

The 3-D Global Spatial Data Model

This book review will appear in a future ACSM Bulletin.

Book Data

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Introduction

The advent of digital mapping and the popularity of 3D globes like NASA Worldwind or Google Earth may make mapping professionals of all sorts question the long-term need for map projections and flat paper maps. Might not the need for these relics of cartography and mapping be replaced by a single 3D spatial data model for the entire globe, stored in the brains of our computers?

The 3-D Global Spatial Data Model answers this question directly, and promotes the *global spatial data model* (GSDM), the author's flavor of a global 3D spatial data model.

Summary of Contents

The first page of the book indicates the first chapter serves as "a summary of the defining document for the GSDM." It then describes the two (2) primary components of the GSDM, the "functional model component" and the "stochastic model component". The functional model component deals with representing locations in the GSDM, and the mathematical formulas and geometry used to do so. The stochastic model component deals with the question of spatial data accuracy within the GSDM.

The next nine chapters each deal with a separate topic related to the design and use of the GSDM. Each chapter provides a brief summary of the topic being considered and explains how the topic concepts relate to the GSDM. Each chapter is concluded with a list of references.

Chapter 2 is entitled *Spatial Data and the Science of Measurement*. It defines spatial data; describes the three (3) coordinate systems that are part of the GSDM (ECEF, geodetic, and local); describes how different types of measurements are used to create spatial data, and briefly touches on measurement error and how it is handled in the GSDM.

Chapter 3 is entitled *Summary of Mathematical Concepts*. It defines mathematical conventions used in the remainder of the book, and briefly discusses the following mathematical concepts:

- Number Types
- Significant Figures
- Coordinate Systems

- Logic
- Geometry
- Trigonometry
- Calculus
- Arithmetic
- Algebra
- Solid Geometry
- Spherical Trigonometry
- Probability and Statistics

Chapter 4 is entitled *Geometrical Models for Spatial Data Computations*. It reviews 2D mapping and geometry concepts, which include the following:

- 2D Cartesian Models
- Coordinate Geometry
- Circular Curves
- Stationing
- Spiral Curves
- Vertical Curves
- Radial Surveying
- 3D Models for Spatial Data

Chapter 5 is entitled *Overview of Geodesy*. It defines the science of geodesy, describes specialized disciplines of geodesy, looks at the history of geodesy, and concludes with a forecast of what the practice of geodesy will be like in the 21st Century.

Chapter 6 is entitled *Geometrical Geodesy*. It provides details and algorithms for several calculations on the ellipsoid, including:

- Calculating the length of a parallel.
- Calculating ellipsoidal surface area.
- Working with geodetic lines and geodetic azimuths.

Chapter 7 is entitled *Geodetic Datums*. It reviews several common horizontal and vertical datums used in surveying and mapping. Then it describes datum transformations between some of these datums. It concludes with a discussion of the elements of a 3D datum.

Chapter 8 is entitled *Physical Geodesy*. It discusses gravity and the mass of the Earth, the shape of the geoid, physical quantities related to physical geodesy that we can measure, and the need for geoid modeling.

Chapter 9 is entitled *Satellite Geodesy and Global Satellite Navigation Systems*. This chapter provides a brief history of satellite positioning; talks about some of the different "modes" of satellite positioning; and reviews different satellite signals used in satellite positioning systems. The chapter concludes with a discussion of processing the data from satellite positioning systems.

Chapter 10 is entitled *Map Projections and State Plane Coordinates*. It defines map projections and discusses the need for them. It examines common geometrical figures used for map projections,

and talks about the State Plane Coordinate System used in the United States of America. It reviews procedures and algorithms that are used with this State Plane Coordinate System, and provides algorithms for common map projections.

The accuracy of spatial data is the topic of Chapter 11. This chapter begins by defining terms related to spatial data accuracy, looks at the components of spatial data and their accuracy, helps the reader appreciate that all spatial data is "relative" (everything moves), and talks about local and network accuracy.

The final chapter discusses the use of the GSDM.

Review of Books Format and Style

The book contains ample mathematical formulas and black and white graphics. Each chapter is divided logically into sections separated by subheadings and concludes with a list of references. The chapters in the book are ordered logically, and (as a general rule) each chapter could serve as its own self-contained unit.

Conclusion

This book accomplishes some important "firsts" for the surveying and mapping professions. In no other text have I found such a comprehensive approach to the various topics related to determining positions on the Earth. To have such a wide range of mathematical and scientific topics brought together in one volume is very valuable, and to my knowledge, has not been done before. Previous books on the same subject matter focus on just one or a few of the topics covered in this book. If you are an instructor or teacher looking for a list (and summary) of the concepts needed to understand global positioning, this book will be a good starting point. I believe Chapter 5, Chapter 6, and Chapter 8 bring together an understandable overview of geodesy that I have not seen in other text books. This was the best part of the book from my personal perspective.

However, the book's attempt to cover so much ground is also one of its weaknesses. I believe any student of global positioning (or mathematics) will find the coverage of topics in its chapters too shallow. The subjects it attempts to cover are complex, and to be readily understood by the inexperienced require more thorough explanation. As an example, entire books have been dedicated to the topic of error adjustment in spatial data, to the topic of 2D geometry, and to the topic of satellite positioning.

I also believe the author has several serious flaws in his case for the GSDM. One example is his oversimplification of the conversion between NGVD29 and NAVD88 as described on page 196. The practicality of replacing orthometric heights with ellipsoid heights as described on page 211 is another example. Still, I believe the design, implementation, and wide spread adoption of some sort of 3D global spatial data model like the one described by the author would result in a huge benefit for human society, and I applaud the author's efforts to move us in this direction. I am afraid the challenges to reaching this goal seem underestimated in this book.

In conclusion, I believe *The 3-D Global Spatial Data Model* would have been much better as two different books, and not a single book. If the author had left out the proposition of a 3D global

spatial data model, he could have spent the time he needed covering the mathematical concepts of global positioning in greater depth. This would have resulted in a comprehensive (and unparalleled) math textbook for mapping professionals. On the contrary, if the author had left out the coverage of basic positioning concepts covered in other text books, and focused only on making his case for a 3D global spatial data model, he may have had better success in convincing his readers that the widespread use of such a model is practical. In my mind, he failed to address the challenges to making such a model work in the real world, and leaving out the basic conceptual material may have given him the room he needed to present his arguments.