
Contents

Preface..... xi

Acknowledgment xiii

Authors..... xv

Chapter 1 Introduction 1

1.1 Surveying Profession and Instruments: Historical Perspective 1

1.2 Existing Books and Why We Decided to Write Our Book..... 3

1.3 Structure of This Book 6

References 7

Chapter 2 Levels 9

2.1 Optical Levels..... 10

2.1.1 Dumpy Levels 10

2.1.1.1 Accuracy 15

2.1.1.2 Reliability 16

2.1.1.3 Insensitivity to Strong Magnetic and Electromagnetic Fields 16

2.1.2 Automatic Levels..... 16

2.1.2.1 Automatic Optical Levels 16

2.1.2.2 Autofocusing Levels 24

2.1.2.3 Digital Automatic Levels..... 26

2.2 Laser Levels..... 30

2.2.1 Principle of Laser Level Operation 30

2.2.2 Checking and Adjusting of Laser Levels 37

Bibliography 40

Chapter 3 Theodolites 43

3.1 Historical Prototypes of Modern Theodolites..... 43

3.2 Optical Theodolite..... 45

3.3 Electronic Theodolite 46

3.4 Basic Operation Principle of a Theodolite 47

3.4.1 Basic Axes of a Theodolite 47

3.4.1.1 Theodolite Vertical Axis 47

3.4.1.2 Theodolite Horizontal Axis..... 49

3.4.1.3 Theodolite Collimation Axis..... 53

3.5 Main Parts of a Theodolite..... 54

3.5.1 Measuring System of a Theodolite 54

3.5.1.1 Measuring System of an Optical Theodolite..... 54

	3.5.1.2	Measuring System of an Electronic Theodolite.....	55
	3.5.1.3	Influence of Wrong Limb Position on Angular Measuring System Accuracy.....	59
	3.5.2	Vertical Index Compensator of a Theodolite	62
	3.5.2.1	Vertical Index Compensator of an Optical Theodolite	62
	3.5.2.2	Vertical Index Compensator of an Electronic Theodolite	63
	3.5.3	Theodolite Telescope.....	69
	3.5.4	Theodolite Targeting Units	73
	3.5.5	Theodolite Plummets	75
		Bibliography	78
Chapter 4		Electronic Distance Measurer (EDM)	79
	4.1	Physical Fundamentals of Surveying Electronic Distance Measurers (EDMs)	81
	4.2	Time Interval Measuring Methods Applied in EDMs	90
	4.2.1	Pulse Method (Time-of-Flight Method)	90
	4.2.2	Phase-Shift Method.....	99
	4.3	Semiconductor Photodetectors and Light Sources of EDMs....	101
	4.3.1	General Principle.....	101
	4.3.2	Photodiodes	104
	4.3.3	Light-Emitting Diodes and Lasers	105
	4.4	EDM Optical Schemes	107
		Bibliography	112
Chapter 5		Total Stations.....	115
	5.1	Total Station Configuration	118
	5.1.1	Basic Axes of a Total Station	118
	5.1.2	Total Station Telescope.....	119
	5.1.2.1	Infrared Electronic Distance Measurer (EDM) Requiring a Reflector Prism.....	119
	5.1.2.2	Reflectorless EDM with a Red Laser.....	121
	5.1.2.3	Reflectorless Infrared EDM.....	124
	5.2	Additional Appliances of a Total Station Telescope.....	127
	5.3	Robotic Total Stations	129
	5.4	Checking and Adjusting Total Stations	133
		Bibliography	138
Chapter 6		Global Navigation Satellite Systems (GNSS).....	141
	6.1	Fundamental Principles of Global Navigation Satellite Systems (GNSS)	141

