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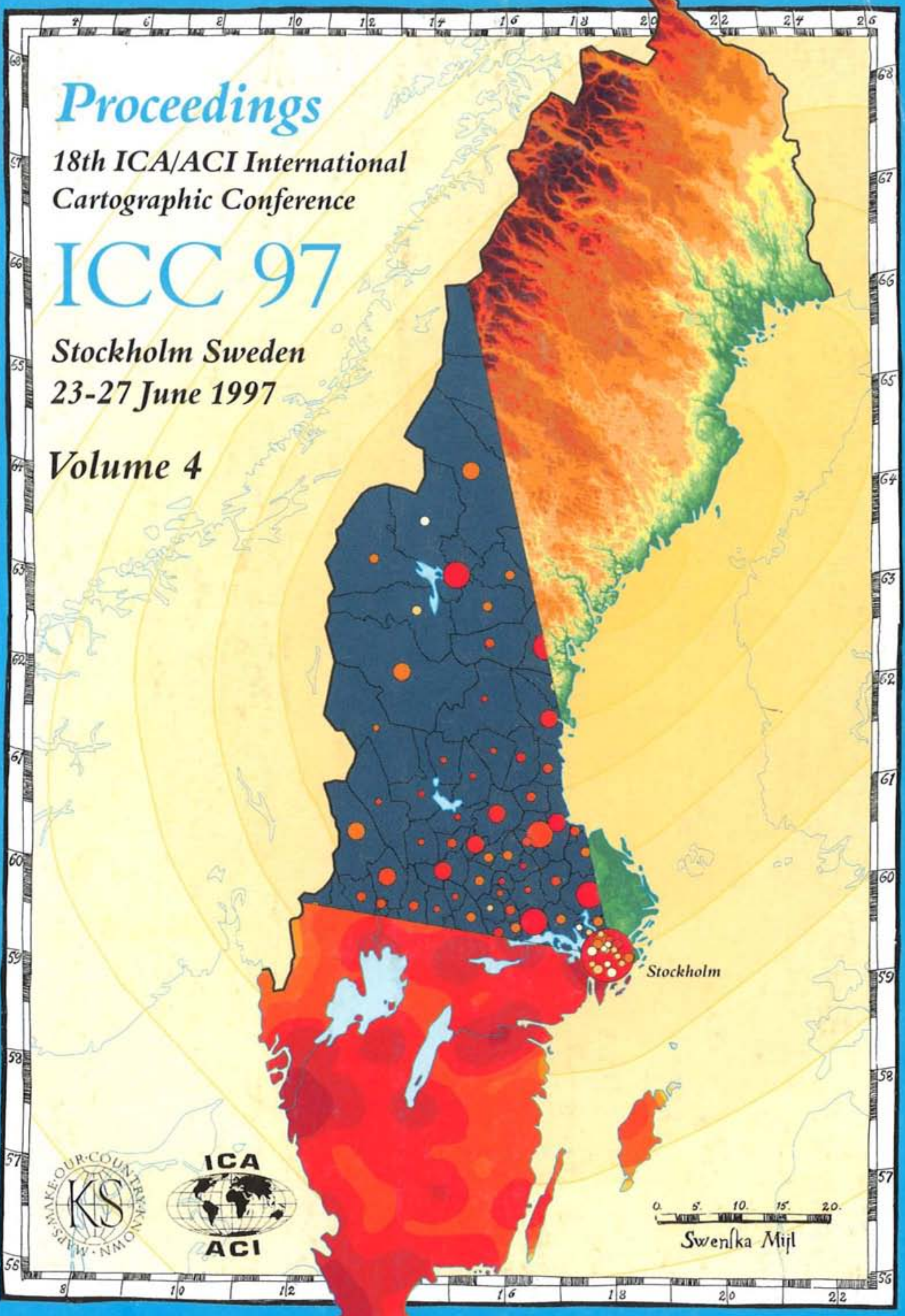
Volume 4



18th ICA/ACI
International Cartographic Conference
Stockholm, Sweden 23 - 27 June 1997

Swedish Cartographic Society

ICC 97

PROCEEDINGS

Volume 4

of the

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Lars Ottoson

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PREFACE

The Call for Papers for the 18th ICA/ACI International Cartographic Conference, ICC 97, was met with a very good response. Thus, almost five hundred proposals for presentations to the Conference were submitted to the Scientific Programme Committee for review. The Organisers decided to include 144 oral presentations divided into 24 sessions in the programme as well as a special lunch session for oral presentations of papers prepared by seven ICA/ACI travel awardees. Moreover 8 poster sessions each including presentations of some 25 papers complete the scientific conference programme.

The review of submitted papers has been carried out by members of the Scientific Programme Committee. Committee members also helped organising the oral and poster sessions. I gratefully acknowledge the help rendered by the following members of the Committee: *Wolter Arnberg, Ulla Ehrensvärd, Curt Fredén, Margareta Ihse, Liqui Meng, Ulf Sandgren, Mats Söderberg, Kennert Torlegård* and *Anders Östman*. Grateful acknowledgement is also due to *Alan McEachren, Andrew Tatham* and *Bengt Rystedt* for assisting in paper review.

Special thanks are extended to all authors contributing to the Scientific Programme of ICC 97. Due to the large amount of papers it has been necessary to divide the Proceedings into four volumes. The papers presented in the Proceedings offer a comprehensive review on contemporary cartographic research and development. The Proceedings will hopefully promote discussion and contribute to progress of cartography.

Finally, the Scientific Programme Committee would like to extend a sincere acknowledgement to the Chairpersons of the Plenary Sessions for accepting this important task for the realisation of the 18th International Cartographic Conference.

Lars Ottoson
Chairman Scientific Programme Committee

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METHODS OF COMPOSITION OF THE MAP (SCALE 1:5000000) ON ENVIRONMENTAL SITUATION IN RUSSIA

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The sharp deterioration of environmental situation in Russia as a whole and in its particular regions has caused catastrophic and critical environment situation. in different areas. Further industrial development of such areas could lead to irreversible environmental changes and turn out to be an ecological catastrophe with morbidity increase, life expectancy decrease and genetical changes.

All this has recently caused the necessity to draw a small-scale map reflecting the whole range of environmental situations in Russia. Such map is necessary for the purpose of Russian mineral raw material base development.

In All-Russian Research Institute of Mineral Resource Economics and Natural Resource Use (VIEMS) the map of ecological situation of the mineral raw material base development in Russia (scale 1:5000000) was made.

For ranging the territory of Russia all environment-describing parameters were assembled in 6 blocks and for each blocks the working maps (scale 1:5000000) were made. All maps have been input into the computer system ARC Info. Then integral maps for each block were drawn and the resulting map of the Russian environment situation has been made on their base. Data processing and formation of the integral maps have been made by the index system using the indices of significance.

Block 1 - Mineral raw material base map of Russia.

In this block there were used:

- the map of the basins with different types of Russian mineral resources,
- 96 general deposits with indication of their main mineral resource, the size of deposit and rate of its development,
- the map of all mining operations, dressing plants, mining-and-metallurgical and mining-and-chemical plants,

- hydro-, heat and nuclear stations and oil and gas pipelines.

The data from this block allow to observe the general plan of the mineral raw material bases development: the distance from deposits to processing enterprises, availability of sources of electric power, distance to existing gas and oil pipelines, etc.

Block 2 - The map of natural factors.

From the number of geological, geographical and climatic factors the main ones, that can affect deposits development and exploration were chosen and the following maps were drawn:

- the map of permafrost,
- the map of avalanche and mudflow areas,
- the map of seismicity,
- the map on intensity of exogenous factors manifestation,
- the map of geological-geomorphological stability of landscape against mechanical damages of the earth surface.

As a result, three following zones were distinguished: zones with either favourable, or relatively favourable, or unfavourable natural situation for exploration and development of mineral raw material base.

Block 3 - The map of unique and valuable natural resources and objects.

Much attention has been recently paid to conservation of natural wealth of Russia. On this map there were indicated:

- current and designed reservation parks,
- cities protective zones, unique lake systems,
- location of blacksoil and iceland moss pastures, forest of the first group,
- rivers with valuable fish, areas of extincted flora and fauna,
- inhabitation of small in numbers people of North and availability of zones for their priority nature use.

Zones with various rate of environment costs depending on availability of one (1-2) or several (more than 2) unique objects can be seen properly on this map.

Block 4 - The hydrogeological map.

On the map there were shown modules of operational resources of underground waters (variated and supposed). And for the areas, on which the data are not available, sites that are prospective for searches of underground waters were allocated. Areas with various mineralization of water and age of main water horizons were designated too. Moreover, the model of hydrogeological certificate of the deposits was elaborated. It includes the data of water-supply terms for mining enterprises, hydrogeological terms of deposit development and the influence of the deposit development upon underground waters resources.

Block 5 - The map of environmental anthropogene changes.

On the map of contamination there were shown:

- the ground damages from various kinds of human activity,
- pollution of soil and rivers, areas of soil and forests degradation etc.
- cities with the gravest pollution of the air.

On the integral map there were distinguished 4 zones:

1. Zone of satisfactory environment situation with small changes,
2. Zone of tense situation with significant changes,
3. Zone of critical situation with grave changes,
4. Zone with the gravest changes of the environmental situation.

This map was made for the certain moment, although general sources of contamination are constant as a rule.

Block 6 - The social - economic map.

