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Proposal

Sabbatical Leave

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Contents

I. Summary

Earl F. Burkholder, PS, PE, Associate Professor in the NMSU Department of Surveying Engineering, proposes a sabbatical leave from NMSU for the 2005-2006 academic year for the purpose of investigating and reporting on the three-dimensional (3-D) characteristics of digital geospatial data as used in the context of surveying, mapping, engineering, and geographic information systems. This effort will enhance both the breadth and depth of the existing Surveying Engineering curriculum and will help assure that NMSU Surveying Engineering graduates are well prepared for employment in any of several careers that involve the use of 3-D digital geospatial data. Specific planned activities include, but are not necessarily limited to:

- Completion of a manuscript that defines and describes use of the 3-D Global Spatial Data Model (GSDM). Writing the book has been an on-going project for several years. The book is about ¾ completed.

- Development of a Windows-based program (to be distributed with the book) that can be used to perform basic 3-D coordinate geometry (3-D COGO) computations.

- Conducting a questionnaire survey of the 3-D spatial data practices of the transportation departments (DOTs) in each state. A similar survey on DOT use of GPS was conducted during a previous sabbatical from Oregon's Institute of Technology in 1990/91. Responses to that survey were obtained from 46 of 50 state DOTs and the results were reported in the ASCE Journal of Surveying Engineering (Burkholder, 1993b).

- Working with the Southern Rio Grande Chapter of the New Mexico Professional Surveyors and the El Paso Chapter of the Texas Society of Professional Surveyors to complete, compute, and document the results of a joint GPS resurvey of that 25-mile portion of the Texas-New Mexico boundary defined in 1850 by the thread of the Rio Grande River.

- Presentation of a paper on "Geomatics Curriculum Design Issues" at the XX North American Surveying Educators Conference in Corpus Christi, Texas, in June 2005.

- Presentation of one or more state meeting seminars (one is already committed for March 2006) on "The Impact of the Digital Revolution on Surveying."

To accomplish these goals, the applicant requests 60 percent support during the 2005-2006 academic year. Adequate substitute faculty will be utilized during the sabbatical leave so that the quality of the Surveying Engineering program is not adversely affected by the applicant's leave from regular academic duties.

II. Introduction

Surveying has long been associated with civil engineering and civil engineers still need and use maps in support of various projects – roads, bridges, dams, pipelines, airports, shopping centers, and many other endeavors relating to location and the environment. In addition, land surveying involves legal issues associated with land ownership, boundaries, and development. In the past 50 years, surveying in the United States has evolved as a separate distinct profession and provides a wide range of services to society. As the scope of surveying continues to be defined and redefined, the Surveying Engineering program at NMSU is ideally positioned to serve the profession, the citizens of New Mexico, and students who enroll in the program.

On a more technical note, the analog-digital revolution during the same 50 years has had an enormous impact on surveying practice. Spatial data, the raw material of which surveys and plats are made, are now characterized as digital and three-dimensional. Personal productivity has soared as individuals have adapted to use of CAD, GPS, computers, and other electronic tools. In addition to the technical challenges, land boundary issues, and continuing interaction with engineering, surveying finds itself interacting more and more with other disciplines that use geospatial data. Traditionally those other disciplines have included mapping, photogrammetry, and geodesy. More recently, newer disciplines such as remote sensing, geographic information systems, and spatial information science are also part of the mix, and the word “geomatics” is used as an umbrella term to describe a wide range of activities involving the use of geospatial data. As described in the award-winning paper, “Viewing Spatial Data from the 3-D Perspective” presented at the 2004 NMSU SETE conference (Burkholder 2004d), the GSDM is the overall focus of the proposed sabbatical and is a unifying concept capable of providing significant benefits to spatial data users in many disciplines worldwide.

Although surveying was taught in the civil engineering department at NMSU for many years, the NMSU Surveying Engineering Department was established as a separate department in the early 1990s and does an excellent job of meeting the educational needs of the surveying profession in New Mexico. With a background in core geomatics concepts, the NMSU Surveying Engineering graduate is not limited to traditional surveying but, in addition to private surveying practice, may find employment opportunities in areas such as off-shore positioning, engineering, construction, seismic exploration, utility companies, transportation departments, various federal agencies, and GIS applications in many environments. The activities proposed for this sabbatical will support the continued relevance of the NMSU Surveying Engineering degree in all of those areas.

