

GPS Information Sources

By James E. Ferguson, OLS

Time flies when you're having fun! It's been almost a year since you last saw a Geodesy Corner in the *Quarterly* - but if I may offer a twist on the old saying, "Absence makes the desire grow larger!" I have what I believe is a treat for you this issue - an article that summarizes the many sources of written information relating to GPS.

With the vast amount of interest in computer based information sources, it is easy to overlook the wealth of data in the

written word, and best of all you can read just about anywhere.

Our colleagues at the University of New Brunswick have been at the leading edge of GPS technology and applications for some time and the author of this article, Richard Langley, is well qualified to write on the subject of GPS. In this article, I found his classification of the reviewed material invaluable in finding relevant work quickly and easily. And, his close association with the who's who

of the industry has helped him see what publications are coming along in the near future.

I hope that you find this article interesting and informative and I urge you to start your own "GPS User's Bookshelf." By the way, if you didn't pick up the free booklet of information related to geodesy and geomatics (Internet sites, publications etc.) distributed at the AGM in London in February, please contact me through the Association office.

The GPS User's Bookshelf

By Richard B. Langley, University of New Brunswick

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In November's column we took a look at the various sources of GPS information in electronic format available through the Internet. This month, we turn to the printed word and present an overview of the growing library of books and other publications about GPS and its many applications.

Innovation is a regular column in GPS World featuring discussions on recent advances in GPS technology and its applications as well as on the fundamentals of GPS positioning. The column is coordinated by Richard Langley and Alfred Kleusberg of the Department of Geodesy and Geomatics Engineering at the University of New Brunswick, who appreciate receiving your comments as well as suggestions of topics for future columns.

Despite the phenomenal amount of information available through the computer networks on almost all topics under the sun, not all aspects of particular topics

are covered, and information on specific subtopics can still be hard to find. Search tools are getting smarter, and more information is being added to the World Wide Web every day, but at least for the time being, printed monographs, conference proceedings, and journals are still an indispensable source of information for the GPS user. And, unlike computer networks, books never go down.

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In this article, I'll briefly discuss most of the GPS books currently available and a few that will be hitting the bookstores soon. In addition, I'll mention some available GPS-related government publications, proceedings of some of the GPS conferences, and journals covering GPS developments. The publications are clas-

sified according to their level of presentation: introductory, intermediate, and advanced. The introductory publications require no previous knowledge of GPS. They use little or no mathematics and carefully explain the basic concepts in general terms. The intermediate-level publications provide more detail on the system, how it works, and how it is used. Although algorithms may be presented, they are typically explained well enough so that an in-depth knowledge of radio engineering, physics, or higher mathematics is not required. At the advanced level, no holds are barred. Not for the faint of heart, these publications present technical details in their full glory.

I have selected primarily publications of a general nature for this article, although a few books dealing with specific applications of GPS are also included. The list is not intended to be exhaustive and may reflect a slight bias toward my own field of geodesy.

INTRODUCTORY

With GPS being used more and more for all kinds of applications, the demand for books clearly explaining the basics of GPS will undoubtedly grow. The following are some good primers already at hand for the GPS newcomer.

The Trimble Booklets. Just getting started with GPS? One of the best introductions to the basic principles of GPS in easily understood language is *GPS: A Guide to the Next Utility*. This 76-page paperback, written by Jeff Hurn for Trimble Navigation (Sunnyvale, California) and first published in 1989, is arranged in two sections. Section 1 answers the question What is GPS? and goes on to explain how GPS works in five easy steps: how to get receiver positions from measured ranges to satellites, how ranges are measured, the need for perfect timing, knowing where a satellite is in space, and the effect of atmospheric propagation delays. Section 2 provides a few more details to understand GPS principles better and discusses pseudo-random codes, differential GPS (DGPS), and criteria for selecting a GPS receiver. The booklet concludes with a glossary of basic GPS terms.

