to other signals,
- Introduction to secondary code acquisition strategies

Phase tracking of future GNSS signals
- Phase tracking based on the pilot channel,
- Phase tracking performance

Code tracking of future GNSS signals
- Use of the pilot channel and secondary code for code tracking,
- Investigation of basic BOC tracking schemes (architecture, performance in thermal noise, tracking ambiguity problem),
- Tracking of BOC-based signals: MBOC/AltBOC (architecture, performance in thermal noise, tracking ambiguity problem)

Updated

TUESDAY, 1:30pm-5:00pm, Room 2
CN434 GNSS Receiver Signal Processing III – Advanced (3.0 CEU)
Dr. Olivier Julien, Ecole Nationale de l'Aviation Civile (ENAC)

This course provides an excellent overview of future GNSS signal processing and the many aspects that affect GNSS receiver performance. The course first investigates specific receiver tracking architectures dedicated to future civil GNSS signals, and then characterizes the resistance of these signals towards multipath and interference environments with respect to GPS C/A. Major topics include:

Advanced code tracking architectures
- MBOC tracking for narrow-band and wide-band receivers
- AltBOC tracking for wide-band and very-wide-band receivers
- Introduction to typical tracking techniques against BOC-related tracking ambiguity

Multipath effects on the tracking of future civil GNSS signals
- Typical multipath model
- Carrier tracking multipath envelopes and general performance
- Code tracking multipath envelopes and general performance

Interference effects on the tracking of future civil GNSS signals
- Main interference threats and models in L1 and E5 bands
- Future GNSS signals capability to mitigate continuous wave, narrow- and wide-band interference on the L1 band.
- Pulsed interference effects and mitigation on GPS L5 and Galileo E5a/E5b

TRACK 3 TUESDAY AM & PM

NEW

TUESDAY, 8:30am-12:00pm, Room 3
CN428 Glonass Fundamentals and Modernization (3.0 CEU)
Sergey Revnivykh, Central Research Institute of Machine Building (TsNIImash) and
Dr. Sergey Karutin, Russian Institute of Space Device Engineering (RISDE)

This course emphasizes the fundamentals and modernization of Glonass. The first third will cover the fundamental aspects of Glonass to include the Glonass signal structure and program overview. The next third will cover orbit optimization and Glonass time determination. Glonass signal processing will follow and Glonass modernization efforts will be details. Major topics include:

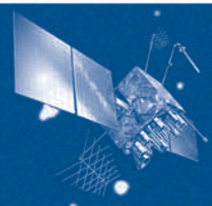
- Glonass program overview and history
- Glonass signal format and structure
- Glonass orbit optimization
- Glonass time synchronization
- Glonass signal processing features
  - FDMA signal processing for relative positioning
- Glonass Modernization:
  - new CDMA signals
  - ground control facilities upgrade
  - SBAS development in Russia

Updated

TUESDAY, 1:30pm-5:00pm, Room 3
CN420: GPS Modernization and Relation to other GNSS; (3.0 CEU)
Thomas Stansell, Stansell Consulting

This course provides information on many aspects of GPS modernization and how these efforts relate to other GNSS systems; the course covers topics on GPS modernization, including signals and satellite capabilities, interoperability with Galileo signal formats and services, QZSS, Glonass, Compass and other GNSS concepts. Major topics include:

- Motivations for modernization
- GPS Modernization:
  - L2C, L5, M-code, and L1C signals
  - Galileo interoperability
  - Performance trade-offs and applications
  - Improved GPS III functionality
    - Program status and schedule
    - New capabilities
    - Service and Power control
- Relationship to other GNSS
  - Quasi-Zenith Satellite System (QZSS)
    - C/A code
    - SAIF signal
    - L1C signal
  - Galileo
  - Glonass
  - Chinese Compass with Beidou-2
  - Indian Regional Satellite System.