III. Problems/Needs

The fundamental problem facing spatial data users is that two separate origins are commonly used for 3-D geospatial data. That is understandable for this reason, ”we are where we are because of where we came from.” As we look ahead to “where we are going,” efficiencies associated with “interoperability” can be realized by using a common spatial data model that has a single origin for 3-D data. Modern data collection methods such as photogrammetry, GPS, and even the electronic total station used by surveyors, already collect 3-D geospatial data that can be used with the rules of solid geometry on a global scale. But, conventional surveying and mapping practice involves the use of two datums - horizontal and vertical. Horizontal location is ultimately tied to a two-dimensional location on the earth, latitude and longitude, and vertical is referenced to a different origin – typically mean sea level or, in North America, to an arbitrary surface. The single-origin earth-centered earth-fixed (ECEF) system defined by NIMA (1997) for the NAVSTAR satellites and GPS positioning provides the basis for “a better way ” to handle geospatial data.

A related problem is that latitude and longitude are expressed in angular units of degrees, minutes, and seconds while vertical is expressed in length units. Although geodesy students learn to work with both length and angular units, that mix of units is more awkward to use than 3-D rectangular coordinates. And, because equations involving latitude and longitude are rather onerous, map projections have been used to “flatten the earth” by providing 2-D rectangular plane coordinates for each latitude/longitude position. These plane coordinates are much simpler and easier to use than latitude and longitude coordinates. Standard practice for 3-D (in the USA) is to use state plane coordinates for horizontal along with elevations for vertical. This is a reasonable solution to the “mixed units” problem with one exception – a map projection is strictly a 2-D mathematical model, yet we work with 3-D data.

Another problem is also associated with using 2-D map projection coordinates along with elevations for the third dimension. The reference surface for elevation is not a flat plane but a curved surface. Rules of solid geometry for rectangular coordinates are globally applicable but, when using state plane coordinates and elevations to perform 3-D computations, 3-D geometrical integrity is limited by our assumptions of a flat earth. Either a correction must be applied or, as some GIS users stipulate, elevation is considered an attribute of horizontal location. These procedures may work as a “stop-gap” measures, but valuable data are lost and “interoperability” suffers.

A fourth problem involves the ground distance versus grid distance dilemma. When using a map projection, it is not possible to portray angles, distances, and area without distorting two of the three elements. Conformal projections as used in surveying and mapping preserve angles, but distances and area are distorted. In the design of the state plane coordinate systems, an arbitrary distance distortion criterion of 1 part in 10,000 was imposed on the ratio of the grid distance over the ellipsoid distance. Well and good, but that distortion is only half the problem. The effect of transforming a horizontal ground distance to the equivalent sea level (ellipsoidal) distance is also a distortion and was not considered in the design of the state plane coordinate systems. Modern surveying and mapping practice must accommodate both the elevation distortion and the scale factor distortion when working with grid distances and ground distances. A discussion of handling this dilemma is documented in the DOT questionnaire conducted in 1990/91 and reported in Burkholder (1993b). Although there are legitimate methods for handling the grid/ground dilemma (see Burkholder, 1993a), practice between DOTs is not standard and practices within the surveying profession are even more diverse. The GSDM solves the ground/grid dilemma by providing the tangent plane horizontal distance and the true azimuth between points (see Burkholder, 1991 and Burkholder, 1997b).

On small projects of limited scope, traditional plane surveying practice assumes a flat earth and that each job is referenced to a local origin. However, with the advent of modern data collection systems, computer databases and geographic information systems, the practice of adding a third dimension to the assumption of a flat earth for local projects is called into question. The GSDM has been defined as a collection of methods and procedures that can be used to bridge the gap between true 3-D geospatial data (already being used by the scientific community) and local "flat earth" applications so prevalent in the spatial data user community. All four of the problems described are addressed and can be mitigated by using the GSDM.

IV. Objectives

There are multiple objectives to this research that parallel the stated activities:

- The book manuscript will be completed and efforts will be made to secure a publisher for the book. Applicant was under contract to write the book prior to employment at NMSU. However, the applicant not being independently wealthy returned to teaching, the book project was put on the back burner and, by mutual agreement, the contract was canceled. The publisher will be asked to reconsider publication once the manuscript is completed.

- A DOS-based menu-driven prototype FORTRAN program called BURKORD™ exists and provides excellent proof-of-concept for 3-D coordinate geometry and error propagation computations. A Windows-based program is being developed with the aid of a professional programmer. A basic version of the Windows-based program will be available gratis to students and will be distributed with the book.

- Development of the GSDM was built, in part, on the results of a questionnaire survey of GPS practices of the transportation departments in each state. The objective of a follow-up survey 15 years later will be to document changes in operational policies and procedures with regard to the use of 3-D digital spatial data. Results of the new survey will be summarized and published.

- The objective of working on the joint GPS Texas/NM Boundary project will be to expose current students and practicing professionals to a real honest-to-goodness 3-D GPS survey and provide an example of procedures and methods for data reduction and computations.