For purposes of exploration and development of mineral raw material base the following factors were taken into account:

- the density of population and natural increase of population,
- cancer morbidity (as parameter of unfavourable consequences of life conditions),
- water supply for population,
- the number of the unemployed (as the factor of destabilisation in society and top zone for development of mineral raw material base and removal of social strain).

The data in block 6 are ranged only according to subjects of federation. For each parameter computer maps in format A-4 were made. On the integral map all subjects of Russia were divided into 4 groups: with either favourable or relatively favourable, or relatively unfavourable and unfavourable social-economical conditions for mineral raw material base exploration and development.

On the final map the main parameters from all working maps were shown:

- border of basins of various types of mineral resources,
- south border of the permafrost,
- zones with significant avalanche and mudflow hazard,
- seismic zones with magnitude more than 7,
- area of blacksoil, iceland moss pasture and forests of the first group,
- zone for priority nature use by of the small-in-numbers people of North,
- locations of mechanical damages and pollution of ground surfaces,
- cities with high pollution of air,

- current and designed reservation parks,
- unique lake systems.

The final map was drawn using the original method considering the value of separate parameters. As a result, four main zones for Russian mineral raw material base were recognised.

1. Territories, where the exploration is prohibited by the law.

This category include reservation parks, cities protective zones, zone of lake Baykal, the areas of the unique lake system etc. Now in Russia there are 84 reservation parks, including 16 biosphere reservation parks, totalling 28400 km^2, this is 1.6% of the Russian territory. In the Russian ecological program it is supposed to increase the number of the reservation parks by 75 , and their area by 44520 km^2 by 2000 and that would be 2.61% of the Russian territory.

2. Territories, that are adverse for development of mineral raw material base of and exploration.

These areas are characterised by difficult natural situation, numerous unique and valuable natural objects, crisis and disaster environmental situation.

3. Territories, that are relatively favourable for development of mineral raw material base and exploration.

They are characterised by relatively simple natural conditions, individual unique and valuable objects, insufficient water supply, intense and critical environmental situation. The level of the nature protection expenditures will be lower than the previous one.

4. Territories with favourable conditions for development of mineral raw material base and exploration.

These territories are characterised by simple natural situation, absence of unique and valuable objects, sufficient water supply and either normal, or satisfactory state of geological environment.

The data base for 96 deposits was made, considering all current parameters and for each deposit all maps (working and final) were collected.

The data base includes 35 indexes. The structure of data base permit to input new deposits, change any indexes, look through the maps with any given deposit.

Digitising and drawing of electronic maps were made in the laboratory of Prof. E. Cherimisina in the VNIIGeosistem Institute.

Thus, the map of Russian environmental situation allowed to carry out the division of the territory by the rate of favourable for development of mineral raw material base. In general, for any point of the Russian territory we have all ecological characteristics of the environmental situation and ecological-economical indices which allow to identify the whole complex of ecological problems that are necessary to decide while developing specific Russian areas.

INTEGRATED STRUCTURE TO SUPPORT MULTIMEDIA FUNCTIONS IN A GEOGRAPHIC INFORMATION SYSTEM (GIS)

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ABSTRACT

Two types of information, namely spatial and non-spatial information, exist in a conventional Geographic Information System (GIS). Besides the standard non-spatial information, one can consider another sets of non-spatial information. *Picture*, *voice*, *text*, and *animated sequence* (or *videos*) can be new part of information within a GIS.

Despite existence of tools in some GIS environments to utilize this kind of information, there is no certain policy to perform multimedia functions. The integrated structures for handling different multimedia file format in unique files by use of attribute handling in the database file in a GIS are presented in this paper. The variety of structures is also modeled and suggested depending on the application needs in the context of a GIS.

1 Introduction

As computer edge into more and more aspects of everyday life, they take on new roles. We consider these roles: computer as a music player, as a narrator, as a presentation tool, as an educational tool, and as a research assistant. Of course, the main role of GIS in the context of this paper is a platform for running a GIS application.

Multimedia plays a part in each of these roles because it combines two familiar communication media, sound and sight, in a single environment and gives the control over producing and delivering sound and visual effects.

1.1 Needs to Audio-visual Information

The fact that maps are the best tools for showing form and nature of an area is quite acceptable among people who deals terrain and events on it. They can perceive a lot of facts about an area by simply looking at a map. However, it is not possible to keep all details of an area on a map. There is of course a certain level of abstraction to model the real world. Scale, purpose of mapping, and nature of area define this level. Digital maps, and furthermore, GISes also make an abstract of the real world and bring the realities into the some degree of abstraction.

Audio-visual information helps us to understand more about locations and events taking place at a certain place. This type of information does not necessarily accompany every location on a map, but exists when the conventional types of information can not describe a feature well enough. For example, we can present a building by a rectangular shape on a 2D map. By linking to a database, we would be able to relate that shape to some attributes. However, we are not able to depict the condition of that building by simple alphanumeric data. A picture can give better information about appearance, conditions, and other type of qualitative information about that building. A national-wide map can demonstrate topography and thematic data of a country, but are not capable of playing a folk music or showing a typical landscape of different areas of that country.

1.2 Role of Multimedia in a GIS

As stated in examples in 1.1, graphic and attribute data are not solely capable of presenting all aspects of features. Besides, some characteristics of features may not be described by numeric values or textual expressions. Although, in some cases, texts like legal documents for land parcels are not possible to be placed in database. They need to be retrieved in GIS applications. The other applications of multimedia in GIS might be:

- Displaying floor plan and aspects of buildings
- Playing sound file containing oral description about a feature, an area, or a region for educational purposes (geographic explanation of a province for school children)
- Showing pictures belonging to features, places, landscapes, historic monuments, etc.
- Playing a video about an event taken place at a location, or how to approach to that location (in rescue operations)
- Presenting files including textual information about features

2 Multimedia Functions

There are several ways to use multimedia means. We can play all of the many multimedia functions available. Included are animations, text readers, slides, voices, texts, and more. We are also able to record simple messages, tunes, or videos and embed them in dataset we create in GIS applications. We can move beyond the simple applications to a multimedia authoring application and create multimedia presentations and applications.

2.1 Embeding Sound, Video and Pictures in Applications

One of the promises of multimedia is that one can integrate pieces from different applications into a unified presentation. In its simplest form, a multimedia presentation may consist of a file that embedded sound, video, or pictures.

Sound, video, and picture can be embedded in to a file by using of three methods in Windows environment:

- Starting from a player, a recorder, or a presentation software and copy the media sequence, sound or picture to the Clipboard, then switching to the target application and pasting the object into the target document. This is the simplest method resulting an icon being placed in the document. Double-clicking the icon starts the associated program and automatically plays the media sequence, sound or picture.
- Starting from target application, selecting that application's Insert Object command, and selecting a media clip, sound object, or picture to insert. This starts the associated program. After setting up a media sequence, sound or picture and selecting update command or existing the program, the document will be updated.

- Using the Object Packager accessory to package a media object together with the related application and embedding the object as an icon in the target document.

To embed sound, video, and picture in a file, all the applications involved must support object linking and embedding, or OLE. The application in which we want to embed a sound or video object must be an OLE client.

3 integrated Structures for Multimedia

3.1 Integrated Structures Versus Linked Files

Embedding multimedia files in a document, as stated as previous section, involves a lot of applications and/or individual files. Since each multimedia file is associated to a specific application, A scattered collection of applications might be used in a document due to run the appropriate sound, video, or picture (figure 1).

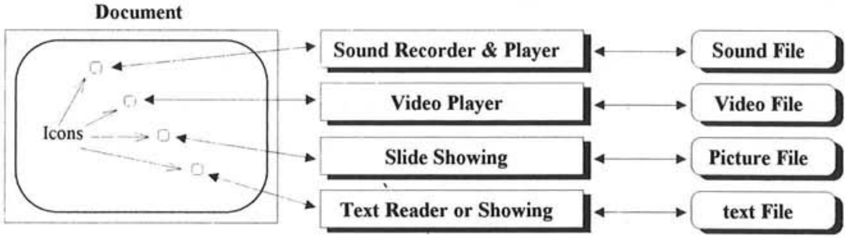

Figure 1. Conventional approach to embed multimedia file

Each application is run individually and apart from the others. Multimedia files are also not related to each other. They may be placed in different locations on computer file system. In general, this method does not give central control over all applications and files.

Instead of unrelated applications, we may have an integrated structure to make connection between features on a document (a map) with associated multimedia files. In this method there is only one associated application for integrated multimedia parts (figure 2).

