COUNT

CONSORTIUM OF OHIO UNIVERSITIES ON NAVIGATION & TIMEKEEPING

2013 Short Courses

May 29-31, 2013

Hilton Garden Inn
3520 Pentagon Blvd.
Beavercreek, OH 45431

Wednesday, May 29th	
8:00 – 8:30	Short Course Registration
8:30 – 11:30	Adaptive Antennas for GNSS Receivers Dr. Inder "Jiti" Gupta, The Ohio State University, ElectroScience Laboratory
12:00 – 13:00	Lunch (provided)
13:30 – 16:30	Low-Frequency Radionavigation as a Robust Multi-Modal Backup for GNSS Dr. Wouter Pelgrum, Ohio University, Avionics Engineering Center
Thursday, May 30th	
8:00 – 8:30	Short Course Registration
8:30 – 11:30	GNSS and Space Weather Dr. Jade Morton, Miami University of Ohio
12:00 – 13:00	Lunch (provided)
13:30 – 16:30	Network-Based RTK GPS and Precise Point Positioning Dr. Dorota A. Grejner-Brzezinska, The Ohio State University, SPIN Laboratory
Friday, May 31th	
8:00 – 8:30	Short Course Registration
8:30 – 11:30	Image-Aided Navigation Dr. John Raquet, Air Force Institute of Technology
11:30	Adjourn

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2013 COUNT Short Course Program

Wednesday May 29, 2013 8:30 – 11:30

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.

Wednesday May 29, 2013 13:30 – 16:30

Low-Frequency Radionavigation as a Robust Multi-Modal Backup for GNSS, Wouter Pelgrum, Ohio University, Avionics Engineering Center

Global Navigation Satellite Systems (GNSS), such as GPS, have dramatically changed the world of Positioning, Navigation, and Timing (PNT). High-performance PNT is now almost ubiquitously available at low cost for hundreds of millions of users. However, GNSS' relative low power levels make it susceptible to Radio Frequency interference and spoofing. Therefore, safety, environmental, and economically critical applications require an alternate or backup system that has dissimilar failure modes from GNSS. Low-Frequency radionavigation has those required dissimilar characteristics. Loran-C, for example, operates at 100 kHz, compared to 1.5 GHz GPS and its transmitted power of up to more than a Mega Watt makes the system resilient against jamming. The transmitters have more than 1000 km effective range, and a considerable infrastructure is already available worldwide. However, the 1958 quarter nautical mile Loran-C system does not fulfill the performance requirements of most modern applications, and therefore required an upgrade. Considerable effort has been undertaken over the past 15+ years to upgrade legacy Loran-C to the high performance eLoran. For example, eLoran Harbor Entrance and Approach (HEA) accuracies of 10 meter 95% were first demonstrated in Tampa Bay

Florida in 2004, and are now routine in the harbor of Harwich (UK). HEA capability in the UK will be expanded to seven harbors in the upcoming years.

This seminar will discuss Low-Frequency radionavigation with an emphasis on Loran-C and eLoran. First a basic overview of the Loran-C system will be presented, outlining the transmitter, modulation, timing, propagation, and receiver. Next, various novel technologies are detailed that transition Loran-C into eLoran: transmitter synchronization, data broadcast, propagation modeling, differential and spatial propagation correction techniques, H-field antenna design, and receiver processing algorithms. Integral to the presentation are the results of various measurement campaigns that highlight the added value of those eLoran improvements and show eLoran's potential as a multi-modal backup for timing, aviation, maritime, and land-mobile usage. The seminar will conclude with a short overview of the world-wide status and initiatives in the area of Low-Frequency radionavigation.