- The objective for presenting seminars is to promote the use of the 3-D GSDM and to persuade more students to attend and earn a degree from the NMSU Department of Surveying Engineering.

V. Sustainability of Surveying Engineering Program

The applicant normally teaches three courses each semester and carries additional responsibilities with regard to student advising and serving as Faculty Advisor of the ACSM/NMPS Student Chapter. Dr James P. Reilly, former Surveying Engineering Department Head is available to teach one course each semester and other persons will be hired to teach other courses (details are still being worked out). With regard to other responsibilities, colleagues Wurm and Frank have graciously agreed to fill in with regard to student advising and serving as Faculty Advisor for the ACSM/NMPS Student Chapter.

VI. Benefits of the Proposed Sabbatical:

The following benefits are expected from the proposed sabbatical leave:

1. Benefit to the applicant. Professor Burkholder will have an uninterrupted opportunity to complete the manuscript he is writing on the global spatial data model (GSDM) and to develop a Windows-based 3-D coordinate geometry (3-D COGO) program to be distributed with the book. The same software to be distributed with the book will also be available gratis for student use.

2. Benefits to the Surveying Engineering Department and NMSU. Completion of these activities will serve to enhance both the breadth and depth of the existing Surveying Engineering curriculum and will help assure that NMSU Surveying Engineering graduates are well prepared for employment in any of several careers that rely on the use of 3-D digital spatial data. The proposed work will also result in considerable exposure of the NMSU Surveying Engineering program and the College of Engineering within the profession, throughout the United States, and around the world.

3. Benefits to society and the profession at large. The proposed work will provide the basis and procedures for spatial data users in many disciplines to take advantage of modern technology in working with spatial data and spatial data accuracy. The local Texas/NM Boundary project will provide an immediate and visible example that can be used, studied, and emulated. The profession at large will benefit by being able to use a common spatial data model to support the concept of "interoperability" in which spatial data users all over the world can use the same set of equations and procedures for manipulating spatial data.

VII. Intellectual Property

Prior to employment at NMSU, the applicant obtained a trademark on the word BURKORD. A "google" search on BURKORD will provide some information. More information can be found on the applicant's web site, www.zianet.com/globalcogo/. The BURKORD trademark is owned by Global COGO, Inc and covers two specific items - software written by the applicant to perform 3-D coordinate geometry computations and design of a 3-D database that contains the geocentric coordinates and covariance matrix of each point. The "Global Spatial Data Model" or GSDM is generic and consists of a collection of equations and procedures that are in the public domain. Other than copyright on articles written by the applicant, no intellectual property claim has or will be made on the use of the GSDM. Prototype BURKORD™ software provides excellent proof-of-concept but, in part because it is DOS-based and menu-driven, it is not very user-friendly. The software was developed prior to applicant coming to NMSU in 1998, and subsequent revisions have not involved the use of NMSU resources. BURKORD9 software is provided gratis to anyone requesting it.

A "basic" user-friendly, mouse point-and-click, Windows version of BURKORD is currently being developed with the aid of a professional programmer being paid by the applicant and will be included as a part of the book when published. Given a 2-semester sabbatical is approved, the 60% salary support received from NMSU will be allocated to finishing the book, to the DOT questionnaire and report, and to the joint Texas/New Mexico GPS boundary project. As discussed with the current Surveying Engineering Department Head and the NMSU Intellectual Property Office, any development of BURKORD software will fall under the 40% release allocation and not subject to any intellectual property claim by NMSU. An agreement between NMSU and the applicant containing pertinent details will be executed as part of the sabbatical contract.

VIII. References:

To Work by others:

Many people deserve credit for developing the concepts brought together in defining the GSDM. The goal in formulating the GSDM was to begin with fundamental, almost self-evident, concepts and to arrange them in ways that accommodate the use of new technology while remaining consistent with established practice. Although innumerable persons including historical figures, professional colleagues, and students have provided input, the following deserve specific recognition: NIMA (1997) defines the underlying Earth-centered, Earth-fixed (ECEF) geocentric coordinate system. Appendix C in Bomford (1971) is titled, "Cartesian Coordinates in Three Dimensions;" Leick (1990 and 1995) defines the 3-D Geodetic Model; Mikhail (1976) provides a comprehensive discussion of functional and stochastic models; and, when discussing models, Moritz (1978) comments on the simplicity of using the basic global rectangular X/Y/Z system without an ellipsoid. Neither is the concept of a GSDM new. Seeber (1993) states that H. Bruns proposed the concept of a global three-dimensional polyhedron network as early as1878. The difference now is that GPS and other modern technologies have made a global network practical and the polyhedron need not be limited to Earth-based points. When the aforementioned concepts are combined in a systematic way, with particular attention to the manner in which spatial data are used, the synergistic whole – the GSDM - appears to be greater than the sum of its parts.