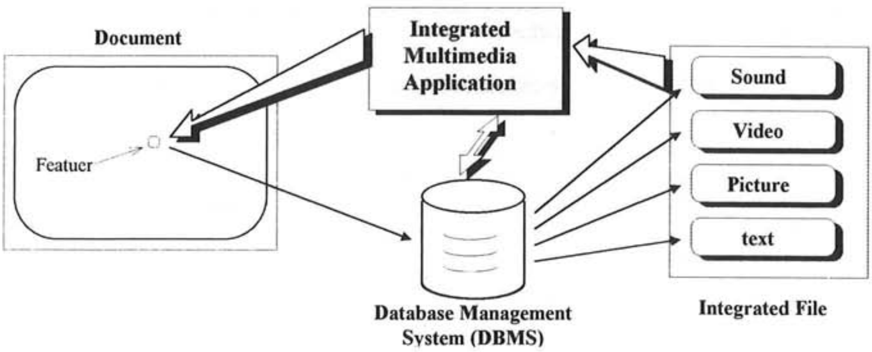

Figure 2. Multimedia Integrated Structure Schema

The advantages of this model are:

- Integrating several multimedia files in a unique files to have better management an access
- Use of single application to play different multimedia parts
- Central control over multimedia parts (video, picture, sound, and text) through a database management system (DBMS)
- Possibility of querying about associated multimedia parts because of using DBMS
- Handling different integrated files in a unique schema

3.2 Different Structures for Different Applications

Three types of structures are presented with the model. In the first structure, multimedia parts are placed sequentially and may be played or showed from a menu optionally (figure 3.a). The second structure includes a video plus a sound (in mixed) that played simultaneously (figure 3.b). In this case multimedia parts are run immediately without any option. Groups of related sound, picture, and text are integrated in the third structure (figure 3.c). Each group is run individually in such a way that picture is shown first, then text is opened on another window, and finally related sound is played. As long as sound is played, the related picture and sound remain on the screen. This procedure is repeated until the End_of_Group is encountered.

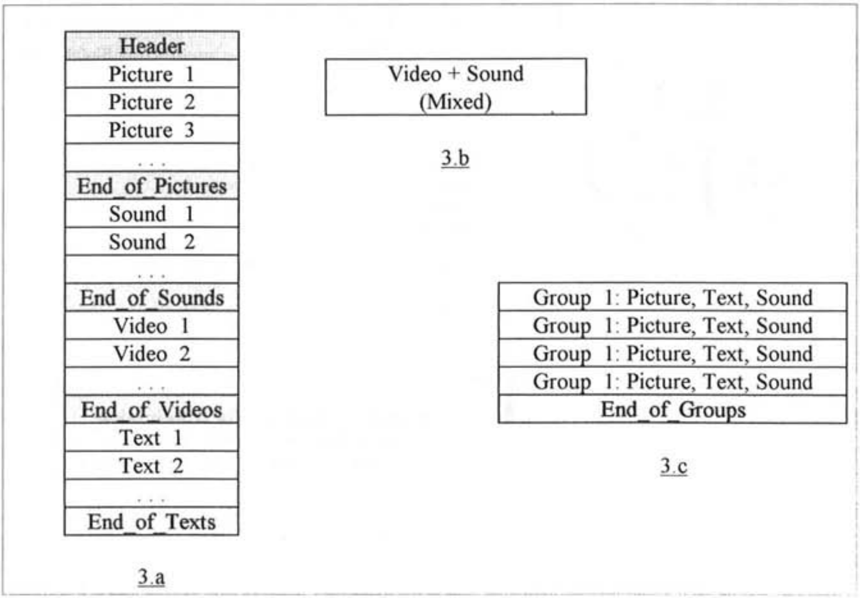

Figure 3. Three types of multimedia file structure

3.2.1 File Integrator Program

In order to make benefit of integrated structures, we have to integrated different multimedia files into the appropriate file structure. These files then become parts of the structures and can be retrieved and updated later.

A program has to be developed for this purpose, capable of whether aggregating or disaggregating the multimedia parts. The program integrates the multimedia files according to the file structures described in 3.2 and is able to separate the parts to individual files for changing or editing.

3.3 Handling Different Structures in a Unique Database-oriented Schema

Handling different structures in a unique schema is made by using a DBMS to maintain type of structures and location of integrated file and passing these two attributes to *Integrated Multimedia Application (IMA)* as arguments (figure 4).

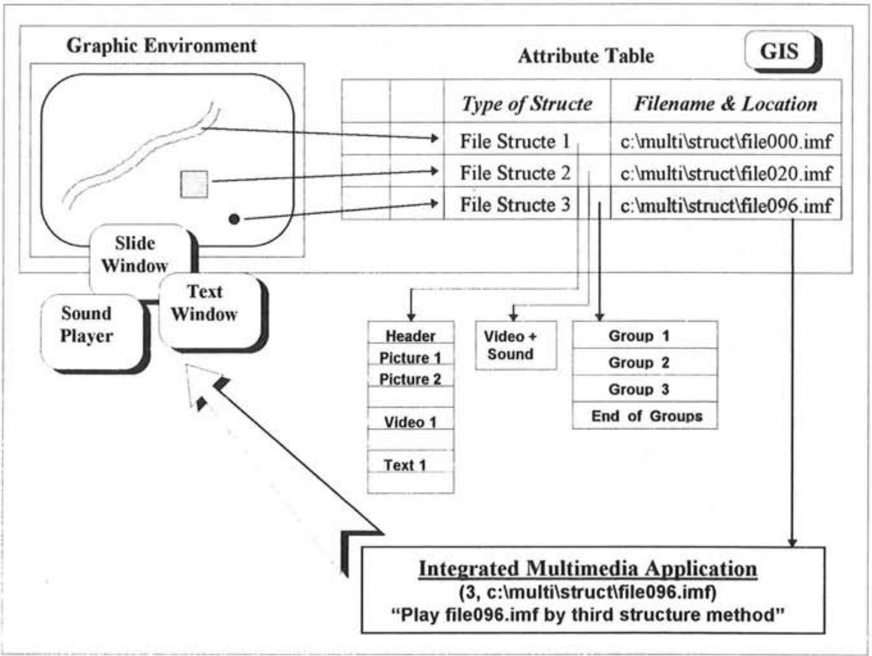

Figure 4. Handling different structure

In the first instance, user selects a feature through the specific icon of playing multimedia. Then the corresponding record in the database is retrieved and gives type of structure defined and location of integrated multimedia file of that feature. These two fields are passed to IMA. IMA treats them as arguments, and runs the internal procedures according to the structure type and user input. Obviously, a graphic user interface is responsible for handling user input through option lists, data entry fields, radio buttons, check boxes, etc.

4 Conclusions

Multimedia information can be the exciting part of a geographical information system. This type of information gives better explanations and descriptions about features on the Earth. Locations and events occurring on the locations may be explained or demonstrate better by means of audio-visual information.

Operating systems, such as Windows™ 3.1, Windows NT™, and Windows 95™, offer good tools and functions for multimedia. Several programs may be used in a application to utilize multimedia functions. However, in a GIS application, using dispersed programs and utilities to obtain these functions is not without difficulty. Running different multimedia files needs associating different applications.

In order to maintain efficiency in or GIS applications, we may integrate multimedia file in the unified structures. We are also associate all multimedia file structures to a unique application. Therefore, the unique application plays all type of multimedia parts according to the structure of the file.

Relation between multimedia files and features inside a GIS is estabilised upon a DBMS instead of icon placed in the graphic environment. The DBMS supports query and searching facility for a specific theme within the database files.

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CHALLENGES IN THE PRODUCTION OF THE NATIONAL ATLAS OF IRAN

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Abstract

These days mapping, multimedia systems or computer animation are applied to the representation of spatial information in many domains, such as regional planing, environmental impact assessments and in the field of public works. Maps are one of the appropriate tools to transfer spatial data. Consequently, atlases which comprise of a collection of maps, diagrams, pictures, texts and recently sounds and movies perform and depict much more information than a single sheet of map.

Mapping in the Islamic Republic of Iran is widely used for planning and decision making, and is considered as a basic tool for socio-economic development. In 1991, the National Cartographic Center (NCC) which is the organization in charge of all civilian mapping activities became officially responsible for the production of the national atlas. The project was initially divided into two phases: to publish a general atlas which contains different themes in one volume, and to produce several atlases with specific themes for each.

In this paper, the characteristics and the considerations in design and implementation of the National Atlas of Iran are described. Also, the efforts in the transition from conventional to digital atlas production will be discussed, and at the end, the approaches for creating a multimedia atlas will be explained.

Introduction

A map is a generalized model of the real world. Nowadays, the complexity of new life and the increasing rate of spatial data gathering necessitates the rapid depiction of information in order to be utilized by those generalized models. Hence, increasing amount of information has led to increasing number of maps.

Like many countries, today several ministries and organizations in Iran are involved in continuous gathering of spatial data on all their related activities. But gathering all those up-to-date data is of little use if they cannot be communicated readily and efficiently to users. The fact that, in many cases, atlases can be more useful than a single sheet of map has made it a very powerful medium for planning. This fact has brought the Iranian government to produce the national atlas and to make use of information driven from it.

The real steps to start the project of publishing a complementary national atlas was taken in 1991. The National Atlas of Iran like all national atlases is a combination of different themes. It is the first atlas of the country in its history at the national level. The main task and purpose of elaboration of the national atlas of Iran is to show cartographically the changes made so far, present condition, as well as changing tendencies in the Iranian living conditions.

Backgrounds

Despite the need for the production of a comprehensive atlas in Iran, no organization had become responsible for this important task. Some ministries, several governmental organizations and many private companies had proposed to start the national atlas project.

The production of some atlases (not at national level) had been carried out in different times and with different themes. At times, the responsibility had been given to governmental organizations, and occasionally to private cartographic companies with rather ephemeral mandates. Some of the examples are as follows:

- Climatology atlas (produced by the University of Tehran)

- Historical atlas (produced by the University of Tehran)

- Culture atlas of Tehran (produced by the Culture and Art Society)

- Hydrology atlas (produced by Ministry of Energy)

- Agricultural atlas (produced by National Cartographic Center)

- Health atlas (produced by National Cartographic Center)

Design Considerations

At the beginning of the project, cartography experts and specialists were of fundamental necessities. There were not enough cartographers with rather high level of cartographic studies in NCC. Therefore, some surveying engineers were selected to be sent abroad in order to become more familiar with modern cartographic techniques.

