### Description

This 5-day course enables attendees to achieve proficiency, not merely familiarity, with the essential aspects of using GPS/GNSS signals. Not only does it thoroughly address current and future GPS signals, but it also drills deeply into available details of signals from other satellite-based positioning and timing systems. As attendees understand similarities and distinctions among different systems and signals, they will become equipped to take advantage of signals from multiple systems.

Receiver processing techniques are described along with ways to characterize the performance of receiver processing. These processing techniques are customized to specific characteristics of signals from GPS and other satellite systems. Specialized topics, including dealing with interference and with multipath, differential satnav, and assisted satnav, are also addressed.

Attendees will be given review questions each day that will be reviewed in class the following morning. These review problems and solutions help attendees understand and apply key concepts.

### Course Objectives

To develop proficiency with advanced receiver processing of modernized and new signals from GPS, GLONASS, Galileo, BeiDou, and QZSS, supplemented by systems engineering skills, integrated with techniques for assessing performance and performing design trades concerning receiver processing.

### Prerequisites

Attendees should have a solid background in GPS and be ready to develop advanced skills. Prior exposure to basic signal processing techniques and terminology as well as familiarity with engineering mathematics is needed.

### Materials You Will Keep

- A color electronic copy of all course notes will be provided on a USB Drive or CD-ROM.
- A black and white hard copy of the course notes will also be provided.

### Book Allowance

Book allowances for on-site group contracts, if any, are negotiated as part of the contract. For your allowance, we encourage you to consider the book by John Betz, Ph.D., *Engineering Satellite-Based Navigation & Timing: GNSS, Signals, & Receivers*, Betz-Wiley—IEEE Press, 2015.

### What Attendees Have Said

"He [Dr. John Betz] had a very methodical and logical way to present the material and build on it. It was very effective. He took questions well and answered them thoroughly and encouraged questions. Understanding the trade-offs that Dr. Betz presented in an elegant way helps us decipher when and how to use the different parameters for receiver design and signal processing and which techniques to use.

— Gina Guiducci, U.S. Army, Aberdeen Proving Grounds, January 2017"

"Main objectives: To learn more about GPS/GNSS receiver algorithms. To learn more about GNSS signals. The course met and exceeded my objectives.

— Patrick Pitoscia, U.S. Army"

### ON-SITE COURSE

**Course 551: Using Advanced GPS/GNSS Signals and Systems (3.0 CEUs)**

<table>
<thead>
<tr>
<th>DAY 1</th>
<th>DAY 2</th>
<th>DAY 3</th>
<th>DAY 4</th>
<th>DAY 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dr. John Betz, MITRE</strong></td>
<td><strong>Dr. John Betz, MITRE</strong></td>
<td><strong>Dr. John Betz, MITRE</strong></td>
<td><strong>Dr. John Betz, MITRE</strong></td>
<td><strong>Dr. John Betz, MITRE</strong></td>
</tr>
</tbody>
</table>

**Day 1 Morning**
- **Objectives:** Review basics of satellite-based positioning and timing, establish common terminology and notation, explore satellite orbits and constellations, understand satnav signal fundamentals

**Day 1 Afternoon**
- **Objectives:** Establish rigorous mathematical models of satnav signals, become proficient with systems engineering tools

**Day 2 Afternoon**
- **Objectives:** Complete exploring details of GPS signals and SBAS signals, begin receiver engineering with an overview, followed by details of receiver front end design

**Day 3 Afternoon**
- **Objectives:** Describe approaches for massively parallel initial synch and evaluating initial synch performance, describe procedures for tracking loop design and implementation, followed by carrier tracking

**Day 4 Afternoon**
- **Objectives:** Describe algorithms and considerations for calculating position, velocity, and time; provide integrated view of dealing with interference; introduce Galileo system and signals

**Day 5 Afternoon**
- **Objectives:** Summarize other satnav systems and signals (GLONASS, BDS, QZSS), provide overviews of differentially assisted satnav, assisted satnav, and multipath considerations, wrap up course

**Links to Other Sections**
- Galileo System and Signals
- BDS
- QZSS

**What Attendees Have Said**

"He [Dr. John Betz] had a very methodical and logical way to present the material and build on it. It was very effective. He took questions well and answered them thoroughly and encouraged questions. Understanding the trade-offs that Dr. Betz presented in an elegant way helps us decipher when and how to use the different parameters for receiver design and signal processing and which techniques to use.

— Gina Guiducci, U.S. Army, Aberdeen Proving Grounds, January 2017"

"Main objectives: To learn more about GPS/GNSS receiver algorithms. To learn more about GNSS signals. The course met and exceeded my objectives. I especially like the review questions. I also like the real-world examples and anecdotes from Dr. Betz’s experience developing real systems."

— Patrick Pitoscia, U.S. Army

### Instrucor

Dr. John Betz,