COUNT

Consortium of Ohio Universities on Navigation & Timekeeping

2014 Short Course Series

May 12-14, 2014

Hilton Garden Inn
3520 Pentagon Blvd.
Beavercreek, OH 45431

Monday, May 12th	
8:30 – 9:00	Short Course Registration
9:00 – 12:00	Adaptive Antennas for GNSS Receivers Dr. Inder (Jiti) Gupta, The Ohio State University, ElectroScience Laboratory
12:00 – 13:00	Lunch (provided)
13:00 – 13:30	Short Course Registration
13:30 – 16:30	GNSS Remote Sensing Dr. Jade Morton, Miami University of Ohio
Tuesday, May 13th	
8:30 – 9:00	Short Course Registration
9:00 – 12:00	Image-Aided Navigation Dr. John Raquet, Air Force Institute of Technology
12:00 – 13:00	Lunch (provided)
13:00 – 13:30	Short Course Registration
13:30 – 16:30	Sensors and Sensor Integration in Navigation Dr. Charles K. Toth, The Ohio State University, SPIN Laboratory
Wednesday, May 14th	
8:30 – 9:00	Short Course Registration
9:00 – 12:00	Alternative Positioning, Navigation and Timing Dr. Wouter Pelgrum, Ohio University, Avionics Engineering Center
12:00	Adjourn

2014 COUNT Short Course Series

Monday May 12, 2014 9:00 – 12:00
Adaptive Antennas for GNSS Receivers
Inder (Jiti) Gupta, The Ohio State University ElectroScience Laboratory

GNSS receivers are vulnerable to radio frequency interference. One can use signal processing techniques, e.g. FIR filters, frequency domain excision, etc. to suppress the interfering signals. However, the signal processing techniques are limited to narrowband interfering signals. Spatial processing using adaptive antenna, therefore, has become the universal choice for suppression of radio frequency interference in GNSS receivers. An adaptive antenna consists of multiple antenna elements. The signals received by various antenna elements are weighted and summed to produce a common output signals (for a given satellite signal frequency band) for all GNSS satellites in view or individual signal for each satellite in view. The elements weights are calculated in real time and depend on the radio frequency environment. There are many approaches to calculate the antenna element weights. Thus, the performance of an adaptive antenna not only depends on the physical characteristic (size, number of elements and distribution of elements, etc.) of the antenna array but also depend on the weighting algorithm. In this short course, we will discuss the various parameters that affect the performance of GNSS adaptive antennas. The performance metrics will include C/N as well as antenna induced biases in GNSS receiver measurements.

Monday May 12, 2014 13:30 – 16:30
GNSS Remote Sensing
Jade Morton, Miami University of Ohio

The atmosphere is a pathway through which all space-based radio communication, navigation, and surveillance signals must travel. Understanding the atmospheric effects on radio signal propagation and using radio waves to study atmospheric phenomena and properties are two inter-dependent active research areas. In recent years, GNSS has gained recognition as a powerful and versatile means for atmospheric remote sensing because of its well-defined signal structure, global coverage, and distributed and passive nature. For satellite navigation users, the atmosphere is a complex and dynamic medium that interferes with GNSS signal propagation, cause errors that critically impact the precision and robustness of GNSS systems. This course will present the basic characteristics of the atmosphere including both the ionosphere and troposphere, their effect on GNSS signal propagation, and techniques developed by both the navigation and atmospheric communities to measure the various atmospheric properties such as TEC, water vapor, temperature, and pressure.

Tuesday May 13, 2014 9:00 – 12:00
Image-Aided Navigation
John Raquet, Air Force Institute of Technology

This course will describe the fundamentals of image-aided navigation, with an emphasis on integrating image measurements with inertial systems. Topics to be covered include camera modeling and camera calibration, the scale-invariant feature transform (SIFT), simultaneous localization and mapping (SLAM), and tight integration of image and inertial measurements. Simulated and real data examples will be given for indoor and aircraft scenarios.

Tuesday May 13, 2014, 13:30 – 16:30
Sensors and Sensor Integration in Navigation
Charles Toth, The Ohio State University SPIN Laboratory

Navigation and imaging sensor technology advancements as well as integration methods have recently seen remarkable developments, fueled by rapidly advancing sensor performance, increasing processing power, and, most importantly, by growing need from a large number of applications. The classical Extended Kalman filter-based GPS and IMU integration model, introduced two decades ago, has been extended with new sensor input and error models. Moreover, alternative integration solutions have been developed. This course will provide a review of sensors and sensor error models, the theoretical foundation of integration models, and some typical applications in navigation and remote sensing.

Wednesday May 14, 2014 9:00 – 12:00
Alternative Positioning Navigation and Timing (APNT)
Wouter Pelgrum, Ohio University, Avionics Engineering Center

Global Navigation Satellite Systems (GNSS) play an essential role in the FAA NextGen and Eurocontrol's SESAR intended Performance-Based Operations (PBO), Trajectory-Based Operations (TBO), and surveillance functions. The vulnerability of GNSS to, for example, interference, solar activity, and also system anomalies warrants the development of an "Alternative Positioning, Navigation, and Timing" (APNT) system. This course will start with a brief overview of NextGen and SESAR, the envisioned APNT CONcept Of Operations (CONOPS), and the resulting APNT performance requirements in terms of Accuracy, Integrity, Availability, Capacity, and Coverage that are currently drafted by FAA and Eurocontrol.

Various APNT architectures are considered, with different levels of complexity, performance, and required investments for the provider and user. The course discusses these architectures in detail as well as their enabling technologies. The capabilities and shortcomings of current "legacy" navigation solutions, consisting of (a mix of) NDB, VOR, DME, and IRU, are covered first in the context of APNT. Next, candidate APNT architectures are discussed such as "enhanced DME-DME", the Mode-S based "Diverse Ranging" (proposed by Saab-Sensis), "SSR-Mode N" and LDACS-based positioning (the latter two proposed in Europe.)

The enhanced DME-DME solution is discussed in detail. This architecture fully leverages the advances that already have been made on DME/N interrogator and transponder equipment performance combined with revolutionary performance enhancements of eDME. eDME deploys novel techniques such as DME carrier phase, broadcasting of a “beat” signal, multipath bounding, the combination of one-way and two-way ranging, DME passive ranging, and DME data broadcast. These novel techniques will be discussed in detail, including a draft Signal In Space definition, required changes to ground and airborne equipment, and recent flight test results.