Meanwhile, the study of the content of the atlas began. The project was initially divided into two phases. The purpose of the first phase was to produce a general volume comprising different themes. Another objective of this phase was to get familiar with the atlas production line and the problems associated with it. A small division with predefined aims was established in cartography department of NCC. In this division, a committee was founded and named "Atlas Committee" and the actual work started in 1992.

The first step in design phase was the consideration of the size and layout of each page. Considering the area of the whole country and sizes of different scale maps, it was decided to utilize 1:6,500,000 scale map of the whole territory in one page. Therefore, according to this scale, the size of each page of atlas was determined. If a larger scale was chosen, the size of the atlas would be too big and not so convenient for users. If a smaller scale was selected, the information would become too generalized.

The preparation of the base maps were the next step. If the largest scale had been prepared, production of the base map had to be carried out from the larger existing base maps. The administrative boundaries were not available precisely until that time. A group became officially responsible to gather all information or maps from the Ministry of Interior which was the most reliable source. The administrative boundaries were extracted from 1:250,000 scale maps and generalized to 1:6,500,000 scale. The international boundaries were generalized from existing 1:1,000,000 scale map. All of the information was combined and finally a base of 1:6,500,000 which comprises of precisely all boundaries was produced. From this base map, smaller scale bases were produced for the pages in which more than a single sheet had to be arranged. Two bases for scale 1:10,00,000 and 1:13,000,000 were derived by applying generalization methods.

The design of the content of the general volume was another important issue which was in progress parallel to the technical efforts for producing the bases. The whole volume was divided into four chapters. Each chapter comprises of related topics and themes. After determination of the general theme of each chapter, another group became responsible for gathering thematic information from the regarding ministries and organizations. This activity was too time consuming because of the coordination that was needed with related ministries for obtaining the data or information in advance. Also, unreliability of some sources caused the atlas committee to process and compare all information with other sources. Therefore, all thematic data had to be processed and purified.

The next step was cartographic processing. Design of the method of depicting all those thematic information had to be approached very carefully. Most of this step was accomplished by the cartographers who stayed in the country and did not go abroad. Meanwhile, the specialists who had studied new cartographic techniques came back and were involved in the project. They applied those fundamental cartographic design considerations in the rest of the General National Atlas. Finally this volume became ready for reproduction and printing.

The General National Atlas of Iran consists of the following chapters:

- Political maps: (includes 6 maps)

- Natural maps (includes 66 maps and 16 diagrams)

- Population maps (includes 32 maps and 3 diagrams)

- Economical maps (includes 36 maps and 10 diagrams)

The specific-purpose national atlases

After completion of the General Atlas, the atlas committee decided to publish national atlases in more details and in different volumes. So, the most important themes such as population, health, energy, geology, transportation, etc. were determined. This decision was made in 1994 and the second phase began with the goal of producing twenty volumes. The working groups were made active, and in each group, a person became responsible for acquiring data from related organizations. The problems in this respect was much more serious because these atlases needed more information and had to be more accurate compared to the first phase. Unfortunately, like the first experience, the data gathered from different ministries or organizations was not fully reliable and in some cases additional information was obtained for the same subject but from other sources. Therefore, like the first volume, the data gathering process was carried out by inquiry of the most reliable sources and analysis of such data..

The first specific-purpose volume was the population atlas. In this atlas, all topics relating to the Iranian population structure were discussed. Many photographs were selected, and many diagrams were designed to depict the changing tendencies in the Iranian population.

The atlas project was supposed to be equipped with modern technology for the production of the second phase, but due to some limitations, the transition from conventional to digital method took place at the end of production of the first specific-purpose volume. So, in population atlas, most of the cartographic drawing and reproduction steps was accomplished by the conventional methods. Beginning with the second specific-purpose volume which deals with the theme "Health", all of the design and drawings were done by computers. All of the personnel were trained in order to be able to utilize the software that they needed to apply. Statistical data was analyzed by computerized methods and some software and computer programs were developed by the atlas project personnel. For example, classification of the statistical data, the limitations of some using software, were all tackled by the above mentioned specialists. Image setters and scanners were also utilized for the reproduction processes.

The other specific-purpose volumes which their productions followed by the first volume were: health, energy, geology, agriculture and gardening atlases. The other specific-purpose atlases are expected to be produced by the year 2000.

Multimedia Iranian Atlas

Electronic maps support the interactive integration of time-based data, allowing dynamic visualization of spatio-temporal information by animation and sounds. Electronic mapping systems help to bring the cartographic visualization process better with the map user's contemporary perception habits. Multimedia atlases provide a variety of analogue and digital forms of data such as maps, graphs, animated films, texts, sounds and satellite images.

In Iran, multimedia atlases which is the state-of-art technology is also another task of the atlas project. It has been decided to create a multimedia atlas which possesses only the data which was used for population, health, energy, and geology atlases as a pilot project. The scenario of the multimedia atlas has been made. Two approaches to provide information have been considered: location and theme.

To implement the location approach, a map of the country in which every province has become sensitive was produced. When the user points to a specific province, a map of that province at a larger scale is displayed and some general information of that province will be offered by sounds and pictures. Then, different names of considered themes will be displayed on the screen. If the user clicks on a theme, information in hierarchy form of that certain theme will be displayed graphically. Also sound and pictures will be shown. Alternatively, a user may first selects a general theme and hierarchically proceed to a detailed subject. Then the sequence of graphics will be carried out.

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VENUS SYSTEMATIC CARTOGRAPHY AND GEOLOGIC MAPPING

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Abstract

Systematic 1:5M scale mapping of Venus using radar images acquired by the Magellan mission provides the basis for global geologic and thematic mapping. All of the Magellan data are now available on CD ROMs. Recently, a complete set of full resolution digital mosaics on CD ROM has been created by the U. S. Geological Survey. All of these digital products meet rigid cartographic standards. They are fully documented and can be viewed in any map projection. These cartographic data sets provide the synoptic and local base maps that support continuing research into the global history of the planet. Various mapping efforts are revealing a complex history of techtonism and volcanism. Ideas about Venus have evolved and changed as more work is done with the Magellan data.

Geophysical models based on the global topography and gravity data continue to provide new insights into the processes that have shaped Venus. NASA has initiated a program of systematic geologic quadrangle mapping to providing a basis for discussion of global stratigraphy concepts and to establish details of regional geology that will allow global correlation of geologic units. Detailed mapping will help answer the basic questions about timig and the stratigraphy of voolcanic and tectonic resurfacing that has affected the most recent geologic era of Venus. This paper will cover the status of the systematic mapping of Venus and the cartographic work that supports the efforts.

DEVELOPMENT OF THE TACTILE PRODUCING SYSTEM USING DIGITAL GEOGRAPHIC DATA

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Abstract

The Geographical Survey Institute (GSI) made a study about a tactile map for four years from 1993 and developed the tactile map producing system for visual handicapped persons using the latest personal computer technology and the digital geographic data (vector type data) . This is a report of the study and development of the tactile map producing system.

1 Introduction

It is said that there are about 420,000 visual handicapped persons in Japan. Tactile map is a tool which is used when visual handicapped persons try to get geographical information. At present, tactile maps of small area, for instance, a guide map around some stations, an event meeting place map, etc are made by hand occasionally by social welfare organizations, volunteer groups, and so on.

However, visual handicapped persons cannot use a tactile map in daily life because there are many problems, such as making methodof a map, map quantity, making time, making cost, the inconsistency of the map symbol, and others.

Therefore, GSI made a study in order to achieve next two points using the newest computer technology from 1993.

(1) To develop a system which can make and provide a tactile map including respective geographic information for each visual handicapped person easily by the operation of sighted persons after

solving the problems mentioned above.

(2) To develop a system in which visible handicapped persons can receive geographic information services same as sighted persons after designing map symbols easy to recognize by the sense of touch.

2 Outline of the system

The system which was developed by this study is consisted of a personal computer, peripheral equipment, the software for a tactile map making, and the stereo copying system. In this system, a map will be output from an ordinary printer using various digital geographic data, and then the image will be copied onto the special paper using the stereo copying system. Finally, the image on the special paper will be swelled by the developing machine.

The concrete way of working is as follows.(Figure 1)

(1) Selecting mapping area and the map scale

(2) Editing

  a. Deciding the expression way of the map symbol(Figure 2)

  b. Selecting symbols to be shown

  c. Changing map symbols to tactile map symbols

  d. Editing roads, rivers and others

  e. Input of necessary geographic data(Figure 3)

  f. Input of the title and the explanation

(3) Output of a map by an ordinary printer(Figure 4,5)

(4) Sterol Copying System

  a. Copying the image of the output map onto the special paper

  b. Swelling the image on the special paper by the developing machine (Figure 6)

In this system, sighted persons hear the request about the information of visual handicapped persons, and make the output map. About most of the operation, they use only a mouse. It is possible to edit a tactile map considering the situation of each visual handicapped person.

3 Contents of the study

The contents of the study are as follows.

(1) An investigation of needs of visual handicapped persons

We sent out questionnaires to the 70 blind school (total 1,352 persons).