Other titles published by Trimble are *GPS Surveyor's Field Guide, A Field Guidebook for Static Surveying*, *GPS Surveyor's Field Guide, A Field Guidebook for Dynamic Surveying*, and *Differential GPS Explained*. The 45-page static surveying guidebook, first published in 1991, covers different aspects of conventional, static baseline surveying, in which GPS receivers record data for half an hour or longer and only while on station. The booklet tells readers how to plan GPS observations, design a network, carry out a survey, measure antenna heights, and manage the collected data. It even has a handy equipment checklist. The 71-page companion booklet on dynamic surveying, published one year later in 1992, compares three types of dynamic sometimes called kinematic surveys: kinematic (also called stop-and-go), pseudostatic (also called pseudokinematic), and fast (or rapid) static. The latest booklet in the series is on differen-

tial GPS. As its subtitle says, *Differential GPS Explained* is an expose of the surprisingly simple principles behind today's most advanced positioning technology. After reviewing the basics of how GPS works, author Jeff Hurn defines DGPS, explains why we need it and how it works, who's using it and what's on the horizon. Given the rapid pace of GPS developments, what was on the horizon in 1993 when the 55-page booklet was published - real-time kinematic positioning using carrier-phase observations to get centimeter-level accuracies in real time - is already here today! As with the other booklets in the series, this one on DGPS is written in easily understood language. Even the buzzwords in this booklet are explained in a useful back-of-the-booklet glossary.

Getting Started with GPS Surveying. For an entertaining as well as instructive introduction to surveying with GPS, get a copy of *Getting Started with GPS Surveying*. This 186-page paperback book uses a minimum of mathematics and lots of diagrams and cartoons to introduce the basic operational aspects of static GPS surveying. The concepts in this layman's guide are illustrated by a cast of cartoon characters including Arthur, the boss; Ralph, the party leader; Bill and Ben, the field hands; and Simon, the young graduate. Topics include how GPS works, how to squeeze millimeter results out of GPS observations, how to plan and carry out a GPS survey, how to process the data, and how to fit all the pieces of the GPS jigsaw puzzle together (combining baselines into a network). The book was first published in 1992 (and subsequently updated in 1994) by the Global Positioning System Consortium (Bathurst, New South Wales, Australia), a group of four Australian organizations with interests in GPS: the School of Geomatic Engineering, University of New South Wales, the Australian National University, the Technical and Further Education Commission, and the Land In-

formation Centre of the New South Wales Department of Conservation and Land Management. The book was written by Simon McElroy with contributions from consortium members. And although Australian in origin, the book uses only a few words of Strine (Australian slang), so you won't need an Australian/English dictionary to read it. A North American edition is currently in the works.

A Comprehensive Guide to Land Navigation with GPS. Unlike some other books, this publication does not concentrate on how GPS works, but rather on how to use GPS for land navigation. Although general and recreational consumers are the target audience, those with a

professional land navigation requirement, such as public safety, forestry, and perhaps even military personnel, might find it of interest. Practical and hands-on, the 187-page paperback guide, published in 1994, covers GPS land navigation in seven chapters. The first four discuss the integration of GPS into a variety of navigational situations. Topics include the four-step land navigation procedure (location awareness, route planning, route following, and destination recognition), geographic and grid coordinates, the language of maps, and spatial relationships. The fifth chapter provides a guide to the use of one particular manufacturer's handheld receiver. Although specific to that unit, this chapter could be of benefit to owners of other models because the author provides additional information on various receiver functions, many of which are common to all makes and models. This chapter will also show someone who is contemplating the purchase of a GPS receiver how easy it is to set up and operate one. The sixth chapter is a GPS land navigation practice exercise in which the author provides some suggestions for setting up a short orienteering course and some hints on how to successfully negotiate one. The brief seventh chapter discusses the future of GPS and its impact. In addition, *A Comprehensive Guide to Land Navigation with GPS* comes with a handy Military Grid Reference System (MGRS)/Uni-

"... minimum of mathematics and lots of diagrams and cartoons ..."