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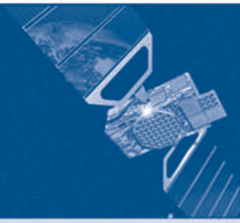

TRACK 4 MONDAY AM & PM

Updated

MONDAY, 8:30am-12:00 pm, Room 4
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

Updated

MONDAY, 1:30am-5:00 pm, Room 4
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

TRACK 5 MONDAY AM & PM

Updated

MONDAY, 8:30am-12:00pm, Room 5
CN414: 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:

- Space Based Augmentation Systems (SBAS)
- Wide Area Augmentation System (WAAS)
- European Geostationary Navigation Overlay System (EGNOS)
- Ground Based Augmentation System (GBAS)
- GPS, GLONASS & GALILEO
- WAAS Overview
- Geo Uplink Subsystem (GUS) Overview
- Ionospheric Delay Estimation
- Geostationary Communication & Control Segment (GCCS)
- Iono & Range Kalman Filter at GUS
- Code & Frequency Control at GUS
- Code Noise and Multipath
- GEO & GPS Orbit Determination
- GEO Clock Steering
- SBAS Signal Integrity

Updated

MONDAY, 1:30pm-5:00pm, Room 5
CN471 Integrated Navigation Systems for Low Cost Applications (3.0 CEU)
Dr. Demoz Gebre-Egziabher, P.E., University of Minnesota

This course emphasizes the fundamentals of multi-sensor system design and performance analysis for 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, velocity, and attitude
  - 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 1 MONDAY EXTENDED EVENING

Updated

MONDAY, 6:45pm-9:30pm, Room 1
CN407 GNSS Signal Propagation: Theory & Practice (2.5 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

TRACK 2 MONDAY EXTENDED EVENING

Updated

MONDAY, 6:45pm-9:30pm, Room 2
CN430 GNSS Receiver Signal Processing I (2.5 CEU)
Dr. 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. Major topics include:
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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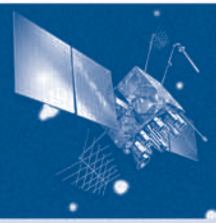

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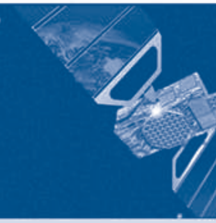

TRACK 4 TUESDAY AM & PM

Updated

TUESDAY, 8:30am-12:00pm, Room 4
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 needed for application to GPS/INS integration. Main topics include:

- What is Navigation
- Discrete Kalman Filter
- Continuous Kalman Filter
- Relationship Between Discrete and Continuous Process Noise
- Example (One State)
- Example (6 States)
- Measurements as Scalars
- Problems and Solutions
- Nonlinear Kalman Filters
- Examples
- Sigma Point (Unscented) Kalman Filter
- Square Root Filtering
- Examples with UDUT
- Prefiltering

Updated

TUESDAY, 1:30am-5:00pm, Room 4
CN 481: Fundamentals of Kalman Filtering for GPS/INS Integration II (3.0 CEU)
Dr. Mohinder S. Grewal, California State University, Fullerton

This course utilizes the fundamentals of Kalman filtering for 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:

- Fundamentals of Inertial Navigation
- Measurement Models
- Feed Forward/Feedback Configuration
- Tightly/Loosely Coupled
- Deep INS/GPS
- Lever Arm Compensation
- Automobile Applications
- INS Error Models and Sensor Parameters
- Tightly Coupled (4, 8, 11 States)
- Tightly and Loosely Coupled (17 State)

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

TRACK 5 TUESDAY AM & PM

Updated

TUESDAY, 8:30am-12:00pm, Room 5
CN441 GNSS Antennas I - Fundamentals (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/Design and Evaluation:
  - Computer simulation tools
  - Component level evaluations
  - Antenna test range options
  - Field test characterization
- Phase and group delay calibration (overview)

Updated

TUESDAY, 1:30pm-5:00pm, Room 5
CN445 GNSS Antennas II - Special Topics (CEU: 3.0)
Dr. Rama Rao, Mitre Corporation

This course explores selected topics in GNSS antenna technology which are important to users interested in recent GNSS applications

