These two courses are intended for engineers, scientists, R&D/operations personnel and data analysts involved in antenna systems for communications, navigation and surveillance systems. Many of the design and illustration examples for these courses are from aviation, land, and maritime applications. Teachers and researchers at tertiary institutes and research centres will also find the courses beneficial. The courses would even be useful for sales /marketing managers and system integrators, but they do contain a significant amount of technical detail.

Program 1

Fundamentals of Antennas for Communication, Navigation and Surveillance (CNS) Systems

3 – 5 December 2007
York Hotel Singapore
9 am - 5 pm

Dr Chris G Bartone

Program 2

Fundamentals of Global Navigation Satellite Systems (GNSS)

6 – 7 December 2007
York Hotel Singapore
9 am - 5 pm

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Program 1 : Fundamentals of Antennas for Communication, Navigation, and Surveillancve (CNS) Systems

3 - 5 December 2007 - York Hotel Singapore

Overview

This course begins with presentation of the fundamental parameters for antennas including, antenna field components, radiation patterns, beamwidth, gain, efficiency, polarization etc. Antenna aperture, the Friis transmission equation and the Radar Range equations will be presented with examples for a communications, navigation and surveillance systems. Various types of antenna will be presented including, line/wire, loops, apertures, arrays, broadband and smart antennas. Other practical aspects dealing with antenna accessories, antenna specification and siting will be presented. Popular electromagnetic computation simulations will be presented to illustrate their usefulness in the design and test process. Other test and evaluations methodologies for antennas will be presented including component, outdoor, indoor, anechoic chamber and outdoor field characterization of antenna performance. Approximately ½ of the course will concrete on the fundamentals of antennas with good theoretical and practical presentation. The second half will concentrate on CNS systems and their applications to real world systems. Data will be presented on the basics of several CNS Systems (UHF, VHF, voice and data Communications, etc.), Navigation (GPS, ILS, MLS, VOR, DME, etc.) and Surveillance (i.e., Radar, ATC, TCAS, Mode-S, ADS-B, etc.) systems. Various CNS antennas will be highlighted with respect to their size, cost, complexity, mounting consideration, radiation characteristics and performance.

Course Outline

Fundamentals of Antennas

- Introduction to Antennas
- Radiation mechanism
- Antenna field components (i.e, near-field, far-field)
- Beamwidth
- Radiation patterns
- Theory of antenna reciprocity
- Antenna impedance and Radiation resistance
- Antenna matching
- Radiation intensity, directivity, gain, and efficiency
- Mismatch losses, SWR, polarization)
- Bandwidth
- Wave and Antenna Polarization
  - Linear, Elliptical, Circular, etc.
- Standing Wave Ratio (SWR)
- Noise Temperature, Noise Factor, Noise Figure
- Antenna aperture
- The Friis transmission equation with Comm and GPS link examples
- Radar Range Equation with Marine Radar example

Antennas Types

- Linear wire antennas
  - Dipoles, monopoles, bowtie, batwing, etc.,
- Image Theory
- Loop antennas
  - Coil, Ferrite loaded, Helix, quadrafilar helix
- Aperture antennas (e.g. horns, waveguides, dishes etc.)
- Patches
- Reflector antennas
- Yagi-Uda Array
- Broadband antennas
  - Log-periodic dipole array
  - Spiral antennas and variations
- Arrays
  - Linear, Planar and Circular
- Smart Antennas

Antenna Accessories

- Low noise amplifiers
- Power splitter/combiners
- RF cables and connectors
- Ferrite RF isolators, DC Blocks and Bias-Ts

Antenna Specifications

- Existing manufactory spec
- New development spec

Antenna Siting Issues

- Mask and Coverage Considerations
- Influence of ground plane and craft structure effects on antenna patterns