Thursday May 30, 2013 8:30 – 11:30

GNSS and Space Weather, Jade Morton, Miami University of Ohio

As a weakly ionized plasma bathed in the Earth's magnetic field, the ionosphere is an unavoidable pathway through which all space-based radio communication, navigation, and surveillance signals must travel. Sandwiched between the neutral atmosphere and outer space, the ionosphere serves as a critical link in the Sun-Earth system, and influences our global climate. Understanding the ionosphere effects on radio signal propagation and using radio waves to study ionosphere phenomena are two inter-dependent active research areas. In recent years, GNSS has gained recognition as a powerful and versatile means for ionosphere remote sensing because of its well-defined signal structure, global coverage, and distributed and passive nature. For satellite navigation users, the ionosphere is a complex and dynamic medium characterized by erratic behavior and spatial irregularities, which interfere with GNSS signal propagation, cause unpredictable delay in ranging code and advancement in carrier phase measurement, and critically impact the precision and robustness of GNSS systems. This course will have three parts. In part 1, we will present the basic characteristics of the ionosphere, GNSS signal code phase delay, carrier phase advance, and Doppler shift caused by propagation through the ionosphere. Part 2 provides a review of techniques developed by both the navigation and ionosphere communities to measure the ionosphere total electron content (TEC), which is an important parameter describing the state of the ionosphere and affects first order ionosphere propagation error on GNSS measurements. Part 3 discusses the scattering and diffraction of GNSS signals propagating through the ionosphere and the resulting ionospheric scintillation effects on GNSS carrier tracking loop performance. Throughout the short course, the impact of space weather activity on the fundamental ionosphere characteristics, GNSS measurement errors, and GNSS receiver performances will be highlighted.

Thursday May 30, 2013 13:30 – 16:30

Network-Based RTK GPS and Precise Point Positioning, Dr. Dorota A. Grejner-Brzezinska, The Ohio State University SPIN Laboratory

The instantaneous long-range real-time kinematic (RTK) technique is the most challenging GPS data reduction method. As the base-rover separation increases, many distance-dependent biases, such as atmospheric or orbital errors, may become significant even in differential mode, which complicates the ambiguity resolution process. This, in turn, may seriously corrupt the positioning and time transfer results, unless these effects are properly accounted for. The success of precise GPS positioning over long baselines depends on the ability to resolve the integer phase ambiguities when short observation time spans are required, which is especially relevant to RTK applications. Over the past several years, the use of a GPS reference station network approach has shown a great promise in extending the inter-receiver separation. The implementation of multiple reference stations in a permanent array offers several advantages over the standard single-baseline approach. It improves the accuracy and reliability of the mobile receiver positioning, and makes the results less sensitive to the length of the baselines, at the same time acting as a filter for lower quality measurements coming occasionally from some stations.

Moreover, the availability of high-accuracy GPS satellite orbits and clock corrections, provided by the International GPS Service (IGS), and atmospheric corrections, broadcast by local or regional networks, such as the Continuously Operating Reference Station (CORS) networks, makes Precise Point Positioning (PPP) competitive among other positioning methods. PPP can provide an interesting alternative to relative positioning applications, in particular in geodesy, surveying and navigation, enabling precise positioning with a single-receiver (i.e., low-cost), providing independence on any reference station (except for the broadcast correction source). The PPP applications are not limited by the baseline length, and can be applied to different platforms, i.e., static and kinematic. Both PPP and network-based RTK enable the use of single-frequency receivers. It may be expected that centimeter-level accuracies will be achievable in RTK PPP mode in the future (current accuracy is at decimeter-level), especially after the GPS modernization is fully implemented (improved signal quality, additional frequency, etc.), offering a more attractive and economic alternative to traditional methods.

This workshop will provide an overview of network-based RTK and introduction to PPP techniques, including basic algorithms and methods, as well as descriptions and quality assessments of the available orbital, timing and atmospheric corrections and models, with a special emphasis on ionosphere modeling. Practical examples based on the Ohio CORS network data using a research software package developed at The Ohio State University will be offered.

The participants are expected to have a basic understanding of GPS carrier phase-based positioning in differential mode. However, a brief review of basic models and error sources will be provided at the beginning of the workshop.

Friday May 31, 2013 8:30 – 11:30

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.