1. Bomford, G., 1971, Geodesy 3rd Ed., Oxford University Press, Oxford, UK.

2. Leick, A., 1990; GPS Satellite Surveying, John Wiley & Sons, NY, NY.

3. Leick, A., 1995; GPS Satellite Surveying 2nd Ed., John Wiley & Sons, NY, NY.

4. Mikhail, E., 1976; Observations and Least Squares, Harper & Row Publishers, NY, NY.

5. Moritz, H., 1978; "Definitions of a Geodetic Datum," Proceedings – Second International Symposium on Problems Related to the Redefinition of North American Geodetic Networks, Arlington, Virginia, hosted by the U.S. Department of Commerce, the Department of Energy, Mines & Resources (Canada), and the Danish Geodetic Institute.

6. NIMA, 1997; "Department of Defense World Geodetic System 1984: Its Definition and Relationships with Local Geodetic Systems," NIMA TR8350.2 Third Edition, 4 July 1997, National Imagery and Mapping Agency, Bethesda, MD.

7. Seeber, G., 1993; Satellite Geodesy, Walter de Gruyter, Berlin, New York.

Articles and Papers by Applicant

1. Burkholder, EF, 2004a, "A 3D Datum for a 3D World" Geospatial Solutions Magazine, Volume 14, No. 5, May 2004, pp 38-41. See www.geospatial-online.com.

2. Burkholder, EF, 2004b, "Fundamentals of Spatial Data Accuracy and the Global Spatial Data Model (GSDM)" is registered with the U.S. Copyright Office, Washington, D.C., April 2004. click here .

3. Burkholder, EF, 2004c, "When is the best time to implement a better model?" is a perplexing question. The technology is in place and the model is well-defined. Jan 2004. Click here.

4. Burkholder, EF, 2004d, "Viewing Spatial Data From the 3-D Perspective" as presented at the NMSU Science, Engineering, and Technology Education Conference, January 9, 2004. click here . Note, the author was given the "Best Paper Award" for the Conference

5. Burkholder, EF, 2003, "The Digital Revolution Begets the Global Spatial Data Model (GSDM)" was published in the April 15, 2003, issue of EOS Transactions American Geophysical Union. click here .

6. Burkholder, EF, 2002a, "Global Spatial Data Model White Paper" offers a 2-page summary of the GSDM. June 2002.

7. Burkholder, EF, 2002b, "Elevations and the Global Spatial Data Model," presented June 25, 2002, at the 58th ION Annual Meeting in Albuquerque, New Mexico. click here .

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9. Burkholder, EF, 2001, "Spatial Data, Coordinate Systems, and the Science of Measurement," ASCE Journal of Surveying Engineering, November 2001, Vol 127, No. 4, pp 143-156.

10. Burkholder, EF, 2000, "The Global Spatial Data Model" presented March 27, 2000, at the International Discrete Global Grids Conference hosted by the NCGIA in Santa Barbara, CA.

11. Burkholder, EF, 1999a, "Geomatics Education and the Global Spatial Data Model" presented at the XVII North American Surveying Educators' Conference, Purdue University, July, 1999. click here.

12. Burkholder, EF, 1999b, "3-D: A Challenge for Surveying in the 21st Century" printed in the Spring 1999 issue of The Aggie Surveyor newsletter published by the Department of Surveying Engineering at New Mexico State University.

13. Burkholder, EF, 1999c, "Spatial Data Accuracy as Defined by the Global Spatial Data Model (GSDM)." ACSM Surveying & Land Information Systems Journal, March, 1999. click here.

14. Burkholder, EF, 1998, "A Practical Global Spatial Data Model (GSDM) for the 21st Century," presented at the Institute of Navigation National Technical Meeting, Long Beach, CA, January 1998. click here .

15. Burkholder, EF, 1997a, Professional Surveyor Magazine - Series of 3 articles:
- "The Global Spatial Data Model (GSDM): A Tool Designed for Surveyors," October, 1997.
- "Using the Global Spatial Data Model (GSDM) in Plane Surveying," November/December 1997.
- "Positional Tolerance Made Easier with the GSDM," January 1998.

16. Burkholder, EF, 1997b, "The 3-D Azimuth of a GPS Vector," ASCE Journal of Surveying Engineering, Vol. 123, No. 4, November, 1997.

17. Burkholder, EF, 1997c, "3-D Global Spatial Data Model (GSDM)," The Civil Engineering Surveyor, GIS/GPS Supplement, Fall 1997, pp 15-18. (UK)

18. Burkholder, EF, 1997d, "Description of a Simple, Three-Dimensional Global Spatial Data Model (GSDM), ACSM LIS/GIS 97, Fall Technical Meeting, Cincinnati, Ohio, October, 1997.

