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Introduction to Geodetic Datum and Geodetic Systems

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Content Summary

This book systematically and comprehensively discusses and explains the fundamental issues in geomatics and in surveying and mapping, such as geodetic datums and geodetic control networks, geoid and height systems, reference ellipsoid and geodetic coordinate systems, Gauss and UTM conformal projections, plane coordinate systems, and the establishment of geodetic coordinate systems. It also deals with various relevant geodetic data collection techniques.

The book can be used as a general textbook for undergraduates majoring in geomatics and in surveying and mapping in higher education institutions. For the technicians who are engaged in geomatic and surveying engineering, this book is strongly recommended as a basic and useful reference guide.

Preface

Geodetic datums and geodetic systems play an important role in surveying and mapping engineering. Geodetic datums refer to the reference surfaces, reference points, and their relevant parameters in surveying and mapping, including coordinate datums, vertical datums, sounding datums, and gravity datums. They are the reference surfaces or points against which measurements are made and they provide the basis for establishing geodetic systems. Geodetic systems are the extension of different types of datums realized through establishment of the nationwide geodetic control networks, which include the geodetic coordinate system, plane coordinate system, height system, and gravimetric system.

Geodetic datums and geodetic systems, as the common foundation for every subject of geomatics and surveying and mapping, are regarded as the main topic of this book. The book is designed to be used either as a reference for teaching or for learning subjects related to geodesy, surveying engineering, or geomatics. Some specific parts are written to fill literature blanks in the related area. For instance, we have extended the terms of traditional formulae with computer algebra systems to meet the accuracy of modern geodesy and have described modern geodetic coordinate systems and so on. The framework and structure of this book are formed through decades of teaching practice. The contents are systematic and the chapters proceed in an orderly and gradual way.

In writing this book, the authors put effort into building a new textbook system, attempting to avoid piecing together bits of knowledge from different courses. Due to the rapid and continuous developments in the field, it was necessary to be selective and to give more weight to some topics than to others. The material selected is particularly well suited to university-level students in line with twenty-first century education and the training requirements for a basic knowledge of geodesy. Therefore, in this textbook particular importance has been given to the fundamentals and to applications. It is a textbook that integrates classical materials with modern developments in geodesy, and balances practical applications and pure theoretical treatments by additionally highlighting some important and cutting-edge research issues in the field. Therefore, students who intend to pursue further studies in the field of surveying engineering should also find it helpful.

The book consists of seven chapters, a bibliography, an index, and a list of abbreviations. Summaries of the individual chapters are listed below.

Chapter 1 provides an overview of the discipline's objectives, roles, classifications, history, and trends in the development of geodesy.

Chapter 2 introduces the methods and principles of geodetic data collection techniques such as terrestrial triangulateration, height measurement, space geodetic surveying, and physical geodetic surveying.

Chapter 3 discusses the concept of geodetic datums and the methods, principles, and plans for establishing horizontal and vertical control networks, satellite geodetic control networks, and gravity control networks.

Chapter 4 deals with the basic concepts of the theory of the Earth's gravity field, discusses the definition of height systems, and establishes the relationship of transformation between different height types.

Chapter 5 discusses the reference ellipsoid, its relevant mathematical properties, methods for reducing the elements of terrestrial triangulation and trilateration to a reference ellipsoid, and establishes the models to transform mutually between the geodetic coordinate system, geodetic polar coordinates, and geodetic Cartesian coordinate system.

Chapter 6 is devoted to the methods and models of Gauss conformal projection and the Universal Transverse Mercator (UTM) conformal projection and establishes the relationship between the geodetic coordinates on the ellipsoid and the coordinates on the projection plane as well as the methods for coordinate transformations. The projection of geodetic networks from the ellipsoid onto a plane is also discussed so that they can be computed in the projected plane coordinate system.

Chapter 7 considers the principles of establishing classical and modern geodetic coordinate systems, establishes the transformation models between different coordinate systems, and provides an overview of the geodetic coordinate systems in China and throughout the world.

This book has been revised and extended by Zhiping Lu and Yunying Qu based on the first edition of the book, which was published in the Chinese language in 2006. In writing and adapting the original Chinese edition, Zhiping Lu wrote Chaps. 1, 4–7; Shubo Qiao and Jianjun Zhang wrote Chaps. 2 and 3. The numerical examples and illustrations in the book were designed and constructed by Shubo Qiao, Zhiping Lu, and Yupu Wang. English teachers Yali Zhang, Wen Zhang, and Yanxia Li helped with parts of the translation of the manuscript. Ph.D. candidates Zhengsheng Chen and Lingyong Huang and graduate students Yupu Wang, Hao Lu, and Kai Xie helped sort out part of the manuscript, read the manuscript, and offered some suggestions for revision.

The three reviewers of this book are Prof. h.c. Dr. Guochang Xu of the German Research Center for Geosciences (GFZ), Potsdam; Dr. Timmen Ludger of the University of Hannover; and Prof. Dr. Jörg Reinking of Jade University, Oldenburg. Dr. Timmen Ludger also mailed and presented two books for our reference. A grammatical check and correction of English language has been performed by John Kirby from Springer, Heidelberg.

