PRIVATE GROUP LIVESTREAM REMOTE COURSE. RESTRICTED TO U.S. GOVERNMENT AND ITS CONTRACTORS

Course 335: Military GPS Receiver Performance in Jamming, with Mitigations (U.S. Military Only) (1.5 CEUs)

Day 1	Day 2	Day 3
Day 1 Morning **Introduction (1 hour)** • GPS, satnav, and other current and prospective sources of position, velocity, and time, with their strengths and limitations. Shows why GPS and satnav will remain essential for decades to come. **Satnav and GPS Fundamentals (2 hours)** • Basics of how satnav works. Construction of signals, receiver functions, jamming and spoofing, positioning and timing errors, GPS details including differences between civil and military signals, overview of foreign satnav systems.	**Day 2 Morning** **Review questions (1 hour)** • Discussion of previous day's material based on review questions that are solved and used as a springboard for further explanation and discussion. **Antennas (1 hour)** • Antenna basics (gain, polarization, …), fixed reception pattern antenna (FRPA) characteristics, FRPA types, antenna arrays—controlled reception pattern antenna (CRPA) characteristics, adaptive antijam antenna system processing architectures (single-tap power minimization, SFAP and STAP power minimization, constrained SFAP and STAP), advantages and disadvantages of different architectures, stresses on architectures. **Acquisition and Initial Synch (1 hour)** • Initial receiver states; initial time uncertainty and initial frequency uncertainty; time-frequency space, tiles, and cells; receiver processing overview; cross ambiguity functions, coherent and noncoherent processing; other functions in acquisition; representative acquisition thresholds.	**Day 3 Morning** **Review Questions (1 hour)** • Discussion of previous day's material based on review questions that are solved and used as a springboard for further explanation and discussion. **End to End Examples (1.5 hours)** • Putting all the pieces together with practical "toy examples" that integrate everything over the past two days including planning tests, comparing user equipment, understanding benefits of M-signal. **Wrap-up (0.5 hour)** • Revisiting the key points of the past 15 hours of class, putting the material in context.
LUNCH IS ON YOUR OWN		
Day 1 Afternoon **Military Signals and Receivers (1 hour)** • Frequency bands, overview of P(Y) and M signals, binary offset carrier (BOC) spreading modulations, types of military receivers, receiver operating states, channel states. **Decibels (0.5 hours)** • Refresher on decibels, dBW, dBm. Rules of thumb, examples, and tricks in using decibels for engineering calculations. Practical examples. **Receiver Performance Measures (1.5 hour)** • Effective C/N0, spectral separation coefficients (SSCs), J/S, Eb/N0, tolerable jamming power (TJP). What they mean, why they are important, how they are interrelated, how they are used, with practical examples.	**Day 2 Afternoon** **Tracking and Data Demodulation (1 hour)** • Concept of tracking received signal parameters, concept of tracking loops, tracking loop considerations, carrier tracking (S-curve, loss of lock, performance), code tracking (S-curve, loss of lock, performance), data message demodulation, inertial measurement units in tracking (loose coupling, tight coupling, vector tracking, ultratight coupling), calculating jamming thresholds. **Concepts of Jamming and Mitigations (0.5 hours)** • Types of jamming waveforms in time, frequency, and amplitude domains. Types of jamming mitigations. **Situational Awareness (0.5 hours)** • Concepts and candidate architectures. **Link Budgets and Propagation Loss (1 hour)** • Space to earth link budgets, radio line of sight, terrestrial link budgets, effects of foliage and buildings.	

Course Description

This two and a half-day course is targeted at military operators, testers, and planners involved in specification, operations, planning, evaluation, testing, and use of military GPS user equipment. The course level assumes attendees do not have deep familiarity with satellite-based navigation (satnav) or GPS, or with electrical engineering principles and concepts. Important principles and concepts are conveyed without resorting to deep mathematics or theory. Extensive examples that employ simple back of the envelope calculations are used to equip attendees with the tools needed for understanding and assessing various aspects of military user equipment capabilities. Extensive use of practical examples allows attendees to apply the concepts in practice.*Note: This course is restricted to employees of U.S. government agencies and their U.S. government contractors.*

Prerequisites

The course level assumes attendees do not have deep familiarity with satellite-based navigation (satnav) or GPS, or with electrical engineering principles and concepts. Important principles and concepts are conveyed without resorting to deep mathematics or theory. Extensive examples that employ simple back of the envelope calculations are used to equip attendees with the tools needed for understanding and assessing various aspects of military user equipment capabilities. Extensive use of practical examples allows attendees to apply the concepts in practice.

Who Should Attend?

This course is targeted at military operators, testers, and planners involved in specification, operations, planning, evaluation, testing, and use of military GPS user equipment. Note: This course is restricted to employees of U.S. government agencies and their U.S. government contractors.

Materials You Will Keep

- A color electronic copy of course notes (provided in advance) on USB drive or CD-ROM
- Ability to use Adobe Acrobat sticky notes
- NavtechGPS Glossary of GNSS Acronyms
- A black and white hard copy of the course notes
- A book from the list below.

Book Allowance

Book allowance is part of private group contracts. For your allowance, we suggest the book by John Betz, Ph.D., *Engineering Satellite-Based Navigation & Timing: GNSS, Signals, & Receivers,* Betz. Wiley-IEEE Press, 2015.

What Attendees Have Said

"The instructor was one of the best instructors of any short course I've ever had. It is hard to narrow down one or two important aspects of the course, but signal strength and how to characterize through space was my biggest objective. If we'd had more time all of the topics could be expanded by Dr. Betz, as he is incredibly knowledgeable and experienced."
— Name withheld upon request, June 2019

"Dr. Betz is an expert who made many complex factors associated with nav testing very understandable. In particular, I got additional ideas on how to plan for user equipment testing and planning regarding jamming/testing. Excellent course. Thank you."
Name withheld upon request, June 2019

"You can tell Dr. Betz is an expert by how he can simplify advanced subjects so he we can understand, especially what goes on inside receivers in presence of jamming. I would recommend this course to all navigation and weapons engineers."
— Cole Johnson, Edwards AFB, June 2019

Instructor

Dr. John Betz