19. Burkholder, EF, 1997e, "Definition of a Three-Dimensional Spatial Data Model for Southeastern Wisconsin," January 1997, a report prepared for the Southeastern Wisconsin Regional Planning Commission Waukesha, Wisconsin. click here

20. Burkholder, EF, 1997f, Definition and Description of a Global Spatial Data Model registered with the U.S. Copyright Office, Washington, D.C., April, 1997.

21. Burkholder, EF, 1994, "3-D Coordinates - A Universal Rectangular Coordinate System for a GIS and Other Spatial Databases," ASCE, First Congress on Computing in Civil Engineering, June 20-24, 1994, Washington, D.C.

22. Burkholder, EF, 1993a, "Design of a Local Coordinate System for Surveying, Engineering, and LIS/GIS," ACSM Surveying & Land Information Systems Journal, Vol. 53, No. 1, March, 1993.

23. Burkholder, EF, 1993b, "Using GPS Results in True 3-D Coordinate System," ASCE Journal of Surveying Engineering, Volume 119, No. 1, February, 1993.

24. Burkholder, EF, 1991, "Computation of Level/Horizontal Distance," ASCE Journal of Surveying Engineering Volume 117, No. 3, August, 1991.

IX. Appendices:

Appendix A – Outline of Book

"The Global Spatial Data Model (GSDM):

Foundation for the Global Spatial Data Infrastructure (GSDI)"

Earl F. Burkholder, PS, PE

Annotated Table of Contents – June 8, 2004

I. The Global Spatial Data Model (GSDM) Defined **20 pages**

- A. Introduction
- B. Definition
  1. Functional model
  2. Stochastic model
- C. BURKORD®
  1. Software
  2. Database
  3. Summary
- D. References

The purpose of this first chapter is to provide a concise overview of the GSDM. The reader is not expected to understand everything in this chapter the first time through. But, with the framework of the GSDM in place, it will help each reader understand the appropriate context for spatial data concepts as they are presented in the rest of the book.

II. Spatial Data and the Science of Measurement **16 pages**

- A. Introduction
- B. Spatial data defined
- C. Coordinate systems give meaning to spatial data
  1. ECEF
  2. Geodetic
  3. Local (flat earth)
  4. Spatial data types
- D. Spatial data visualization is well defined
- E. Direct/indirect measurements contain uncertainty
  1. Fundamental physical constants
  2. Measurements/observations
- F. Errorless spatial data must also be accommodated
- G. Primary spatial data are based upon:

1. Measurements that contain errors
2. Errorless quantities

H. Derived spatial data are computed from primary spatial data
I. Establishing and preserving the value of spatial data
J. References

This chapter defines spatial data, identifies three fundamental coordinate systems, lists types of spatial data, examines the measurement/observation process by which spatial data are generated, looks at errorless spatial data, makes a distinction between primary and secondary spatial data, and closes by suggesting that efforts to preserve the value of spatial data deserve consideration along with efforts devoted to generating spatial data.

III. Summary of Mathematical Concepts **44 pages**

A. Introduction
B. Conventions
C. Logic
D. Arithmetic
E. Algebra
F. Geometry
G. Solid geometry
H. Trigonometry
I. Spherical trigonometry
J. Calculus
K. Probability & statistics
L. Hypothesis testing
M. Matrix algebra
N. Models
O. Error propagation
P. Error ellipses
Q. Least squares
R. Applications to the GSDM
S. References

This chapter identifies mathematical concepts that are relevant to use of spatial data. Written concisely at a fairly comfortable level, it will be a review for many readers. But, as each reader finds his/her own level, it should become obvious that there are some fairly sophisticated mathematical tools that are available for manipulating spatial data. Those needing more than summary information will be directed to other more extensive texts on the various topics. The applications section summarizes concepts that are critical to successful use of the GSDM.

