全国高等院校测绘专业规划教材

Fundamentals of Geomatics in English

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测绘学英语

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内 容 简 介

该教材按照国内多数高校测绘工程专业“数字测图原理与方法”课程大纲要求，结合中国测绘技术现状并参考英美等国测绘技术特点，采用全英文系统地介绍了测绘学基础的理论与技术，包括：测绘学(Geomatics)的基本概念与发展变革、高程测量、角度测量、距离测量、误差理论与简易平差方法、小区域控制测量、大比例尺数字测图和地形图应用等教学内容。每章均附有习题和参考答案，附录中还包括以中文总结了该课程的知识要点和该教材中出现的500余条术语的英中文对照。

该书可以作为本科“数字测图原理与方法”课程进行双语教学和“测绘英语”课程的教材，也可以作为研究生相关课程的教材和测绘工程技术人员的参考书。

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序　　言

2005 年，主编主讲的一门课程“测绘学基础”(过去称为“地形测量学”或“普通测量学”，现在亦称“数字测图原理与方法”)被评为辽宁省本科精品课程，却苦于没有配套的英文教材进行双语教学。当时虽设法搜集了英、美等国家高校类似的教材，但其涉及的知识体系和内容与我国测绘学科对该门课程的教学要求相去甚远，完全不适应中国国情和测绘工程专业的实际情况。为此，我们只好自行编写了一部符合国内测绘专业使用的英文教材“Fundamentals of Geomatics in English”。到 2009 年，将其作为内部双语教学的教材先后修改和印制了 3 次，在测绘工程、地理信息系统和资源环境与城乡规划管理3 个本科专业的“测绘学基础”课程教学中试用了 10 个学期。

本书涵盖了有关测绘学基础理论和技术，重点介绍数字测图的原理与方法，内容包括：第一章绪论；第二章测绘学的基本理论与知识；第三章水准测量；第四章角度测量；第五章距离测量；第六章测量误差理论；第七章小区域控制测量；第八章大比例尺地形图测绘；第九章地形图的应用。同时，每章均配合本章教学内容安排了若干习题。此外，考虑到学生掌握专业英语阅读和实际需要的具体情况，在附录中包括了中英文对照的各章节知识要点与习题参考答案及本书中出现的 500 余条个专业词汇的英中文对照。

本书适合测绘工程及相近专业的“测绘学”等课程，用于双语教学或“测绘英语”课程，同时也适合测绘工程领域内科技人员阅读和研究生的专业考试的复习之用。

本书与其他两部英文教材的研究与编写，是辽宁省高等教育教学改革研究项目“测绘工程专业主干课双语教学研究与实践”的成果之一，并于 2012 年 5 月 8 日获得国家首届“测绘地理信息教学成果奖”。

参加本书编写和绘图的有：中国矿业大学银川学院马振利、黄恒，辽宁工程技术大学裴亮、王崇倡、张继超、任东风、范强，沈阳建筑大学任家强、刘茂华等老师。

编写一部适应中国国情的测绘专业英文教材，是我们的一次斗胆尝试，敬请各位专家学者和使用本教材的读者对书中可能出现的技术错误和“Chinglish”现象给予批评斧正，对此深表谢意。

此次本书得以正式出版，首先十分感谢清华大学出版社的各位编辑。其次，对本教材修改中提出宝贵意见的各位任课教师和学生们表示深深的谢意。

编　者

Preface

Nowadays, more and more attention has been paid to the subject *Geo-Spatial Information Science* or *Geomatics*. It mainly includes the 3-S techniques, that is, GNSS (*global navigation satellite system*), GIS (*geographic information system*), and RS (*remote sensing*), together with its two supporting technologies—computers and communications used to collect, measure, analyze, store, manage, display, and distribute geo-spatial data. Geomatics is a preceding field in earth science and it is a significant element in geographic information science.

It is still in its infant period, an integrated theoretical structure is badly in need of being built. Particularly the techniques for geo-spatial data collection, storage, management, representation, and distribution want also to be developed.

In order to introduce the principal technology and knowledge of modern surveying theory and practice, this English version is published and referred currently to as "Fundamentals of Geomatics", namely "Elementary Surveying and Mapping". Since the new term, Geomatics, is now generally accepted in a majority of countries worldwide, and is consistent with modern theory and practice as currently evolving in China, it is an advisable addition to the textbook's title. It is expected that this version will not only meet the needs of higher education in the bilingual teaching for the specialty of surveying and mapping, but be suitable for the engineers of spatial data users in various other engineering fields.