Design, and Test and Evaluation

- Computational Electromagnetics (CEM):
  - Additional tool besides analytical design, and actual device testing
  - Most popular techniques: MoM, FEM, FDTD, GTD/UTD/PO
- Component Level: Network Analyzer:
  - Impedance
  - VSWR
- Pattern Characteristics:
  - Antenna Range
    - Indoor Range (mostly shielded and/or anechoic)
      - Free-space Range (i.e., doing direct far-field measurements)
      - Near-field Range
      - Compact Range (far-field characterization only)
    - Outdoor Range (almost never shielded or anechoic)
      - Elevated Range (a.k.a. Free Space Range)
      - Reflective Range
      - Slant Range
    - Installed system
      - As-installed antenna measurements
      - In-flight pattern measurements
    - System-level performance characterization

CNS Fundaments and Antennas for CNS Systems

1) Communications Systems - Overview
   - Voice, Data (ACARS, SELCAL, ELT, UHF/VHF Data, etc.)
   - Examples of Communications Antennas and their details with emphasis on monopole blades, patches, and combination antennas for aviation
     - Emergency Locator Transmitters (ELT)
     - Satcom/INMARSAT
2) Navigation Systems – Overview
   - Loran-C, VOR, DME, MLS, GPS
   - Examples of Navigation Antennas and their details
     - Non-directional beacons (NDB)
     - VHF Omni-directional Ranging (VOR)
     - Distance Measurement Equipment (DME)/TACAN
     - Electric monopoles and Magnetic H-field antenna for Loran-C
     - Instrumented Landing System (ILS)
     - MLS antenna systems (ground and air)
     - GPS patch antennas
     - Antenna Multipath considerations: design, metrics, and technology comparison (patch, survey, integrated multipath limiting antenna (IMLA))
     - Advanced GPS survey antennas for multipath mitigation with Antenna Performance Analysis Case Study
3) Surveillance Systems – Overview
   - Radar, Secondary Radar, ATC, Mode S, UAT
   - Examples of Surveillance Antennas and their details
     - Ground-based radar surveillance systems (ASR-9, ASR-11)
     - Secondary radar directional antenna systems
       1) Interrogator/Receiver Side Lobe Suppression
       2) Air Traffic Control Radar Beaconing Systems (ATCRBS)
       3) Mode S
       4) Traffic Collision and Avoidance System (TCAS)
       5) Automatic Dependence Surveillance-Broadcast (ADS-B)
   - Radar Altimeters

Program 2 : Fundamentals of Global Navigation Satellite Systems (GNSS)

6 - 7 December 2007 - York Hotel Singapore

Overview

The course begins with the fundamental concepts of positioning and navigation, followed by some historical and current "legacy" navigation systems. GNSS will be introduced with emphasis on the fundamentals of GPS. An introduction of the three core segments for GPS; Space, Control and User Segments will be presented. Other GNSS Systems; Galileo, Glonass, Compass/Beidou will be presented form an overview perspective. The core functions that need to be performed to obtain a user solution using GPS in an error free environment will be presented. An introduction to an error budget in GPS, the CORS network, data formats and on-line positioning services will be presented.

After the GNSS overview error-free positioning has been presented the fundamentals of GNSS with emphasis on GPS in the presence of various error sources (i.e., multipath, atmospheric (troposphere, ionosphere), clock, etc.) will be presented. The course will provide details on the nature of various error sources in GNSS, their impact and methods for mitigation. An introduction to receiver autonomous integrity monitory (RAIM) will be presented. The concept of Precise Point Positioning (PPP) will be presented and its limitations discussed.

Differential GNSS (DGNSS) with emphasis on Differential GPS (DGPS) will next be presented to illustrate its effectiveness to reduce common systematic errors in GNSS. The course will explore additional error mitigation techniques and methods for various high performance applications for various baseline lengths. Performance aspects with respect to accuracy, integrity, continuity, and availability will be presented.

Advanced error mitigation techniques and the fundamentals of real-time kinematic (RTK) techniques with focus on GPS Baseline RTK applications will be presented in the afternoon of the second day. The overall concepts for advanced error mitigation and RTK techniques will be presented.