IV. Geometrical Models for Spatial Data Computations **32 pages**

A. Introduction
B. Conventions
C. Two-dimensional Cartesian models

D. Coordinate geometry
    1. Forward/inverse
    2. Intersections
    3. Perpendicular offset
    4. Area by coordinates
E. Circular Curves
    1. Definitions
    2. Degree of curve
    3. Elements and equations
    4. Stationing and station equations
    5. Area formed by curves
F. Spiral Curves
    1. Spiral coordinates
    2. Intersecting a line with a spiral
    3. Computing area adjacent to a spiral
G. Radial surveying
H. Vertical curves
I. Three-Dimensional Models for Spatial Data
    1. Volume of rectangle
    2. Volume of sphere
    3. Volume of cone
    4. Prismoidal formula
    5. Traditional 3-D models
        a. Geographic
        b. State plane
        c. Local flat earth
    6. The Global Spatial Data Model (GSDM)
J. References

Admittedly, this chapter begins by stating the obvious. But the concepts are organized to provide each reader an overview of spatial data manipulation. There is the math/science coordinate system (counter-clockwise rotation from the x-axis) used as the default standard. Then, when using spatial data, there is the surveying/engineering coordinate system used for land based bearings (azimuths) and distances. The GSDM accommodates both. The underlying rectangular geocentric ECEF coordinate system uses the math/science system convention, but the local tangent plane (flat earth) coordinate system follows established conventions of clockwise azimuth from north. This chapter also helps bridge the gap between working primarily in 2 dimensions to the more general frame of visualizing and working with 3-D spatial data.

V. Geodesy Overview From an Applications Perspective **17 pages**

A. Introduction: Science & art
B. Fields of geodesy
C. Goals of geodesy
D. Historical background
E. Developments during the 19th & 20th centuries
F. Forecast for the 21st century
G. References

The purpose of this chapter is to provide an historical perspective of geodesy and to describe its contributions to spatial data concepts. An attempt is also made to view the role of geodesy in a broader context than just that of pure science.

VI. Geometrical Geodesy **43 pages**

A. Introduction
B. Two-dimensional ellipse
C. Three-dimensional ellipsoid
    1. Normal section and radius of curvature
    2. Geometrical mean radius
D. Rotational ellipsoid
    1. Equation
    2. Geocentric and geodetic coordinates
    3. Transformations
        a. BK1 – converts lat/long/height to X/Y/Z
        b. BK2 – converts X/Y/Z to lat/long/height
            1. Iteration
            2. Vincenty
    4. Meridian arc length
    5. Length of parallel
    6. Surface area
E. Geodetic Line
    1. Description
    2. Clairaut's constant
    3. Geodetic azimuths
        a. Target height correction
        b. Geodesic correction
F. Geodetic position computations – forward & inverse
    1. Puissant
    2. Numerical integration
    3. Geodetic position by state plane coordinates
    4. GSDM
G. Modern applications:

1. Distances
2. Azimuths
3. Local view of the earth

H. References

This chapter begins with simple fundamental relationships of the 2-dimensional ellipse as found in the meridian section of the earth. From there it expands into three-dimensional relationships of the ellipse rotated about its minor axis--the ellipsoid. Classical geodetic position computations of forward and inverse are discussed and the topic of surface area is summarized. Newer methods of numerical integration and the GSDM are introduced.

VII. Physical Geodesy **25 pages – approx.**

A. Introduction and definitions
B. Level surfaces
C. Gravity
D. Geoid and elevations
E. Leveling
F. Software and procedures for determining geoid heights
G. References

High-level material on physical geodesy is left to the scientists. However, the concept of gravity and a description of the measurement environment determined by the local plumb line must be included so spatial data users can understand the difference between elevation and ellipsoid height. The concept is not that difficult, but it is quite specific. On-going research into geoid modeling has provided excellent tools for computing geoid heights but the limitations and procedures both need to be discussed carefully. This will be an important chapter in the book.

VIII. Satellite Geodesy & Global Positioning System (GPS) Surveying
30 pages - approx.

A. Introduction & history
B. Satellite systems
C. Modes of positioning
D. Types of GPS satellite data
E. Processing GPS data – vectors
F. GPS Networks - Using and storing results
G. References

The advent of GPS is driving widespread use of spatial data. Earlier, understanding and using GPS data was primarily the domain of geodesists and other technical disciplines. However, low cost and ease of use have brought GPS technology into the purview of many spatial data users. This chapter will present the overall concepts of GPS positioning and extend those to a careful description *of two very different GPS products, e.g., the precise baseline vector (based upon carrier phase observed differences) and the less precise GPS point position based upon pseudoranging. The chapter ends with a description of results (positions and covariance) obtained from combining GPS vectors into networks.*

IX. Geodetic Datums **30 pages – approx**.

A. Definition – general
B. Horizontal
   1. Definitions - specific
   2. North American Datum of 1927
   3. North American Datum of 1983
   4. High Accuracy Reference Networks – HARN
   5. Continuously Operating Reference Stations (CORS)
   6. Datum conversions
C. Vertical
   1. Definitions - specific
   2. Mean Sea Level Datum
   3. International Great Lakes Datum
   4. National Geodetic Vertical Datum of 1929 (NGVD 29)
   5. North American Vertical Datum of 1988 (NAVD 88)
   6. Datum conversions
D. Combined 3-D datum
   1. Conceptual deficiency
   2. Computational efficiency
   3. GSDM
E. References

When referencing spatial data to existing coordinate systems, it is important for purposes of consistency to make sure all the data are on the same datum and to document which datum is being used. This chapter includes a discussion of datums routinely encountered in the United States and describes how data are moved from one datum to another. Summary details will also be included as to establishing compatibility between datums in other parts of the world. Concepts of a combined 3-dimensional spatial datum will also be presented and intended computational efficiencies will be described in terms of the GSDM.

