

# GEOGRAPHIC INFORMATION SYSTEMS

<b>1.</b>	<b>GEOGRAPHICAL INFORMATION SYSTEMS AND GEOGRAPHICAL INFORMATION</b>	<b>1</b>
1.1	BASIC CONCEPTS	1
1.2	SOCIO-ECONOMIC CHALLENGES	8
1.3	BENEFITS OF COMPUTERISING INFORMATION	17
1.4	USERS	21
<b>2.</b>	<b>HISTORICAL DEVELOPMENT – GEOGRAPHICAL DATA AND GIS</b>	<b>23</b>
2.1	EARLY DEVELOPMENTS	23
2.2	THE FIRST AUTOMATIC PROCESSING OF GEOGRAPHIC INFORMATION	26
2.3	MICROPROCESSORS AND RECENT DEVELOPMENT	28
<b>3.</b>	<b>FROM THE REAL WORLD TO GIS</b>	<b>31</b>
3.1	THE REAL WORLD	31
3.2	REAL WORLD MODEL	31
3.3	DATA MODEL	34
3.3.1	Graphical representation of objects	36
3.3.2	Object attributes	39
3.3.3	Object relations	39
3.3.4	Object quality	39
3.4	FROM DATABASE TO GIS TO MAP	40
<b>4.</b>	<b>DIGITISING THE REAL WORLD</b>	<b>41</b>
4.1	GENERAL	41
4.2	VECTOR DATA MODEL	42
4.2.1	General	42
4.2.2	Coding digital data	43
4.2.3	Storing vector data	48
4.3	RASTER DATA MODELS	53
4.3.1	General	53
4.3.2	Storing raster data	58
4.4	AUTOMATIC CONVERSION BETWEEN VECTOR AND RASTER MODELS	59
4.5	VECTOR VS. RASTER MODELS	60

4.6	TABULAR DATA AND COMPUTER REGISTERS	61
4.7	LINKING DIGITAL MAP AND REGISTER INFORMATION	65
4.8	GEOMETRIC DESCRIPTION OF CONTINUOUS TERRAIN SURFACES – DIGITAL TERRAIN MODELS	67
4.9	GEOREFERENCES AND COORDINATE SYSTEMS	71
4.9.1	Continuous georeference systems	71
4.9.2	Discrete georeference systems	75

## 5. HARDWARE AND SOFTWARE FOR GIS

**77**

5.1	HARDWARE	77
5.1.1	Computers	77
5.1.2	Displays	80
5.1.3	Quantizers	82
5.1.4	Plotters and other output devices	84
5.2	SOFTWARE	87
5.2.1	General	87
5.2.2	Communication between users and computers	88
5.2.3	User requirements	92
5.3	WORKING ENVIRONMENT	93

## 6. SOURCES, COLLECTION AND INTEGRATION OF DATA

**95**

6.1	INTRODUCTION	95
6.2	DIGITISING MAPS	96
6.2.1	Manual digitising	96
6.2.2	Scanning	101
6.2.3	Manual digitising or scanning	107
6.3	SURVEYING AND MANUAL COORDINATE ENTRY	108
6.3.1	Surveying	108
6.3.2	Manual entry of coordinates	110
6.4	AERIAL PHOTOGRAPHS AND PHOTO INTERPRETATION	110
6.5	PHOTOGRAMMETRIC MAPPING	112
6.6	POSITIONING SYSTEMS	115
6.6.1	Global positioning system, GPS	115
6.6.2	Inertial navigation	118
6.7	SATELLITE DATA	118
6.7.1	Optical remote sensing	118
6.7.2	Analytic methods	123
6.8	TEXT DATA	126
6.9	COMPUTER AIDED DESIGN (CAD)	127
6.10	ATTRIBUTE DATA	127
6.11	IMPORTING COMPUTERISED INFORMATION TO GIS	130

6.11.1	Background	130
6.11.2	Standard transfer formats	131
6.12	DATA STRUCTURING	132
6.13	FORMAL PROBLEMS IN ESTABLISHING GIS	136

## **7. DATA QUALITY**

7.1	SELECTION CRITERIA	139
7.2	MEASUREMENT ACCURACY AND PRECISION	141
7.3	POSITIONAL ACCURACY	142
7.4	ATTRIBUTE DATA ACCURACY	144
7.5	GEOMETRY-ATTRIBUTE LINK CONSISTENCY	145
7.6	LOGICAL RELATIONSHIP CONSISTENCY	146
7.7	DATA COVERAGE AND DATA RESOLUTION	146
7.8	DATA CURRENTNESS	147
7.9	PROBABLE SOURCES OF ERROR	148

## **8. DATABASES**

8.1	INTRODUCTION	151
8.2	FILES	153
8.3	DATABASE SYSTEMS	154
8.3.1	Hierarchical database systems	155
8.3.2	Network database systems	156
8.3.3	Relational database systems	157
8.4	ADAPTING DATABASES TO GIS USES	159
8.4.1	General	159
8.4.2	Databases for map data	161
8.4.3	Object oriented database systems	165
8.5	SAFEKEEPING AND SECURITY ROUTINES	167

## **9. GIS TOOLS**

9.1	INTRODUCTION	169
9.2	ORGANISATION OF DATA STORAGE OPERATIONS	171
9.3	DATA ENTRY FUNCTIONS	173
9.4	IMPORTING EXISTING DIGITAL DATA	173
9.5	FUNCTIONS FOR CORRECTING AND ADAPTING GEOMETRIC DATA FOR FURTHER USE	173
9.5.1	General utility functions	173
9.5.2	Editing and correcting errors and omissions	174
9.5.3	Creating topology	175