Course Outline

Introduction to Navigation & Fundamentals of GNSS and Positioning

- Positioning vs Navigation
- The GNSS Timeline
- GPS Segments – overview:
  - Space Segment; GPS Blocks, numbers, capabilities, timeline
  - Control Segment: Legacy and Modernization efforts
  - User Segment: Various applications introduced
- Coordinate frames and datum's used in the application of GNSS.
  - Terrestrial and Inertial Reference Frames
  - Earth Centered Inertial (ECI)
  - Earth Centered Earth Fixed (ECEF)
  - Latitude, Longitude, Height (LLH), Mean Sea Level (MSL)
  - Height: Geodetic, MSL, WGS-84, Undulation
  - Other datum's used in the World
  - Local Level Tangent (LLT)
  - Coordinate Conversions
- GPS signal structure formats for current and future signals.
  - Basics of Direct-Sequence Spread Spectrum (DSSS) systems
  - Auto and Cross correlation of spreading codes
    - M-sequences
    - Gold codes
    - Random codes
  - GNSS Signal formats and encoding
  - BPSK, BOC, and MBOC modulations
  - Legacy GPS code formats: C/A, P(Y)
  - Modernized GPS:
    - L2C
    - L5
    - L1C status and plans
    - Ground Control Segment
- Galileo GNSS Introduction
- Galileo Signals and Services:
  - Open Services (OS)
  - Commercial Services (CS)
  - Safety of Life (SOL)
  - Public Regulated Services (PRS)
  - Search and Rescue (SAR)
- Glonass
  - Compass/Beidou
  - The system, signals, and status
- GPS Link Budget
- GPS Receiver Architecture Overview
- GPS Navigation Message Data Format Descriptions
  - NAV & CNAV message formats
- GPS Modernization
- Calculation of the GPS space vehicle (SV) position using the broadcast Kepler parameters (ephemeris and almanac)
- GPS Time Considerations
  - UTC
  - Local time
- Calculation of user state (i.e., position and time)
- Associated performance parameters (i.e., dilution of position terms)
- GPS error budget (overview)
- On-line positioning services
- Continuous Operating Reference Stations (CORS)
- Common GNSS receiver file formats:
  - Rinex, Binex, Manufacture unique and how to handle.
- Real-time GNSS data (e.g., Ntrips)

Fundamentals of GNSS with Error Mitigation for a Single Point User

- GPS error budget (review)
- Overview of receiver types and receiver technologies
  - Receiver block diagram
  - Carrier phase tracking
    - Frequency Lock Loops
    - Phase Lock Loops
  - Loop order considerations
  - Code Tracking
    - Coherent Delay Lock Loops
    - Non-coherent Delay Lock Loops
- Overview of various GNSS antenna types and antenna technologies
- Satellite orbit errors and introduction of mitigation methods
- Satellite clocks and their errors
- Signal Multipath Error characterization and mitigation techniques
  - Code phase multipath
  - Carrier phase multipath
- Error mitigation by smoothing
  - Single-frequency smoothing
  - Dual-frequency smoothing
- Atmosphere Errors:
  - Troposphere error sources and characterization
    - Simple exponential model
    - wet & dry component
    - Advanced troposphere models and error mitigation
  - Ionosphere error sources and characterization
    - Ionosphere measurement methods and mitigation
    - GPS Broadcast model (i.e, Klobuchar Model)
    - Advanced Ionosphere models and mitigation
- GNSS Receiver Autonomous Integrity Monitoring (RAIM)
- Precise Point Positioning (PPP)

Differential GNSS & Augmentation Systems

- Differential GPS (DGPS) and different ways to implement it
  - Local
  - Wide
  - Regional
  - Global
  - Correction-based
  - Measurement-based
  - Absolute vs Relative DGNSS
- Correlation and de-correlation of errors over error type, baseline length, and time for differential GNSS architectures
- Integrity of a DGNSS
- GNSS Translators
- Remote Tracking, positioning, and control
- Differencing techniques;
  - Single difference
  - Double difference
  - Triple difference
- Data link considerations for DGNSS systems.
  - RTCM SC104 standard for DGNSS
  - Message structure and versions
- Example Systems:
  - NDGPS
  - Space Based Augmentation System (SBAS)
    - Overview of SBAS and various systems
    - The Wide Area Augmentation System (WAAS)
      - Overview of WAAS, the system, signals, and intended use
      - Message Types and their implementation for:
        - Integrity
        - Pseudorange corrections
        - Orbit & Clock corrections with case study
        - Ionosphere corrections
    - WAAS troposphere model for the user
    - WAAS multipath mitigation
  - Local Area Augmentation (LAAS)
  - Global area augmentation systems