X. Map Projections **30 pages – approx.**

A. Introduction: round Earth - flat map
B. Projection criteria
C. Projection figures
D. Permissible distortion and area covered
E. State plane coordinate systems
    1. Lambert
    2. Transverse Mercator & UTM
    3. Oblique Mercator
    4. Transformations
    5. Advantages
    6. Disadvantages
F. References

Almost all spatial data users have encountered map projection (in the USA, state plane) coordinates. This chapter will present the fundamental concepts of a map projection and describe some of the advantages obtained by using a map projection to "flatten the world." Details will be included so that those needing to can implement and use map projection (state plane) coordinates in defined areas. Focus will be on U.S. state plane coordinate zones, but details for other parts of the world will also be included. The advantages and disadvantages of using the map projection 2-dimensional model will be discussed.

XI. Using Spatial Data **30 pages – approx.**

A. Hardcopy map vs digital
B. Conventions and mode of use
C. Disadvantages imposed by using obsolete models
D. Modified state plane systems
E. Use and examples
F. Spatial Data Accuracy
G. References

This chapter will provide a summary describing how the form of spatial data has evolved in recent years from analog hardcopy maps to electronic digital data. The chapter will also look at how spatial data are used with consideration given to the preservation of their economic value. Blind acceptance of default models creates problems that have been addressed, in part, using modified map projection models, i.e., surface coordinates. Continued use of a 2-dimensional model for 3-dimensional data is inappropriate for geometrical integrity and computational efficiency. Examples will be given.

XII. 3-D Global Spatial Data Model (GSDM) **30 pages – approx.**

A. Definition/description
B. Functional model
C. Stochastic model
D. Data base design consideration
E. Implementation issues
F. Features/advantages
G. Applications and incorporation into existing practice
H. Examples
I. References

Parts of this chapter will be a summary because the fundamental pieces have all been defined previously. The definition and description of the GSDM will show how the various pieces fit together and how the functional model and stochastic model support each other relative to preserving the value of spatial data. Implementation issues will be discussed and several examples presented, but the focus will be on the features of the model. Many persons in various disciplines will use the model as the underlying standard for many other applications that go far beyond the scope of a book devoted to definition of the model.

Appendices **25 pages – approx.**

A. Listing of subroutines for various operations
B. State plane coordinate zone constants
C. Other major map projections

7.20.70 Leaves - Sabbatical

Purpose: The purpose of a sabbatical leave is to promote professional growth and increased competence among faculty members by subsidizing significant study and research, creative work, or some other program which is judged to be of equivalent value and which cannot be accomplished during the fulfillment of normal academic duties and responsibilities. All departments and colleges including branch campuses are encouraged to participate fully in the sabbatical program.

Qualifications and Options: Application for sabbatical leave may be made by any tenured full-time faculty member (above the rank of instructor) with at least 12 regular semesters of full-time service at the university without a sabbatical. A faculty member who is in the last year of the probationary period may be considered for sabbatical leave if a favorable decision on tenure has already been made. Sabbatical leave may be taken in conjunction with earned annual leave, personal leave, or educational leave without pay. Personal leave and educational leave without pay must comply with university policies. In instances where, for good and sufficient institutional reasons, a sabbatical leave is delayed (not to exceed 2 years), the faculty member will become eligible for a succeeding sabbatical leave after an equivalently reduced period. A faculty member should be given as much notice as possible if a sabbatical leave cannot be approved for the time frame requested. Sabbatical leave is available under the following options:

- One semester at no reduction in annual salary.
- One full contract year at 60 percent salary (Those within 5 years of retirement should consult the Employee Benefits Office about the possible negative impact on the retirement benefit formula.)
- Semester II (spring) of 1 year and Semester I (fall) of the following year, at 30 percent annual salary for each semester of leave.

When a person has served as both a 9-month and 12-month employee in the 6-year period immediately prior to the requested sabbatical, the amount of time allotted for the sabbatical will be prorated. A faculty member employed on a continuing basis on a 12-month contract may take a 6-month leave at full salary or a 12-month leave at 60 percent salary.