6.1.1	Principle of Signal Transit Time Measuring	141
6.1.2	Basic Principles of Satellite Navigation	141
6.1.3	Signal Travel Time	143
6.1.4	Determining the Position	145
6.1.5	Effect and Correction of Time Error.....	146
6.2	Coordinate Systems	147
6.2.1	Geoid	147
6.2.2	Ellipsoid and Datum.....	148
6.2.2.1	Ellipsoid	148
6.2.2.2	Customized Local Reference Ellipsoids and Datum	149
6.2.2.3	Worldwide Reference Ellipsoid WGS-84	150
6.2.2.4	Transformation from Local to Worldwide Reference Ellipsoid	151
6.2.2.5	Converting Coordinate Systems	152
6.3	Types of GNSS	153
6.3.1	Introduction to GPS.....	153
6.3.2	Description of GPS.....	153
6.3.3	GPS Space Segment	154
6.3.3.1	Satellite Distribution and Movement.....	154
6.3.3.2	Satellite Signals in GPS	155
6.3.4	GPS Control Segment	155
6.3.5	GPS User Segment	155
6.3.6	GLONASS: The Russian System	156
6.3.7	Overview of Galileo	157
6.3.8	The Chinese System: BeiDou 1 and BeiDou 2/ Compass	158
6.3.8.1	Current System: BeiDou 1.....	158
6.3.8.2	Future System: BeiDou 2/Compass.....	158
6.4	Differential GPS and SBAS (Satellite-Based Augmentation Systems).....	158
6.4.1	Sources of GPS Error	159
6.4.2	Possibilities for Reducing the Measurement Error	160
6.4.3	Differential GPS (DGPS) Based on Signal Travel Time Delay Measurement	162
6.4.3.1	Detailed Description of How It Runs	162
6.4.3.2	Definition of the Correction Factors.....	162
6.4.3.3	Transmission of the Correction Values.....	164
6.4.3.4	Correction of the Measured Pseudoranges	164
6.4.3.5	DGPS Based on Carrier Phase Measurement.....	164
6.4.3.6	DGPS Postprocessing (Signal Travel Time and Phase Measurement).....	165

- 6.4.3.7 DGPS Classification according to the Broadcast Range 165
 - 6.4.3.8 Standards for the Transmission of Correction Signals 166
 - 6.4.3.9 Overview of the Different Correction Services..... 166
 - 6.4.4 SBAS 167
 - 6.4.4.1 Most Important SBAS Functions..... 167
 - 6.4.4.2 Overview of Existing and Planned SBAS 168
- 6.5 GNSS Receivers 170
 - 6.5.1 Basics of GNSS Handheld Receivers 170
 - 6.5.2 Basic Design of a GNSS Module 172
- 6.6 GNSS Applications..... 173
 - 6.6.1 Description of the Various Applications 177
 - 6.6.1.1 Location-Based Services (LBS) 177
 - 6.6.1.2 Commerce and Industry 178
 - 6.6.1.3 Communications Technology 179
 - 6.6.1.4 Agriculture and Forestry 179
 - 6.6.1.5 Science and Research 180
 - 6.6.1.6 Tourism and Sport 181
 - 6.6.1.7 Military..... 181
 - 6.6.1.8 Time Measurement 181
- Bibliography 182

Chapter 7 Obtaining and Processing Unmanned Aerial Vehicle (UAV) Data for Surveying and Mapping 183

- 7.1 Obtaining Surveying Data Using Small Unmanned Aerial Vehicles (UAVs)..... 183
 - 7.1.1 Principles of UAV Use for Surveying and Mapping Projects..... 190
- 7.2 UAV Photogrammetry 191
 - 7.2.1 Image Scale 191
 - 7.2.2 Ground Coverage (Footprint) by Single Image..... 191
 - 7.2.3 Ground Sample Distance..... 193
 - 7.2.3.1 Ground Sample Distance: Comparative Analysis 193
 - 7.2.4 Multiview Processing 193
 - 7.2.5 Photogrammetric Computer Vision: Influence on UAV Imaging Technologies 195
- 7.3 UAV Mapping Project Management Considerations..... 199
 - 7.3.1 Basic Tasks 199
 - 7.3.1.1 Target Area and Preparation..... 199
 - 7.3.1.2 Camera Specifications 200
 - 7.3.1.3 UAV Flight Parameters Specifications 200

- 7.3.2 Mission Planning Sample.....202
 - 7.3.2.1 Project Area202
 - 7.3.2.2 Mission Planner202
 - 7.3.2.3 The Flight Path204
 - 7.3.2.4 Mission Results.....205
 - 7.3.3 Results Analysis205
 - 7.3.4 Factors Affecting the Mission206
 - 7.3.4.1 Atmospheric Conditions207
 - 7.3.4.2 Weather.....208
 - 7.4 UAV Mapping Project Cost Considerations210
 - 7.4.1 Camera and Component Prices210
 - 7.4.2 The UAV.....210
 - 7.4.3 The Mission’s Cost211
 - 7.4.4 Small UAV (Hobbyist Level) Mapping Flight Recommendations212
 - 7.5 Professional-Level SUAV Project Recommendations.....212
 - 7.5.1 Design Project Plan to Meet Project Requirements.....215
 - 7.5.2 Flight Plan Design.....218
 - 7.5.3 Completing the Flight.....218
 - 7.5.4 Application Scenarios Supported by UX5 UAV221
 - References222

Index.....225