High Performance GNSS using Carrier Phase & GNSS Antennas Considerations

- Error Considerations and the need for error mitigation
  - High fidelity model and antenna correction techniques
- Data link encoding standards for real-time kinematic applications
  - RTCM SC104 version 2.3 & 3.0
  - Kinematic Based Systems
- DGPS Solution and Parity Space
- Ambiguity Resolution Techniques and Trade-offs
  - Initialization with code
  - Searching for the right ambiguity set
  - Checking/validation of solution

About the Instructor

Dr. Chris G. Bartone, P.E. is an Associate Professor at Ohio University with over 24 years of profession experience in communications, navigation and surveillance (CNS) systems. 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, performing research development, test & evaluation of CNS systems. 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 graduate and undergraduate courses in the area of GPS, high accuracy GPS, radar and electromagnetic wave propagation and antennas classes.

His research concentrates on all aspects of navigation. Dr Bartone has been active in research areas involving complex CNS stimulation/simulation, air traffic control systems, GPS augmentation with pseudolites, DGPS data link definitions, antenna design simulation, fabrication, and testing in anechoic chambers, including dual-frequency GNSS patch antenna design and high performance relative and absolute DGPS applications for air, land/rail, and maritime.

He is a member of the US Institute of Navigation (ION), and Senior Member of the Institute of Electrical and Electronics Engineers. He is very active with the ION; chaired several programs; Air Representative; Eastern Region Vice President; Chair, ION Outreach Committee; and Editor, ION Virtual Navigation Museum. Chris is a licensed profession engineer in the state of Ohio. Dr. Bartone is the President of GNSS Solutions which specializes in educations seminar, consulting services and expert legal advice.

Registration Details

How to Register

TEL : 64699615 **FAX : 64695190**
Email : eem@pacific.net.sg
Mail complete registration with appropriate payment to :
EEM Advancement Centre Pte Ltd, 170 Upper Bukit Timah Road, #18-01 Bukit Timah Shopping Centre, Singapore 588179.

Course fee for each course per delegate

Fee and Payment :	***Program 1***	***Program 2***
Individual Fee	S$1,790	S$ 1,290
Group Discount for 3 or more delegates	S$1,590	S$ 1,090

Fee includes tuition, training materials, lunches, morning/afternoon refreshments and certificate of completion.

Please made payment in S$ to **"EEM Advancement Centre Pte Ltd"**

Cancellation & Refunds : *You may cancel your registration up to two weeks before the course and your registration fee will be refunded in full. If you need to cancel less than two weeks prior to the course, you (1) may send a substitute, or (2) will be liable for 10% of the fee. Confirmed registrants who fail to attend and do not cancel their registrations in advance are liable for the entire fee.*

The organiser reserves the right to cancel or reschedule the courses without prior notice.

Registration Form

Program 1 :
Fundamental of Antennas for Communication, Navigation, and Surveillance (CNS) Systems - 3 - 5 December 2007

1. Mr/Ms _____
   Designation/Dept _____
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   Designation/Dept _____
3. Mr/Ms _____
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Program 2 :
Fundamentals of Global Navigation Satellite Systems (GNSS)
6 - 7 December 2007

1. Mr/Ms _____
   Designation/Dept _____
2. Mr/Ms _____
   Designation/Dept _____
3. Mr/Ms _____
   Designation/Dept _____

Company _____
Nature of Business _____
Address _____
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Contact Person : Mr/Ms _____
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