Preface

GPS in many ways is like the Internet. Both are gifts of the U.S. Department of Defense to the civil world. Both continue to transform the way we do ordinary, everyday things as individuals and society, delivering wide-ranging economic and social benefits far beyond anything their designers could have dreamed of. And, of course, the Internet now plays an important role in newer GPS applications.

The value of GPS to the military, its main sponsor, developer, and keeper, is illustrated by noting that GPS receiver will become the most widely used military radio (albeit one way), to be carried by every aircraft, ship, tank, truck, soldier, and bomb, even an artillery shell. In civil use, of greater interest in this book, GPS has already become indispensable to millions of car and truck drivers, sailors, pilots, sportsmen, and outdoorsmen. In a less visible role, GPS has become the source of precise time for telecommunications, banking, power generation, and the Internet. A one-chip GPS receiver will soon be built into every cell phone and PDA.

We are gratified by the response of teachers and students of GPS to our First Edition, which appeared in 2001. In this Second Edition, we have corrected, updated, revised, and expanded our treatment of the GPS signals, measurements, and performance, but the basic objective remains unchanged: to offer an introductory textbook for students of engineering and applied sciences and a self-study guide for practicing engineers.

Some background in linear algebra, probability theory, signal theory, and linear system theory is required for this book. An ideal preparation would be an upper-division course in each of these areas. Vector-matrix notation is used throughout. The concepts of mean, standard deviation, covariance, and correlation of random variables are used without explanation. We do, however, review the results from signal theory and system theory before beginning our discussion of the GPS signals and receivers.

The book is divided into four parts. Parts I and II have been revised and expanded but have retained their structure from the First Edition. Part I, now consisting of four chapters, introduces the basic framework of a global satellite navigation system, including coordinate frames, time references, and orbits, and provides an overview of GPS, GLONASS, and Galileo. The three chapters of Part II deal with the measurements, errors therein, and estimation of position, velocity, and time. The biggest change in this edition is in our discussion of the GPS signals and receivers. The treatment of both topics has been expanded significantly. Part III of the First Edition, with its three chapters, has grown into Parts III and IV, with three chapters each.

The treatment of GPS signals and receivers has been expanded in both breadth and depth.
The main results from signal theory and system theory useful to our discussion have been brought together in a review chapter (Chapter 8). An entire chapter is now devoted to the structure of the GPS signals, including the new binary offset carrier modulation (Chapter 9). A chapter each is devoted to signal acquisition and tracking (Chapters 11 and 12). A new chapter has been added for discussion of techniques to cope with signal obstruction and interference (Chapter 13).

We believe this book offers an instructor several options for a one-semester senior- or graduate-level course. The two simplest options are: Chapters 1–7 for a course with emphasis on positioning and navigation algorithms, and Chapters 1, 2, 8–13 for a course with emphasis on signals and receivers. In either case, we hope the instructor would apply and extend the basic ideas of positioning algorithms or receiver design to a specialized application, e.g., geodesy, aviation, land navigation, or assisted GPS.

The CD accompanying the Second Edition has been brought up to date. The GPS data sets used in homework problems and simple MATLAB tools (M-files) to manipulate these data sets are essentially unchanged from the First Edition. Even though the Internet now offers access to a wide variety of raw and processed GPS data collected around the world, we have retained the data sets on the CD for ease of use. The GPS-related documents have been updated.

The First Edition showed signs of smoldering resentment against Selective Availability (SA), the U.S Government policy throughout the 1990s of purposefully degrading the civil signals. Now with SA receding in memory and civil users of GPS feeling indulged, there seems no reason for side-by-side comparison of what the system was capable of and what it was delivering to the civil users in the late 1990s while the First Edition was taking shape. We have, however, retained for the historical record a couple of figures in Chapters 2 and 5 showing effects of SA so a newcomer would know what the fuss was about.

There are now many websites useful to GPS engineers and users, and we have included references to several in this edition. By definition, a website is a changeable entity, sometimes disappearing without notice. We have included sites which we thought would be maintained during the useful life of this book.

We are grateful to the instructors who used the First Edition for classroom instruction and offered ideas for improvement. We thank especially Professors Penina Axelrad and Dennis Akos (both of the University of Colorado at Boulder), Professor Kai Borre (Aalborg University), Professors Michael Braasch and Chris Bartone (both of Ohio University), Professors Elizabeth Cannon and Gérard Lachapelle (both of University of Calgary), Professor Demoz Gebre-Egziabher (University of Minnesota), Professor Richard Langley (University of New Brunswick), Professor Jade Morton (Miami University), Professor Boris Pervan (Illinois Institute of Technology), Dr. Marvin May (Penn State), Dr. Albert Paradis (MITRE Corporation), Professor John Racquet (AFIT), and Professor Christian Tiberius (TU Delft) for their comments and suggestions. We also owe a debt of gratitude to Professor Akio Yasuda and his research team at the Tokyo University of Marine Science and Technology for translating the First Edition into Japanese.

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