The authors\compilers have developed a professional level text designed mainly for sophomore students majored in Surveying and Mapping Engineering, Geographical Information System, and Urban and Rural Planning and Resource Management, and endeavored to present a readable text that provides basic concepts and practical knowledge in each of the areas fundamental to modern surveying (geomatics) practicality. The textbook introduces primary theory and practice in surveying engineering, but its depth and breadth also make it ideal for professional surveyors in self-study. Throughout the text, the authors/compilers have maintained its consistence with all relevant professional standards.

Meanwhile, this book tries to emphasize the theory and practice in topographical survey because it is the integrated application of elementary surveying knowledge. Students are hoped to learn deep into the subject in the other courses such as *Geodetic Surveying*, *Photogrammetry*, *Survey Adjustment*, *Global Positioning System*, *Remote Sensing*, *Engineering Surveying*, *Mining Surveying*, *Cadastration*, *Cartography*, *Geographical Information System*, *Route Survey* and so on in the junior and senior years. At the end of each chapter, there are a number of exercises closely related to the chief topics. Completing both the students and other readers can review the key points in teaching and promote one's capability of analyzing and resolving problems.

For the sake of improving future editions, the authors/compilers will gratefully accept any workable suggestions or constructive criticisms from all the users including the surveyors in various fields, the university faculties and students.

MA, Zhenli

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Chapter 1
Introduction

§1.1 DEFINITION OF GEOMATICS

Geomatics is fairly new. The term was apparently coined by B. Dubuisson in 1969. It includes the tools and techniques used in land surveying, remote sensing, geographic information systems (GIS), global positioning systems (GPSS), and related forms of earth mapping. Being similar in French and English, the term geomatics originally used in Canada, and has been adopted by the International Organization for Standardization, the Royal Institution of Chartered Surveyors, and many other international authorities, although some (especially in the United States) have shown a preference for the term *geospatial technology*.

A good definition can be found on the University of Calgary's web page titled "What is Geomatics Engineering?": "Geomatics Engineering is a modern discipline, which integrates acquisition, modeling, analysis, and management of spatially referenced data, i.e. data identified according to their locations. Based on the scientific framework of geodesy, it uses terrestrial, marine, airborne, and satellite-based sensors to acquire spatial and other data. It includes the process of transforming spatially referenced data from different sources into common information systems with well-defined accuracy characteristics."

Geomatics, was called as *Surveying* in the past, may be usually defined as the subject of making measurements of the relative positions of natural and man-made features on the earth's surface, and the presentation of this information either graphically or numerically. It may date back to antiquity. Dayu, a Chinese leader who lived in about the 2100 B.C., provided the first serious account of surveying techniques. From this it is clear that the work of many famous scientists and surveyors in the world was used in measuring up and setting out. Naturally, much has altered, but nevertheless a few techniques have shown little change in principle over the centuries.

Nowadays the importance of measuring and monitoring our environment is becoming increasingly critical as our population expands, land values appreciate, our natural resources dwindle, and human activities continue to stress the quality of our land, water and air. Using modern ground, aerial and satellite technologies, and computers for data processing, contemporary surveyors are now able to measure and monitor the earth and its natural resources on literally a global basis. Never before has so much information been available for assessing current conditions, making sound planning decisions, and formulating policies in a host of land-use, resource development, and environmental preservation applications.

With the increasing breadth and importance of the practice of surveying and mapping, the *International Federation of Surveying* recently adopted the following definition:

"Practice of the surveyor's profession may involve one or more of the following activities which may occur either on, above or below the surface of the land or the sea, and may be carried out in association with other professionals.

(1) Determination of the size and shape of the Earth and measurement of all data needed to define the size, position, shape, and contour of any part of the Earth.

(2) Positioning of objects in space, and positioning and monitoring of physical features, structures, and engineering works on, above or below the surface of the Earth.

(3) Determination of the positions of boundaries of public or private land, including national and international boundaries, and registration of those lands with appropriate authorities.

(4) Design, establishment, and administration of land and geographic information systems, and the collection, storage, analysis and management of data within those systems.

(5) Study of the natural and social environment, measurement of land and marine resources, and the use of the data in planning of development in urban, rural, and regional areas.

(6) Planning development and re-development of property, whether urban or rural and whether land or buildings.

(7) Assessment of value and the management of property, whether urban or rural and whether land or buildings.

(8) Planning, measurement, and management of construction works, including estimation of costs.

(9) Production of maps, files, charts, and reports.

In the application of the foregoing activities, surveyors take into account the relevant legal, economic, environmental, and social aspects affecting each project."

Since the new technology has developed rapidly day by day, the name, Surveying, no longer adequately reflects the expanded and changing tasks of this profession, so that the new term Geomatics has come forth. Note that the two terms, surveying and geomatics, are both used in the book, even though the former is used more frequently than the latter. However, students should cognized that both of the two terms are practically synonymous. The breadth and diversity of the practice of surveying or geomatics, as well as its importance in modern civilization, are readily apparent from this definition.