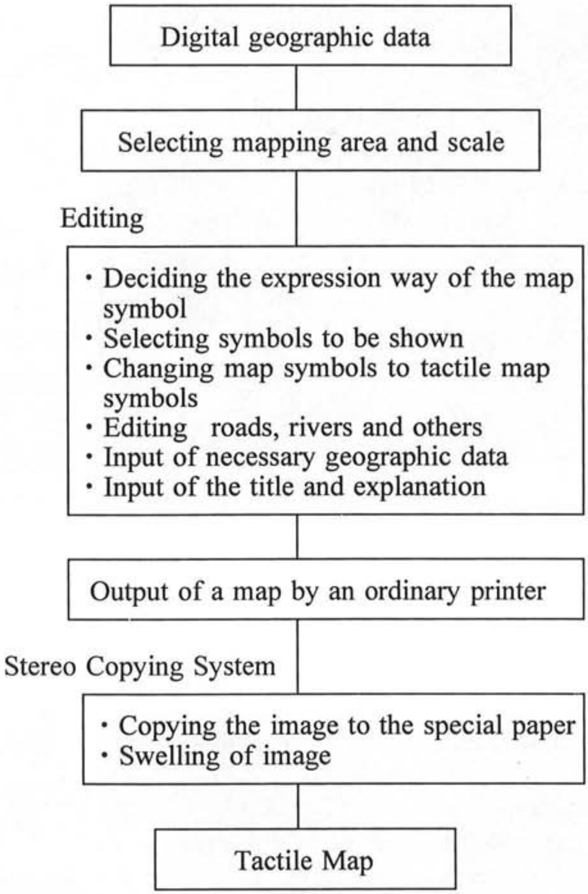

Figure 1 Flow of a tactile map making

Examples of the questions are as follows.

a. what map the visual handicapped persons are looking for

b. what map expression could be understood by them

c. how tactile map symbols should be designed

Based on the result, we made a basic design of the system.

(2) Development of the tactile map producing system

We developed the software which has the function that an output map can be easily made. It can select some information and show it on a display flexibly by the request of visual handicapped persons.

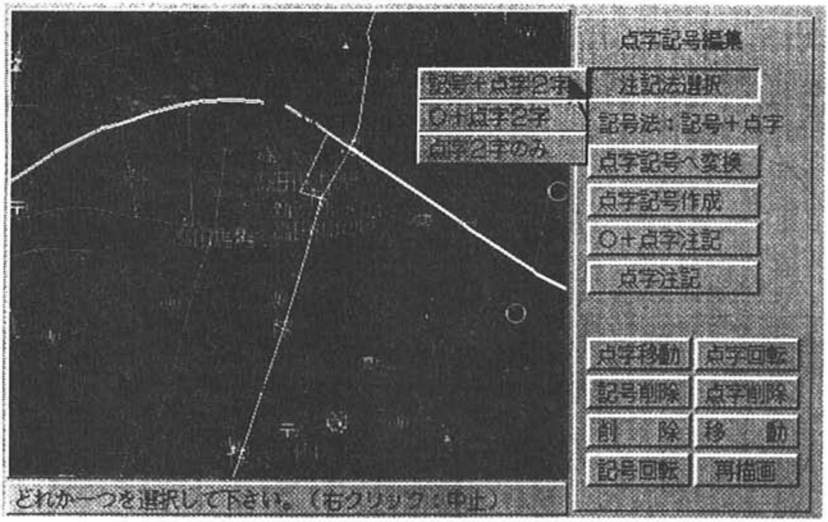

Figure 2　Display screen of the software (The un-editorial time)

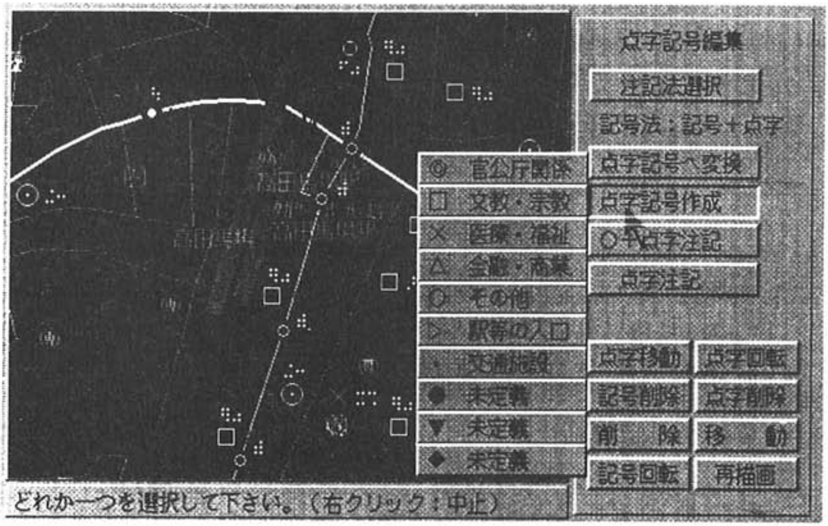

Figure 3　The menu which adds new data

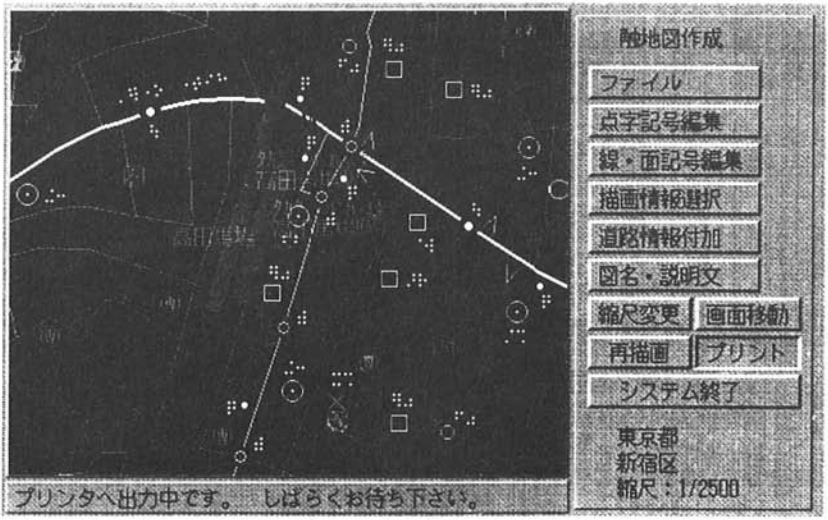

Figure 4　Display screen after editing

Finally, we built the total system by adding the stereo copying system. We can make a tactile map in very short time using this system.

(3) Designing of tactile map symbols

In order to design and to make tactile map symbols for the system, well-informed persons were called and the cart examination committee was established. They examined about the theme from various view points.(Figure 7)

Based on the result, map regulations, about 40 map symbols, and others were created.

(4) Trial use of the software

For the user, not only useful functions of the software but also easy operation in the editorial work are important. Therefore, we sent the tactile map making software and digital geographic data to some groups that have similar hardware with us. They checked the software and the data, and gave us some advices.

4 Result of the study

The results which were got by this study are as follows.

(1) By using digital geographic data, necessary information for visual handicapped persons will be shown on a display in any area where

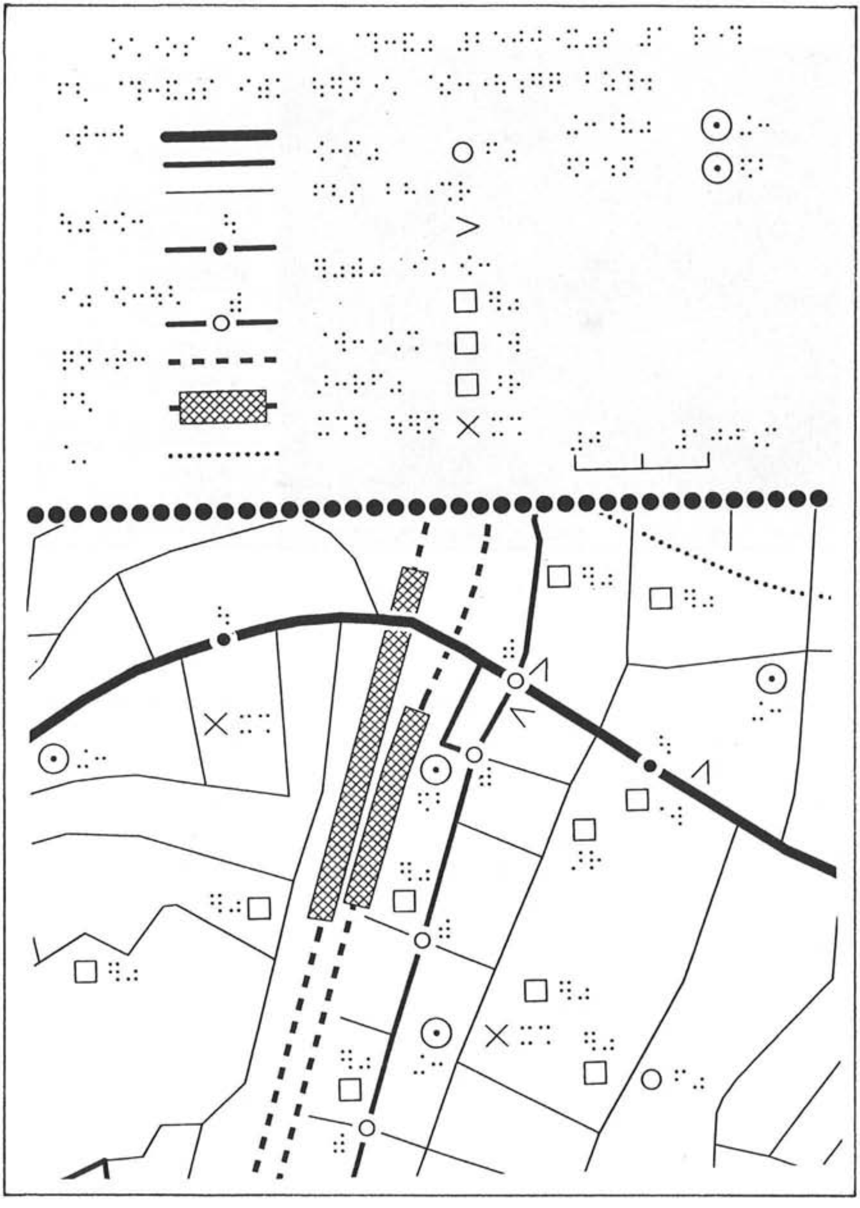

Figure 5 The output map by an ordinary printer "Takadanobaba" station and it's surroundings scale 1:3,000