Applications: Sabbatical leave will not be granted automatically upon the expiration of the necessary period of service. Rather, a qualified faculty member shall, normally at least 6 months in advance of the leave, submit an application and proposed leave program to the department head or chair, with evidence of research, creative activity, or other academic achievement, including publications, to support the program of work which is planned for the sabbatical period. Also, this program shall give reasonable promise of accomplishing the major purpose of the leave. Request for a sabbatical leave should be accompanied by a detailed explanation of the benefits to the faculty member, university, and the state resulting from the sabbatical leave. For main campus faculty, the approval of the cognizant dean, graduate dean and provost are required. For branch campuses, the approval of the division dean, CAO and CEO are required. In addition to the work plan, the leave application should include: (1) a statement regarding choice of options; (2) departmental verification that during the applicant's absence, teaching, research, and service duties can be managed by the department; (3) a statement concerning compensation to be received during the leave. A faculty member on sabbatical leave at full pay usually will not take other paid employment during the leave; and (4) a clear statement of the benefit of the proposed leave to the university. A person on sabbatical at 60 percent time usually will not take more than 40 percent time employment. However, it is recognized that such employment may be necessary for or enhance the leave. In such cases, a request to take compensated employment should be included in the proposal submitted and must have administrative approval. The evaluation of an application should be based on whether the planned program satisfies the aims and goals explicitly set forth in the “Purpose” statement above. These aims and goals may be independent of geographical location of the leave activities and, therefore, the place of the faculty member's residence during leave should be only one factor in considering the merits of the application. However, to ensure that the sabbatical experience provides opportunities not otherwise available to the main campus faculty member, the sabbatical period will normally include a component of study/work away from the home institution. Related Conditions: Time toward each new sabbatical begins immediately after return to full-time service regardless of the semester of return. The sabbatical leave will not adversely affect salary increases or promotions. Institutional participation in faculty retirement and group insurance will be continued for staff on sabbatical leave with pay. A faculty member on sabbatical leave may request, through the department head, travel support for participation in professional meetings. Consideration will be given if the faculty member is an officer of the professional organization or is to participate in some other significant way. Educational or other leaves are excluded as time counted toward eligibility for sabbatical leave. Twelve-month faculty will accrue annual and sick leave (at 60 percent for those on 60 percent pay) and will report annual and sick leave as usual.

Departmental Implementation: Long-range department plans should consider the necessity of, and provide for, temporary absences for sabbatical leave. The initial leave discussions and concomitant management of duties is primarily a matter for discussion and approval by the concerned department. However, in transmitting the final leave request to the dean and provost, the department head should provide assurance that all student needs will be served by the department during the faculty member's absence. In some departments, the absence of one faculty member might place an undue load on the other department members. After a department has taken every step possible to plan for sabbatical leaves, it should submit its proposal to the dean for consideration. The administration will attempt to accommodate these special cases.

Procedures:

1. At least 6 months prior to the requested leave period (exceptions to be considered on a case-by-case basis), application for sabbatical leave is submitted to the department head on a “Request for Leave Form” and includes the supporting materials detailed in the “Application” section.

2. Preliminary approval is obtained when signatures of the department head, cognizant dean, dean of the Graduate School, and the provost are affixed to the “Request for Leave Form.” For branch campus faculty, preliminary approval is obtained when signatures of the department chair, division dean, CAO and CEO are affixed to the “Request for Leave Form”. A supplementary contract, stipulating that the faculty member is obligated and agrees to return to the university to serve a period of 1 year, and failure to do so would require immediate full refund of all salary paid by the university during the leave, is prepared and sent to the faculty member. Upon receipt of the signed supplementary contract, final approval of the leave is granted and the faculty member is notified.

3. Department heads or chairs submit a Personnel Action Form to place the faculty member on sabbatical.

Post sabbatical Obligations: Sabbatical leaves will be approved only with the clear understanding that at the completion of the sabbatical and/or supplemental leave, the faculty member will return to the university for a period of service of 1 year. Failure to do so will require immediate full refund of all salaries and benefits costs paid by the university during the sabbatical, and repayment for any annual leave accrued and used during the extended leave. Within the first semester upon return from the sabbatical, the main campus faculty member shall submit to the provost, through the department head and dean a full report of the research, creative work, publications, or other results of the period of leave. This final report should contain a brief summary of the proposal, including a review of the objectives, as well as a summary of what was accomplished. An explanation should be given in the event that some objective(s) were not met. This report will be incorporated in the faculty member’s annual written report and may be used in the annual performance evaluation process. The dean will forward the report to the provost, with his/her comments and those of the department head: regarding the overall value of the sabbatical to the faculty member and to the university and indicating the extent to which the sabbatical plan was accomplished. Branch campus faculty will submit a similar report to the CEO through their immediate supervisor.