"Even the buzzwords in this booklet are explained ..."

versal Transverse Mercator (UTM) reference map covering the coterminous United States and part of southern Canada that may be used to identify MGRS grid zone designations and 100,000-square-meter identifications. The book was written by Noel Hotchkiss and published by Alexis Publishing (Herndon, Virginia). Hotchkiss was well qualified to write this book: he has been a training consultant to the U.S. Army Research Institute, has been involved in training the military forces of the Kingdom of Saudi Arabia, and is the principal of a high school near Syracuse, New York!

The Federal Radionavigation Plan.

So far, I've discussed only commercially published books, but some U.S. government publications also belong on the bookshelf of all serious GPS users. Foremost among these is the *Federal Radionavigation Plan* (FRP). Issued biennially by the Department of Defense (DoD) and the Department of Transportation (DoT), Washington, D.C., the FRP delineates policies and plans for federally operated common-use radionavigation systems. These systems include Loran-C, Omega, VOR (Very-high-frequency Omnidirectional Range) and VOR/DME (Very-high-frequency Omnidirectional Range and Distance-Measuring Equipment), TACAN (Tactical Air Navigation), ILS (the Instrument Landing System), MLS (the Microwave Landing System), Transit, aeronautical and marine radiobeacons, and, last but not least, GPS.

The latest version, the 1994 FRP, follows the format of earlier editions. The main body of the plan contains four chapters. The first, Introduction to the Federal Radionavigation Plan, outlines the plan's objectives, delineates DoD and DoT policies and responsibilities, and discusses the various inputs into the decision-making process for determining the future mix of radionavigation systems. The second chapter, Radionavigation System User Requirements, describes the requirements of the different major radionavigation user groups: civil air, marine, and land users; users with specialized applications such as geodesy,

timing, and meteorology; space navigation users; and military users. The third chapter, Radionavigation System Use, briefly describes each radionavigation system, outlines its current use and states the plans for the systems including any scheduled phase-out and termination. The fourth chapter, Radionavigation System Research, Engineering, and Development Summary, briefly describes the research, engineering and development work being carried out by DoT for civil aviation, marine and land navigation using GPS and other systems. Ongoing and

planned research by the National Oceanic and Atmospheric Administration and the National Aeronautics and Space Administration is also mentioned. More than one-third of the plan consists of a series of

appendices that describe the various radionavigation systems in detail; explain reference systems, charts, and datums; and define terms and acronyms used in the plan.

The FRP in hard-copy form is available to the public through the National Technical Information Service and government publication outlets and resellers. The plan may also be downloaded from the U.S. Coast Guard's Navigation Information Center (NIC) through its dial-in bulletin board system or the World Wide Web. For Web users, the Uniform Resource Locator (URL) for the directory containing the parts of the 1994 FRP in Portable Document Format (PDF) is <http://204.217.48.100:70/11%5CRADIONAV%5Cfrp>; Web users can also arrive at this directory through the General Radionavigation Information link on NIC's General Radionavigation Web page.

INTERMEDIATE

The introductory-level books do a good job of presenting the fundamental concepts of GPS and how the system is used in a variety of applications. For the GPS user wanting to get a deeper under-

standing of GPS, including how the observations are made, the algorithms relating observations and positions, the observation error models, and the needs of specialized applications, the following books should help.

The Navstar Global Positioning System. At first sight, the cover of *The Navstar Global Positioning System* appears to be upside down. But then you realize that you're looking up at the earth from the perspective of a GPS satellite. This is only one of the many interesting features of this book. Another is the extensive use of diagrams to help explain and illustrate the details of GPS operation and sidebars that underscore the principles and applications of the technology. Author Tom Logsdon has written this 256-page hard-covered book without any mathematics, yet he does a very good job of explaining the intricacies of how GPS works and how it is used in a variety of applications. He also provides a wealth of background information on such topics as the science of navigation, ground-based navigation systems, the determination of the earth's shape and time keeping and clocks. Logsdon wears several hats. No stranger to writing, he has written more than 20 books on space technology, computer science, and robotics. He is also a senior member of the

technical staff of Rockwell International in Seal Beach, California, where he has performed GPS engineering analyses.