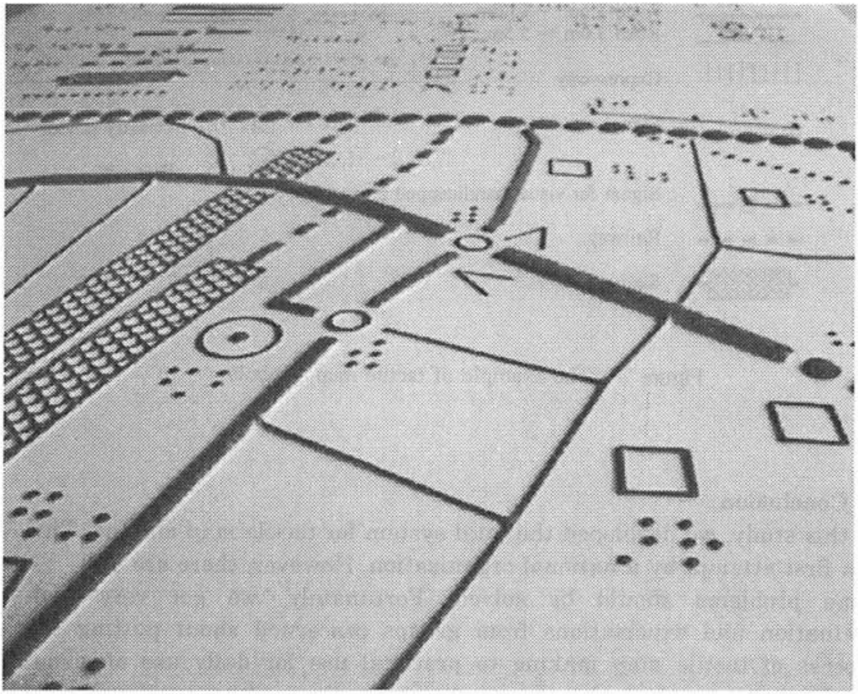

Figure 6 The tactile map

the data are prepared at any scale at the respective requests of them. So an original tactile map can be made easily.

(2) Tactile map symbols are newly designed in order to be recognized by the same standard in any area.

(3) The information which is not prepared as the digital geographic data at the moment can be added and be edited.

(4) The total time from making an output map to a final product is only about 15 minutes using the stereo copying system.

(5) Since the data of an output map is stored in electronic media such as FD, it is easy to revise and renew a map.

(6) Compared with a conventional tactile map, it is no need to prepare some places for the original model of a tactile map, a final result and others.

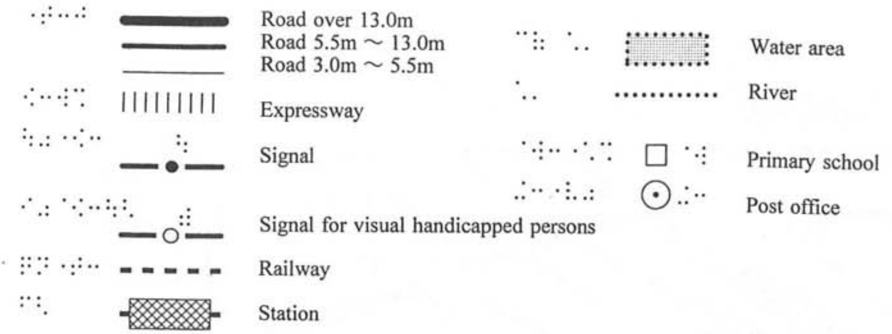

Figure 7 The example of tactile map symbols

5 Conclusion

In this study, we developed the total system for tactile map making. This is a first attempt by a national organization. However, there are still some problems should be solved. Fortunately, we got very high evaluation and expectations from groups concerned about putting the process of tactile map making to practical use for daily use of visual handicapped persons. Also, many visual handicapped persons evaluated our system very highly.

As mentioned above, there are a lot of problems. Next, the best example will be introduced.

For visual handicapped persons, "a map as a tool" is much more important than sighted persons need. And, information that is provided to visual handicapped persons should be new and accurate. But the system

we developped this time doesnot satisfy these points. In order to solve this problem, a social mechanism that can provide the map information which is possessed by the society to the visual handicapped persons should be made. If this plan is realized, the life of them seems to be mainly improved with this system and a lot of other ways.

Such a problem still remains, but the sysytem is almost completed now. Finally, we are going to provide the software and the map data to users.

INTEGRATION BETWEEN GIS AND GROUNDWATER MODELS TO FORECAST AGRICOLTURAL WATER POLLUTION

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Introduction

The management of the environment is more and more oriented to the analysis of complex phoenomena caused by the interaction of different parameters.
The use of Geographical Information Systems allows the user to handle a considerable number of georeferenced data, coming from different sources and presenting various typologies (numeric, vector, raster). On the other hand, statistical and simulation models are useful for the interpretation of the phoenomena and for the forecast of their trend.
Spatial analysis in relation with modeling is becoming a core objective, which requires the extension of GIS features and new sophisticated visualisation techniques.
At the present, the integration between models and GIS is meanly concerned with the input data preparation and the display of model output data on the territory.

ISMAP, an EUREKA project relevant to the monitoring and forecast of agricoltural water pollution, has given the opportunity to develop a series of tools for a major integration among mathematical models, statistical tools and GIS .
Groundwater models require a lot of georeferenced input data. The GIS allows the user to select the area of interest, to acquire automatically all the required data (interpolating them if necessary), to execute the models and to visualize their output on the territory in the same software environment.
Moreover a series of data are prepared directly using the GIS features (for example, the concentration maps of the nitrates, coming from agricoltural practices, are generated from the land use).

Finally, a series of functionalities allows the user to verify if there is a correlation between different parameters (for example, rain and water quality).
In this paper, after a short description of the problems relevant to the integration between GIS and models, two examples are presented.

Integration between GIS and models

The main function of numeric applications relevant to hydrologic problems is to support the correct planning of the politic management of the system resources. In fact, an effective system simulation allows to theoretically evaluate the effects of different management approaches in order to choose the better one.

The capability to select meaningful data, to integrate different data types and to get a fast production of processed maps makes the GIS a suitable tool to be integrated with simulation models which require several georeferenced input data and produce results to be mapped on the territory.

At the present the GIS are overall used in this integration process as a tool for the input data preparation and for the visualisation of the results on a cartographic map.
In these cases input data preparation mainly uses the GIS spatial analysis functionalities like, for example, the intersection function among several maps in order to generate new data from existing ones.
On the other hand, output visualisation consists in the display on the territory of contour lines relevant to the spatial trend of the specific investigated phoenomena, for example the pollutant concentration.

New trends force to a major integration between GIS and models expecially as far as is concerned with the programs devoted to input data preparation (preprocessors).

In fact, the numeric codes, which are used for the simulation of air and water pollution, are usually based on finite elements or finite difference method, which require the domain subdivision in elements organized according to a specific topology. The use of preprocessors, expecially graphic and connected to a mesh generator, reduces the input data preparation time and allows to verify the data correctness.
The next step is to acquire the information necessary to the model from a geographical data base by means of the user selection on the map.
This has been developed in the ISMAP project, connecting two different numeric codes (QUAL2E from EPA and ITACA from CISE) to a GIS.
A more detailed description of this activity will be presented in the following paragraph.

Another integration can be done between GIS and statistic models.
The necessity to get tools for the interpolation and correlation of georeferenced data is becoming more and more urgent. Some GIS contain standard interpolation functions, which are not always sufficient to be applied to some problem, which can require non standard methods (i.e. kriging).
ISMAP has been supplied with a user friendly interface for the processing of complex interpolation algorithms in order to study data relevant to meteorology and water

withdrawing and quality. Figure 1 represents an example of interpolation method selection from the GIS.