Antenna Effects on GNSS Observables:
- Antenna Gain & Beamwidth Requirements
- Antenna Phase Center, Carrier Wrap and Measurement Techniques
- Group Delay and Bandwidth Effects

Special GNSS Antennas
- Multiband GNSS Antennas for Modernized GPS and Galileo

Antennas for Assisted GPS
- Compact Quadrifilar and Ceramic Patch Antennas for Handsets
- Inverted L and Planar Inverted F antennas
- Multisystem Antennas for GPS, Bluetooth, Wireless , etc

Active GPS Antennas
- Performance Metrics and G/T Ratio

Ground Plane & Aircraft Fuselage
- Mitigation of Ground Plane Effects (EBG, RSW Microstrip, Resistivity Taper)
- Aircraft Fuselage Effect Investigations Using Scale Model & Simulation
- Adaptive Antenna Arrays:
- Multiple Element Antenna Arrays for Reducing Interference and Jamming
- Brief introduction to Space Time Adaptive Processing and Beam Forming

TRACK 3 MONDAY EXTENDED EVENING

NEW

MONDAY, 6:45-9:30pm, Room 3
CN409 Precise Timekeeping and GNSS (2.5 CEU)
Dr. Demetrios Matsakis, U.S. Naval Observatory

This course emphasizes the modern timekeeping art, with emphasis on radionavigation. The fundamentals of timekeeping including GPS, UTC, and time transfer will be presented. Timekeeping using radionavigaiton systems, including chip scale atomic clocks for user equipment will be discussed. Major topics include:

- Basics of Timekeeping
  - Fundamentals
  - Statistics
  - Timescale creation
  - Generation of Coordinated Universal Time (UTC)
  - Clock Steering
  - Generation of GPS Time
  - Time Transfer
- Radionaviation
  - GPS as a user and provider of precise time
  - Galileo and interoperability
  - Glonass
  - eLoran
- Parade of Clocks
  - From Stonehenge to Optical combs
  - Predictions for future

TRACK 4 MONDAY EXTENDED EVENING

Updated

MONDAY, 6:45pm-9:30pm, Room 4
CN462 Applications of Strapdown Inertial Navigation Systems (2.5 CEU)
Dr. Andrey Soloviev, Ohio University

This course focuses on practical application aspects of the strapdown inertial navigation technology and integrated inertial navigation. Types of inertial applications, challenges of using strapdown INS for practical application areas are addressed. Specific application examples for stand-alone and integrated INS navigation are presented. Main topics include:

Types of strapdown INS applications:
- Stand-alone applications
  - INS as a core part of integrated navigation systems

Inertial sensors:
  - Sensor specifications – what do they mean and how to “read” them
  - Main sensor technologies, their current state and perspectives

Challenges of using strapdown inertial in practical application areas:
  - Sensor and packaging errors
  - Vibrations
  - Sculling and coning errors

Example stand-alone INS applications:
  - Long-term inertial coasting for aviation applications

Example integrated INS applications:
  - GPS/INS integration for weak GPS signal processing
  - INS-based integrated navigation in GNSS-denied environments

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Track 6 Added:
Navigation Systems
Integration Track by:
Dr. James L. Farrell
see web site:
www.GNSSsolutions.com