Plus, he has lectured extensively on space-based radionavigation. His GPS book was published in 1992 by Van Nostrand Reinhold (New York, New York).

Guide to GPS Positioning. This book was one of the first to be published on GPS. In 1986, a team of 11 Canadian academics and government researchers involved in developing GPS applications got together to form Canadian GPS Associates (Fredericton, New Brunswick, Canada). The partnership was formed to pursue joint projects, the first of which was the production and distribution of this guide. Several of the authors had organized and presented a series of one-day tutorials on GPS in the spring of 1985, for which the hand-out material left much to be desired. It was clear to

"... without any mathematics ... he does a very good job of explaining the intricacies of how GPS works ..."

"... designed to be used as a self-study guide, ..."

them that the need for an introductory, but complete, description of GPS concepts was not met by the reference material then available. The result of the collaboration was one of the first desktop-published books in any field. Prepared under the leadership of University of New Brunswick professor David Wells, the 600-page *Guide to GPS Positioning* is a self-contained introduction to GPS, designed to be used as a self-study guide, as lecture notes for formal postsecondary education courses, or as hand-out material to support short-course and seminar presentations on GPS.

The guide is primarily an introduction rather than an explication of the details of the latest research results concerning GPS. As a result, despite its age, the guide continues to sell well - more than 11,000 copies have been sold worldwide. A minimum of mathematics is used, with most terms fully explained. Each sub-topic discussed in the book's 15 chapters is presented in identical fashion in two pages: a graphic or summary page illustrates the concept or lists the main points, and a text page provides a detailed description. In adopting this format, the authors followed two earlier GPS publi-

cations, *Everyman's Guide to Satellite Navigation*, by Steven D. Thompson and published by the ARINC Research Corporation in 1985, and *The WM GPS Primer*, by Rene Scherrer and published by the WM Satellite Survey Company in 1985, both out-of-print to the best of my knowledge.

Global Navigation - A GPS User's Guide. This book, authored by Neil Ackroyd and Robert Lorimer, is intended primarily for the marine GPS user. In addition to describing how GPS works, the authors discuss how GPS is used in the ship-board environment, such as for coastal navigation and port positioning. They describe DGPS in detail and provide information on private and public broadcast differential services. There is an extensive discussion of the Inmarsat system and how it can be used for message reporting and fleet monitoring. A second edition of this book, released in 1994, extensively updates and expands the material in the original 1990 edition. The 312-page hard-cover book is published by Lloyd's of London Press (New York, New York).

Aviator's Guide to GPS. As its name suggests, this book is dedicated to avia-

tion applications of GPS. Author Bill Clarke covers the basics of how GPS works in the first three chapters. Then he describes the various applications of GPS and, in order to put GPS in context, he briefly describes the alternatives to GPS aircraft navigation, such as VOR/DME, nondirectional radiobeacons, and MLS. The remaining chapters of *Aviator's Guide to GPS* discuss Federal Aviation Administration regulations concerning GPS use, basic and advanced aircraft navigation using GPS, and the characteristics of GPS receivers, both generic and those designed specifically for aviation use. A number of appendices cover topics such as chart reference systems, federal GPS policy and plans, and GLONASS. This 235-page paperback book is published by the TAB Books division (Blue Ridge Summit, Pennsylvania) of McGraw-Hill.



In the next issue, Richard Langley reviews Advanced GPS publications and looks to the future for about-to-be published books that you can add to your GPS Bookshelf.

South Western Regional Group Report

By Andrew Smith, OLS — Secretary-Treasurer

Our big news, is the grand success of the Annual General Meeting! A huge thank you goes out to the many people who came, our generous sponsors and David Raithby's hard working team made up of those from the AOLS and members of the South Western Regional Group who put on this highly successful event. A highlight of our time together was His Majesty's Feast which was made possible by the generous support by a number of firms in the area.

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Congratulations to Murray Fraser and Ross Clarke for their election to Council.

We would also like to thank our outgoing Liaison Representative from Council, Graham Bowden, for all of his efforts on our behalf and at the same time, offer a hearty welcome to our new representative David Urso.