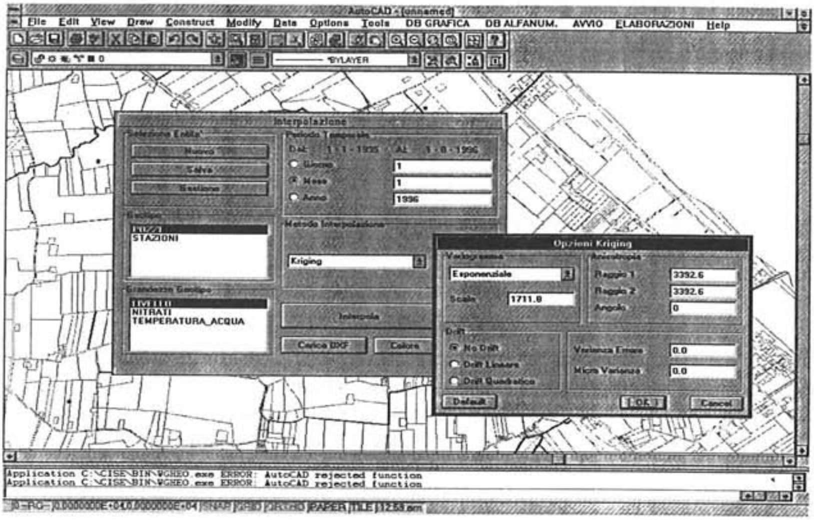

Fig. 1 Example of interpolation method selection from the GIS.

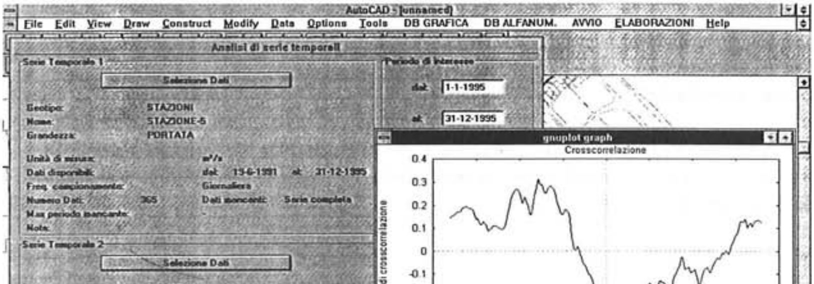

Fig. 2 Visualisation of the crosscorrelation coefficient trend between dissolved oxygen and discharge.

Other interesting phoenomena to be investigated in a GIS are the time correlations between different parameters (for example, rain and water quality). Different algorithms have been implemented in ISMAP for the cross-correlation and the spectral analysis of parameters in order to find possible recurrences of an event. In the example of Fig. 2, the crosscorrelation coefficient trend between dissolved oxygen and discharge is visualized.

GIS and water quality models integration: two examples

Integration between GIS and a groundwater model (ITACA)

General description

ITACA is a 2D/3D finite elements model (developed at CISE) for the simulation of groundwater flow and transport and diffusion of pollutants in heterogeneous anisotropic porous media. It can simulate transport processes of either reactive single-species or reactive multispecies-multicomponents. In the first case the phenomena of adsorption, biodegradation and decay can be simulated.

In the second case the following equilibrium chemical processes can be considered:

- absorption/desorption
- ion exchange
- aqueous complexation
- precipitation/dissolution
- oxidation/reduction.

ITACA has been integrated with chemical U.S.-EPA module MINTEQA2 and with its database, where chemical parameters of more than 100 chemical components, 1000 species and 500 minerals are stored.

Integration with GIS

The main aim of integrating ITACA with GIS can be summarized in the following two points:

1) get the numerical model input data from GIS;
2) display the results of calculations on GIS.

The input data needed by ITACA can be so splitted:

- physical and geometrical characterization (domain geometry and hydraulics parameters values in the area of interest);
- definition of boundary conditions for either the flow problem (effective rain, irrigation, flow rates through pumping wells, etc.) and the transport problem (fertilizer or fungicide spreading).

The domain definition is carried on inside the GIS interface, by contouring with mouse the considered area. This region is divided into finite elements by means of a Delaunay triangulation (Fig. 3); a set of hydraulics parameters (as porosity, conducibility, storativity, dispersivity, etc.) is then associated to each finite element, depending on its barycentre position.

Once the simulation period is defined, ISMAP extract from the GIS database the time evolution of surface infiltration (deriving from rain and irrigation), of water withdrawing and of pollutant load spread on the ground surface.
On the domain boundary ISMAP assumes for the flow problem the default condition of given piezometric head. ITACA calculates the boundary values of the piezometric head by spatially interpolating the data retrieved by ISMAP from the GIS database.
The default condition for the transport problem on the border is an open boundary condition.

All input data supplied by ISMAP can be either directly used to run a simulation or revisioned (and if necessary modified) by preprocessors.
This kind of approach seems to be a good compromise between an easy use of the system and its ability in managing also complex situation. On one site, infact, an user with no experience is anyway able to execute a simulation and to visualize the results; on the other an expert user still keeps the total control upon all the input parameters.

<u>Data exchange between GIS and the stream water quality model (QUAL2E)</u>

Water quality of rivers is simulated using the QUAL2E model. QUAL2E is distributed by U.S. E.P.A.; it can simulate up to 15 water quality constituents and is applicable to dendritic streams that are well mixed. It uses a finite-difference solution of the advective-dispersive mass transport and reaction equations.

Information fluxes between GIS and the water quality model (QUAL2E) can be classified in two categories: model data requirements and graphical and/or geographical representation of model results.

The first phase of data input selection is the definition of the domain of interest, i.e. the delimitation of the river network where simulation of water quality shall be performed. The user must select river reaches of interest so that a tree structure is formed, with one or more input points (where a river channel begins and water enters the network) and one

Fig. 3 Mesh visualisation on the territory.

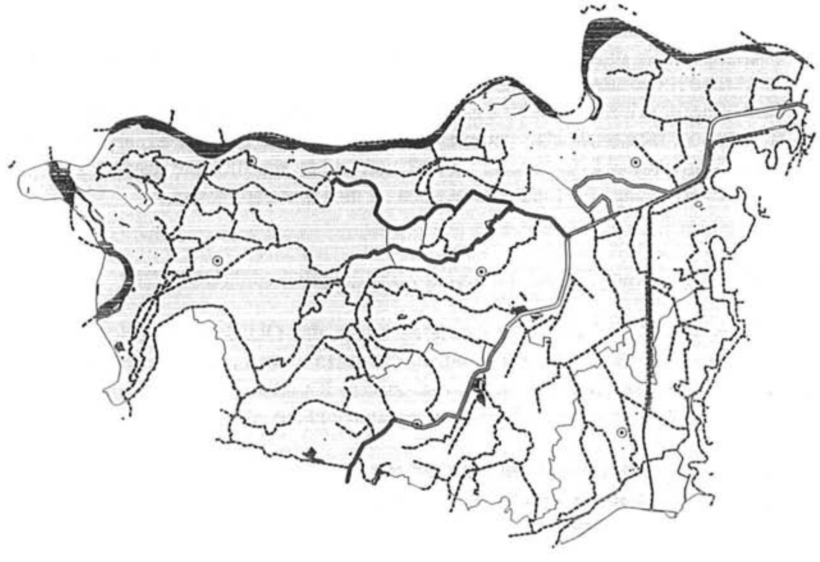

Fig. 4 Example of QUAL2E output on the territory: the dissolved oxygen in the river network is represented with different grey levels.

final point (the most downstream point of the network). Then the system performs several tasks:

1) translates the topographical description of the selected river network in QUAL2E format, identifying headwaters, junctions and reaches;
2) selects, from the geographical database, the hydraulic description of every reach (channel geometry and roughness coefficient or relationships of hydraulic geometry);
3) recognises point sources and withdrawals in the network;
4) selects from the geographical database discharges and water quality of input elements (headwaters, point sources and withdrawals);
5) recognises non-point sources, i.e. identifies the watershed of every reach and possibly computes runoff by means of meteorological data, land use and an agronomic model;
6) selects, from the database, model coefficients (reaction rates, and so on), according to the variables selected by the user;
7) produces the input file for QUAL2E from all collected information.

In this process the user introduces only limited information, related to the general definition of the simulation. Nevertheless he can intervene to modify the usual way of operation (for instance dividing a reach into two) at every step. When the phase of input file building is completed, QUAL2E code is excecuted.

At the end of QUAL2E run, the output file is read into the system and several graphical representations of simulation results are available. The user can select a path in the river network, going from upstream to downstream, and obtain the profile of all simulated variables along the path, both in tabular and graphical form. The plot can be completed with simultaneous visualization of different variables and experimental values and regulatory limits, when available.

Simulation results can be also represented in the geographical map. The user select one simulated variable and the system visualizes the river network by means of cells coloured according to the value of the variable (Fig.4). This option can be applied also to experimental values (by means of an interpolation procedure) to represent the actual water quality state and can be used also before model execution. In fact it can be useful in the model definition, for instance in selecting the river reaches to be included in the simulation.

Conclusions

ISMAP system presents different interesting aspects for the management of water resources. The possibility to take advantage of an integrated system where models, interpolation and correlation functions, GIS and database are available to the user makes easier the environmental data processing in order to analyse complex scenarios. Moreover, the system has been tailored on different user skills, providing automatic information processing but, on the other hand, leaving degrees of freedom.

The system has been installed in different local government in order to support the administrator in decision making.

great extent a literature research, starting from the roots of public participation approach before the "information age". The term spatial planning, as used in this paper, deserves some clarification. It is here used as a generic term for all the planning activities in which the three dimensional geographic space plays an essential role. It obviously includes city planning, master planning, design of buildings (to some extent), planning related to road construction, and planning of transportation (to some extent). The focus in this paper is clearly in urban scale.