	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)	☐ CN413: **GNSS Integrity** (Christophe Macabiau)	☐ CN460: **Intro to Strapdown Inertial Navigation Systems I** (Kevin Dutton)	☐ CN414: **Fundamentals of (SBAS) Design** (Mohinder S. Grewal)
Monday PM 1:30-5:00	☐ CN406: **Fundamentals of GNSS II** (Chris Bartone)	☐ CN426: **GNSS Signal Performance with emphasis on Galileo** (Tony Pratt)	☐ CN477: **Fundamentals of Enhanced Loran** (Ben Peterson)	☐ CN461: **Intro to Strapdown Inertial Navigation Systems II** (Kevin Dutton)	☐ CN471: **Integrated Navigation Systems for Low Cost Applications** (Demoz Gebre-Egziabher)
Monday EVE 6:45-9:30	☐ CN407: **GNSS Signal Propagation: Theory & Practice** (Richard Langley & Peter Dare)	☐ CN430: **GNSS Receiver Signal Processing I** (Christophe Macabiau)	☐ CN409: **Precise Timekeeping and GNSS** (Demetrios Matsakis)	☐ CN462: **Applications of Strapdown Inertial Navigation Systems** (Andrey Soloviev)	☐ CN473: **Autonomous Land Navigation using GPS/INS** (David Bevly) See web site for description.
Tuesday AM 8:30- 12:00	☐ CN410: **Fundamentals of DGNSS** (Hans-Jürgen Euler)	☐ CN433: **GNSS Receiver Signals Processing II - Future** (Olivier Julien)	☐ CN428: **Glonass Fundamentals & Modernization** (Sergey Revnivykh & Sergey Karutin)	☐ CN480: **Fundamentals of Kalman Filtering for GPS/INS Integration I** (Mohinder Grewal)	☐ CN441: **GNSS Antennas I - Fundamentals** (Chris Bartone)
Tuesday PM 1:30- 5:00	☐ CN415: **Fund. of GNSS Baseline RTK & Network RTK applications** (Hans-Jürgen Euler)	☐ CN434: **GNSS Receiver Signal Processing III – Advanced** (Olivier Julien)	☐ CN420: **GPS Modernization & Relation to other GNSS** (Thomas Stansell)	☐ CN481: **Fund of Kalman Filtering for GPS/INS Integration II** (Mohinder Grewa)	☐ CN445: **GNSS Antennas II - Special Topics** (Rama Rao)

Registration Information:

Selection: Choose any time slot. An entire track, or move around to suite your needs, see www.GNSSsolutions.com/ION_GNSS_2008_Tutorials_Seminars.html for course syllabi, prerequisites, intended audiences, alternative track recommendations and updates.

Cost: See table below. Special discounts available (one discount per person/order), detailed at www.GNSSsolutions.com/Registration_info.html

- Lower than GSA Pricing - Quality you can count on.
- Group discounts: Available for organizations that register 3 or more attendees at the same time, see www.GNSSsolutions.com/Registration_info.html for details.
- Flexibility discount: For attendees who want to take some tutorials elsewhere and some from GNSS Solutions, see www.GNSSsolutions.com/Registration_info.html
- ION Members discount: Receive a $30 discount (not valid with student registration).
- Student discount: Full-time Student Rate of $125 per ½ day session ($115 for extended evening) with proof of full-time student status and official school ID.

Handout Booklet: Comprehensive course handout, professionally bound, color, with every tutorial.

Registration Options: Fill out this form & fax it securely via SSL to: 740-205-4123 (f) or 877-444-5770 (f), (US & Canada)
Give us a call: 740-591-1660 (mobile). • On-line securely via SSL at www.GNSSsolutions.com/ION_GNSS_2008_Tutorials_Seminars.html

Payment Options: Credit card, check, transfer, 1556, PO, Cash or on-line at www.GNSSsolutions.com.

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

Location: Marriott Savannah Riverfront, 100 General McIntosh Blvd., Savannah, GA 31401 (free day parking) - Great location!

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 GPS Receiver; one entry for each tutorial.

Changes/Cancellations/Substitutions: Changes by Sept 1/Cancellations by Sept 5/Substitions anytime. See website for details.

Fees:

	Lower than GSA Pricing			
	Early Registration (Before 25 Aug)		Standard Registration (After 25 Aug)	
Number of 1/2 day Sessions	Total Cost for 1/2 Day Sessions	Add an Extended Evening Session	Total Cost for 1/2 Day Sessions	Add an Extended Evening Session
1	$369	$289	$399	$319
2	$738	$289	$798	$319
3	$959	$251	$989	$264
4	$1,079	$212	$1,099	$220

Total Payment:

Total 1/2 day fees: ____________

Extended evening fee: ____________

Group discount: See website or call

Flexablility discount: ____________

ION Member discount: ____________

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☐ Preregister me now, I will pay later.

Certificate of Completion: Individualized with name, tutorials and CEUs listed.

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