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Zhiping Lu

Abbreviations

APSG	Asia-Pacific Space Geodynamics
APT	Asia-Pacific Telescope
ARP	Antenna reference point
AUSLIG	Australian Surveying and Land Information Group
BIH	Bureau International De L'Heure
BJS54	Beijing Coordinate System 1954
CAE	Chinese Academy of Engineering
CAS	Chinese Academy of Sciences
CCRS	Conventional Celestial Reference System
CDP	Crustal Dynamics Project
CEA	China Earthquake Administration
CGBN57	China Gravity Basic Network 1957
CGBN85	China Gravity Basic Network 1985
CGBN2000	China Gravity Basic Network 2000
CGCS2000	China Geodetic Coordinate System 2000
CHAMP	Challenging Mini-Satellite Payload
CIO	Conventional International Origin
CLEP	Chinese Lunar Exploration Program
CMONOC	Crustal Movement Observational Network of China
COGRS	Continuously Operating GPS Reference Stations
CORE	Continuous Observation of the Rotation of Earth
CORS	Continuously Operating Reference System
COSMOS	Continuously Operational Strain Monitoring System with GPS
CRL	Communications Research Laboratory
CSB	China Seismological Bureau
CTRF	Conventional Terrestrial Reference Frame
CTP	Conventional Terrestrial Pole
CTRS	Conventional Terrestrial Reference System
DMA	American Defense Mapping Agency
DORIS	Doppler Orbitography and Radio-positioning Integrated by Satellite
DOSE	Dynamics of Solid Earth

DSP	Double Star Exploration Program
EDM	Electromagnetic distance measurement
EOP	Earth Orientation Parameter
EOS	Electro Optic Systems
EPN	EUREF Permanent Network
ERP	Earth Rotation Parameters
ESA	European Space Agency
ESLW	Equatorial springs low water
EUREF	Regional Reference Frame Sub-Commission for Europe
EUROLAS	European Laser Consortium
EVN	European VLBI Network
FAA'	Federal Aviation Administration
FGCS	Federal Geodetic Control Subcommittee
GEONET	GPS Earth Observation Network System
GFZ	German Research Center for Geosciences in Potsdam
GIS	Geographic Information System
GLONASS	Global Orbit Navigation Satellite System
GNSS	Global Navigation Satellite Systems
GOCE	Gravity Field and Steady-State Ocean Circulation Explorer
GPS	Global Positioning System
GPST	Global Positioning System Time
GRACE	Gravity Recovery and Climate Experiment
GRS75	Geodetic Reference System 1975
GRS80	Geodetic Reference System 1980
GSFC	Goddard Space Flight Center
IAG	International Association of Geodesy
IAGBN	International Absolute Gravity Base Station Network
IAU	International Astronomical Union
IDS	International DORIS System
IERS	International Earth Rotation and Reference Systems Service
IGS	International Global Navigation Satellite System Service
IGSN71	International Gravity Standardization Net 1971
IHB	International Hydrographic Bureau
ILRS	International Laser Ranging System
ILS	International Latitude Service
IPMS	International Polar Motion Service
ISA	International Service Agency
ISLW	Indian spring low water
ITRF	International Terrestrial Reference Frame
ITRS	International Terrestrial Reference System
IUGG	International Union of Geodesy and Geophysics
IVS	International VLBI Service for Geodesy and Astrometry
LAGEOS	Laser Geodynamics Satellite
LEO	Low Earth orbit

LLR	Lunar Laser Ranging
LLW	Lowest low water
LO	Local oscillator
LOD	Length of day
MLLW	Mean lower low water
MLLWS	Mean lower low water springs
MLW	Mean low water
MLWS	Mean low water springs
MOBLAS	Mobile Laser Ranging System
MSL	Mean sea level
NAD83	North American Datum 1983
NASA	National Aeronautics and Space Administration
NAVD88	North American Vertical Datum 1988
NCRIEO	North China Research Institute of Electro-Optics
NGS	National Geodetic Survey
NNR	No-net-rotation
NSFC	National Natural Science Foundation of China
OPUS	Online Position User Service
PPS	Precise Positioning Service
PRARE	Precise range and range-rate equipment
PRF	Pulse repetition frequency
PRN	Pseudo-random noise
RTK	Real time kinematic
SA	Satellite altimetry
SAPOS	German Satellite Positioning Service
SBSM	State Bureau of Surveying and Mapping of China
SELENE	Selenological and Engineering Explorer
SGG	Satellite gravity gradiometry
SI	International System of Units
SLR	Satellite laser ranging
SMBGSH	Surveying and Mapping Bureau of the General Staff Headquarters of the Chinese People's Liberation Army
SNR	Signal-to-noise ratio
SPS	Standard Positioning Service
SSC	Set of station coordinates
SST	Satellite-to-satellite tracking
SSL-hl	High-low satellite-to-satellite tracking
SSL-ll	Low-low satellite-to-satellite tracking
SZCORS	China Shenzhen CORS
TAI	International Atomic Time
TIGO	Transportable Integrated Geodetic Observatory
TLT	Theoretical lowest tide
TRF	Terrestrial reference frame
TRS	Terrestrial reference system

TT&C	Tracking, Telemetering and Command
UNCED	United Nations Conference on Environment and Development
USACE	Corps of Engineers of United States of America
USB TT&C	Unified S-Band Tracking Telemetering Control
USCG	United States Coast Guard
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator
VLBI	Very Long Baseline Interferometry
VSOP	VLBI Space Observatory Program
WAAS	Wide Area Augmentation System
WGS84	World Geodetic System 1984
WPLTN	West Pacific SLR Network

Author Profiles

Zhiping Lu graduated in geodesy from Zhengzhou Institute of Surveying and Mapping, China, and obtained his bachelor and master degrees in 1982 and 1990, respectively. He received his doctorate from Wuhan University in 2001. Having worked as a lecturer from 1982 to 1992, and as an associate professor from 1992 to 1997 at Zhengzhou Institute of Surveying and Mapping, he has been working as a professor (since 1997), Ph.D. supervisor (since 2000), and deputy director of the key laboratory of surveying and mapping and navigation (since 2011) at Information Engineering University, as adjunct professor at China University of Petroleum (2005–2008), and as a visiting senior scientist at the German Research Center for Geosciences (GFZ) for 2–3 months each year (since 2010).

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