§1.2 BRANCHES OF GEOMATICS

The branches of Geomatics or Surveying are usually classified by the different purposes in actual practice as follows at present in China.

1) Plane Surveying

Surveying is divided generally into two fields: plane surveying and geodetic surveying. In *plane surveying*, relatively small areas are under consideration, and it is taken that the earth's surface is flat, i.e. a horizontal plane. Measurements plotted will represent the projection on the horizontal plane of the actual field measurements. For example, if the distance between two points *A* and *B* on a hillside is *l*, the distance to be plotted will be $l\cos\alpha$, where α is the angle that line *AB* makes with the horizontal, assuming a uniform slope.

A horizontal plane is one that is normal to the direction of gravity, as defined by a plumb bob at a point, but owing to the curvature of the earth such a plane will in fact be tangential to the earth's surface at the point. Thus, if a large enough area is considered on this basis, a discrepancy will become apparent between the area of the horizontal plane and the actual curved area of the earth's surface.

It can be shown that for surveys up to 250 km^2 in area this discrepancy is not serious, and it is obvious therefore that plane surveying will be adequate for all but the very largest surveys. However, precautions are required when connecting such surveys to control points established and coordinated by geodetic surveys.

2) Geodetic Surveying (or Geodesy)

In geodetic surveying, large areas of the earth's surface are involved, and the curvature of the earth must be taken into account.

It is actually a branch of surveying distinguished both by use and by technique. In such a surveying, the curved surface of the earth is considered by performing the computations on an ellipsoid approximating the size and shape of the earth. It is become common to do geodetic calculations in a three-dimensional, earth-centered Cartesian coordinate system. The computations involve solving equations derived from solid geometry and calculus.

Geodetic methods are employed to determine relative positions of widely spaced monuments and to compute length and directions of the long lines between them. These monuments serve as the basis for referencing other subordinate surveys of lesser extent. As will be explained shortly, frameworks of angular and distance measurements between points are necessary to control all surveys, and when surveying large areas, such as a whole country or a wide area, these measurements must be taken to the highest possible standard. Modern methods for this task include GPS technique, which can obtain the coordinates of any point on the earth's surface in three dimensions to a high degree of accuracy. The study of the size and shape of the earth and its gravity field is known as *Geodesy*; hence the name of this type of surveying.

3) Topographic Surveying (or Topography)

Topographic surveying is the process of recording the surface features found in a given area or region of the earth, i.e. determining the locations of natural and artificial features and elevations used in map making. The topography of the earth's surface can be drawn on maps or plans. Small-scale mapping is performed mainly by central governmental agencies, but large-scale mapping, on the other hand, is performed primarily in minor area by the local governments, engineering projects and related firms.

There is no clear distinction between a map and a plan, but it is generally accepted that in a plan detail is drawn such that it is true to scale, while in a map many features have to be represented by symbols, the scale being too small. Height information can be added either as spot height, which are individual height points, or as contours, giving a less detailed but more visual representation of the area. Frequently spot heights only are shown on plans. Plans tend to be used for engineering design and administration purposes only, but maps have a multiple of users — navigational, recreational, geographical, geological, military, and explorational — their scales ranging from 1:20,000 to, say, 1:1,000,000.

4) Engineering Surveying

Engineering surveying includes all the survey works required before, during and after any engineering project. Before any undertaking starts, large-scale topographical maps or plans are required as a basis for design. The proposed position of any new item of construction must then marked out on the ground, both in plan and height, an operation generally termed setting out; finally, 'as built' surveys are often required.

For the design and construction of new routes, e.g. roads and railways, besides many other aspects of surveying, it is often required to calculate the areas and volumes of land and data for setting out curves for route alignment.

Typical scales are as follows:

(1) Architectural work, building work, location drawings: 1:50, 1:100, 1:200;

(2) Site plans, civil engineering works: 1:500, 1:1000, 1:2,000;

(3) Town surveys, highway surveys: 1:2,000, 1:5,000, 1:10,000, 1:20,000, 1:50,000.

5) Cadastral Surveying (or Cadastration)

Cadastral surveying or land surveying establishes property lines and property corner markers. These are undertaken to produce plans of property boundaries for legal purposes, in many countries the registration of land ownership based on such plans.

The term cadastral is now generally applied to surveys of the public lands system. There are three major categories: *original surveys* to establish new section corners in unsurveyed areas that still exist in some backlands; *retracement surveys* to recover previously established boundary lines; and *subdivision surveys* to establish monuments and delineate new parcels of ownership. In addition, *condominium surveys*, which provide a legal record of ownership, are also a type of boundary surveys.