9.5.4	Transformations to a common map projection and a common coordinate system	176
9.5.5	Adjustments between map edges and between neighbouring areas	177
9.5.6	Thinning coordinates and smoothing lines	178
9.6	EDITING ATTRIBUTE DATA	179
9.7	FUNCTIONS FOR ANALYSING DATA	179
9.7.1	Logic operations	180
9.7.2	Arithmetic operations	181
9.7.3	Geometric operations	182
9.7.4	Statistical operations	182
9.8	MAP DATA RETRIEVAL AND SEARCH	183
9.9	OPERATIONS ON ATTRIBUTE DATA	183
9.10	CLASSIFICATION AND RECLASSIFICATION	185
9.11	INTEGRATED PROCESSING OF GEOMETRY AND ATTRIBUTES	186
9.11.1	Overlay	187
9.11.2	Buffer zones	192
9.11.3	Procedures in integrated data analyses	192
9.12	EXAMPLE OF THE PRACTICAL APPLICATION OF GIS ANALYTICAL FUNCTIONS: SUPERIMPOSING AND ASSIGNING PRIORITIES TO NATURAL RESOURCE DATA	195
9.12.1	Statement of the problem	195
9.12.2	Procedure	195
9.13	NETWORK AND RASTER CONNECTIVITY OPERATIONS	199
9.13.1	Network operations	200
9.13.2	Connectivity operations on raster data	202
9.14	CONTIGUITY OPERATIONS AND INTERPOLATION	203
9.15	GIS ANALYTIC MODELS	205
9.15.1	Cartographic algebra	205
9.15.2	Expert systems	206
9.15.3	Linear combination	207
9.16	DIGITAL TERRAIN MODELS	207
9.17	FUNCTIONS FOR «ENGINEERING GIS»	212

## 10. CARTOGRAPHIC COMMUNICATION

**215**

10.1	THEORETICAL FOUNDATION	215
10.1.1	Cartographic parameters	215
10.2	SELECTING MAP SYMBOLS	218
10.3	THE POTENTIALS AND LIMITATIONS OF GIS IN CARTOGRAPHIC COMMUNICATIONS	220

11.1	INTRODUCTION	223
11.1.1	Background of the centuries	223
11.1.2	Bridging the gap	224
11.2	THE ORGANISATIONAL EVOLUTION OF A MAJOR GIS IMPLEMENTATION	226
11.2.1	Development of a business concept and identification of goals	227
11.2.2	Appraisal of current tasks, users, data and data flow	227
11.2.3	Review of the experience of others with GIS	229
11.2.4	Financial evaluations: cost – benefit analyses	230
11.2.5	Developing a strategic plan	236
11.2.6	Developing a logical data model	245
11.3	IMPLEMENTING A MAJOR GIS FACILITY: SYSTEM DEVELOPMENT	246
11.3.1	Design requirements	247
11.3.2	Pilot project	248
11.3.3	Pilot project outcome and the decision to change technologies	249
11.3.4	Evaluating and choosing systems	249
11.3.5	Database design	254
11.3.6	Creating a database	257
11.3.7	System operation and maintenance	257
11.3.8	Evaluating new applications	257
11.4	GIS AS AN ANCILLARY	258
11.5	CREATING NATIONAL GEOGRAPHIC DATABASE AND DEVELOPING NEW BUSINESS SECTORS	259
11.5.1	Principles of evolving strategies	259
11.5.2	Market analysis: first user study	260
11.5.3	Defining offerings	261
11.5.4	Cost model	261
11.5.5	Market analysis: second user study	262
11.5.6	Delineating strategies	264
11.5.7	Example of a strategy for national map services	265

**12. GIS IN DEVELOPING COUNTRIES**

12.1	PRESENT SITUATION AND THE NEED FOR GIS	267
12.2	STRATEGIES FOR INITIATING GIS IN DEVELOPING COUNTRIES	270
12.2.1	Ranking	270
12.2.2	Choice of technology	271
12.2.3	Building capabilities	272
12.2.4	Organising and coordinating	273
12.2.5	Financing GIS in developing countries	275

## **13. ELECTRONIC CHART DISPLAY AND INFORMATION SYSTEM (ECDIS)**

**277**

13.1	INTRODUCTION	277
13.2	ECDIS BASICS	277
13.3	ELECTRONIC NAUTICAL CHARTS	280
13.4	OUTLOOK FOR ECDIS	283

## **14. GIS FACILITIES: EIGHT EXAMPLES**

**285**

14.1	OVERVIEW	285
14.2	CITIES	285
14.2.1	Oslo, Norway	286
14.2.2	Edmonton, Canada	288
14.2.3	Burnaby, Canada	290
14.3	ELECTRICITY SUPPLY: DETROIT EDISON, USA	292
14.4	ENGINEERING APPLICATIONS: STOCKHOLM CENTRAL STATION	293
14.5	NATIONAL AND REGIONAL PLANNING	295
14.5.1	National Physical Planning Agency of the Netherlands	295
14.5.2	Geodatasenteret A.S., Norway	297
14.6	GLOBAL RESOURCE INFORMATION DATABASE (GRID)	298

## **References**

**303**

## **Index**

**315**

## **Advertisements**

**321**