2. Public-participation methodology before the information age

It can be discovered from the literature that there was considerable interest in public participation methodology during the time period of about ten years, starting late sixties. Many books were written (e.g.. Burke, 1979; Sanoff, 1978), research was reported in professional journals, one of the most originals being written by Arnstein (1969), and seminars where held (see e.g.. Sewell and Coppock, 1977). The reason for this interest seems to be on *demand,* as identified by Sewell and Coppock (1977:1):

> Planning in the 1970s faces a critical challenge: how to accommodate a mounting demand for a greater degree of public participation. It emerged initially in connections with problems relating to cities, such as urban renewal, the location of noxious facilities and the development of transport networks. Recently it has become even more widespread, embracing such matters as poverty, education and the protection of the environment. While this challenge is not new, it has become increasingly intense in the past decade and is experienced in the United Kingdom, North America and elsewhere.

The book by Burke (1979) has been able to tie together many of the views related to a participatory approach, when applied in urban planning. In the summary part of the chapter on the citizen participation characteristics in planning the following is stated:

> Planning is axiomatically participatory. Historically, however, the base of participation in public planning has changed from a small informal elite to a formal broad base of constituents. The aims of citizen participation have also changed. Citizens now can serve three functions in planning. One is to serve as a constituency of support for the planning agency and its activities. The second is to serve as a means of wisdom and knowledge in the development of a plan and in identifying the mission of the planning agency. The third and emerging function is to act as a watchdog over one's own as well as others' rights in the design and delivery of policies.
>
> There are five roles citizens can play in planning: review and comment, consultation, advisory, shared decision-making and controlled decision making (Burke, 1979:74). Citizens can be enacting more than one of these roles in an organization.
>
> The emergence of a citizen role in planning, as well as the increasing specialized planning agencies, has changed the decision-making base of community planning for purely a public interest orientation to a private interest orientation. Planning agencies function on behalf of a substantive issue and defined constituency.

Many techniques where developed for public participation (Sewell and Coppock, 1977:3), including public opinion polls and other surveys, referenda, the ballot box, public hearings, advocacy planning, letters to editors or public officials, representations of pressure groups, protests and demonstrations, court actions, public meetings, workshops or seminars, and task forces. The obvious fact that each technique has advantages and disadvantages was also recognized.

The descriptive dimensions of public involvement mechanism were analyses by Vindasius (1974), according to Sewell and Coppock (1977:3-5), Table 1. For the purposes of this paper, it is interesting to study the table more in detail. How is the role of mass media going to be changed if/when a community-wide information network is also considered to be a mass media? We can also ask whether we could/should increase degree of two-way communication and level of public activity required also in other areas of public involvement now when the technology for this is available in an ever increasing degree.

Table 1. Descriptive dimensions of public involvement mechanism (Vindasius, 1974).

Type of public involvement mechanism	Descriptive dimensions				
	Focus in scope	Focus in specifity	Degree of two-way communication	Level of public activity required	Agency staff time requirements
Informal local contacts	·	●	●	•	•
Mass media (newspapers, radio and TV)	●	·	·	·	·
Publications	●	•	·	·	•
Surveys, questionnnaires	•	●	·	•	•
Workshop	·	●	●	●	●
Advisory committees	·	●	●	●	●
Public hearings	•	·	·	●	•
Public meetings	•	·	•	•	•
Public inquiry	●	·	·	•	•
Special task forces	·	●	●	●	●
Gaming simulation	·	●	●	●	●
Legend: · low • medium ● high					

The factors affecting the flow of information in an environmental decision-making process have been analyzed in a thorough way by Ingram and Ullery (1977:126-138). Especially the discussion on the character of *communication networks* (1977:127-128) is so lucid for this study that is quoted in the following:

> Any decision-making system has a network of communication channels that services it with information. Channels of communication are the various means by which information is delivered: telephone calls, letters, public hearings, meetings, reports. The channel which is chosen may be more or less suited to procedural or substantive communication. The need to gather information for agenda items which are regarded as experimental may be satisfied through relatively formal channels, such as research reports and public hearings. Procedural channels tend to be easily established and easily ignored. Terminal decisions require the additional kinds of information that are easily transmitted in less formal face-to-face communication. The type of channel utilized in terminal decisions must facilitate feedback. That is, an immediate response is communicated for each transfer of information. Deutch (1966) has argued that the communication network in which feedback occurs sets in motion a learning process which in turn modifies subsequent behavior.
>
> With the introduction of a new item to the agenda decision-makers have a choice of which new channels of information to open. Channels vary in the time, effort and skill required for their use. The participation of new public interest groups is likely to occur initially through low-cost channels because there is a reluctance to invest scarce resources towards uncertain results. Agencies will be tentative in developing channels which may carry information difficult

to digest. They are likely to rely as much as possible on existing channels to gather the required information.

Taken together, communication channels form a network of linkages among participants which traces patters of influence. The structure of patterns is closely related to the degree of a decision-maker's receptivity to new information. In general, when the points in the network are dispersed and decision-making is decentralized and non-hierarchical, there will be greater receptivity to new information. While the dispersion of administrative units and information channels may encourage the capacity of agencies by small clientele groups at the expense of public responsiveness, it can also enliven discussion within an agency and can link authority with knowledge. In a centralized system subordinates who possess a depth of knowledge in a particular area often find themselves overruled by superiors who lack the necessary information. Thus centralization may aggravate the gap between information and power (Rourke, 1969).

3 Computing network as a participatory medium

As widely observed, we are moving toward an era in which WWW-like network is a full fledged media, accessible and used like radio, television, and print today. Schuler writes (1994:41), quoting Grundner (1991), that computing network in a "forth media". "It's not radio, it's not a television, it's not print, but it has characteristics of all three. The main distinction is that community networks are *interactive*. People can interact with one another and with the issue of the day". According to Schuler, community networks promote participation in the following ways:

- *Community-based.* Since the systems are community-based, the participants have aspirations, needs, and issues in common. The system promotes participation because everyone has a stake.
- *Reciprocal.* Any potential "consumer of information", commentary, issues, or questions is a potential producer as well. ...
- *Contribution-based.* Forums - both moderated and unmoderated - are based on contributions from participants. Any input to the forum becomes part of the forum itself - a record which can be printed, distributed further, or acted on.
- *Unrestricted.* Anyone can use the community network. Furthermore, users have freedom from control on their postings,...
- *Accessible and inexpensive.* The systems are readily accessible from a variety of public as well as private locations. Furthermore, the systems are free of charge or have a very low charge.
- *Modifiable.* Since software is the substrate, community networks are (at least potentially) modifiable in several ways. Users can actually design or codesign new user interfaces or services. The openness of the internet substrate, for example, has promoted the development of numerous wide-area information servers such as Gopher, WAIS, WWW, while encouraging ongoing evolution.

We can here conclude that in many respects computing networks, due to their nature, are a nearly exact match with the needs for an interactive media as expressed in previous section.

3. Enabling information technologies for public-participation GIS

Public-participation GIS is a challenging field because there seems to be a need to use a wide spectrum of computer technology, and at the same time to make this technology easily accessible. In this section we briefly review the branches that are considered to be most relevant for the study, to get a broader perspective for further development.

Graphical user-interface. Graphical user-interface based on the use of multiple windows, mouse, and direct manipulation of objects is one of the first innovations that has paved the way for a personal computer to become acceptable and accessible. The first Apple Macintosh computers 1983 made this approach widely known and recognized. It is noticeable, that the *desktop metaphor* was used from the very beginning. Later the study of metaphors in the user-interface design for GIS has gained interest (Kuhn and Frank, 1992; Lindholm and Sarjakoski, 1994).

CAD. Computer aided design is one of the first fields that has relied on the use of 3D computer graphics. Many techniques have been developed for *modeling* objects and for visualizing them using user-selected view-angles and lighting conditions. The techniques of *photorealistic rendering* have been developed to produce remarkable visualizations.

GIS. CAD-programs have been used from the very beginning for storing and maintaining map data in computer files and for producing cartographic outputs from them. This approach can be called *computer aided mapping and cartography.* Basically these data-files still represent *images* whereas in geographical information systems the geographical reality is represented in the form of a numeric-symbolic model that can be used as an input for various analytic tasks. These models do not have as such any visual appearance which rather has to be defined explicitly.

Virtual reality technology and 3D-GIS. Virtual reality technology began to emerge during the late eighties. Photorealistic rendering is the essential component but the goal has already originally been to create an illusion for a user that he/she would move in a real 3D space. Techniques like headsets with stereoscopic viewers and 6D movement tracking have been used. For manipulating virtual objects, devices like data gloves have been developed.

As pointed out by Faust (1995:262), "virtual reality is becoming an overused buzzword, but it is symptomatic of a society that has become dependent on information presented in three-dimensional format". He then defines the functions that would be necessary for a *truly interactive three-dimensional virtual reality GIS:*

1. Such a system would have to be a very realistic representation of the three-dimensional nature of real geographic areas.
2. A user would have to have free movement within and outside the selected geographic terrain.
3. A user should be able to perform all normal GIS functions (search, query, select, overlay, etc.) within the three-dimensional database and view the results from any vantage point.
4. Visibility functions such as line of sight, areas seen, obscuration, etc. should be natural functions integrated into the user interface of virtual GIS.

The interest towards 3D-GIS has been substantial already for a rather long time, from the applications' point of view (Kosonen and Makkonen, 1988) and concerning the theory (e.g. de Hoop et al., 1993). Truly 3D commercial GISs are not available yet. However, by combining software components from CAD and GIS we can tailor a system that satisfies all the criteria above except the GIS functions (3) applied in 3D.

Digital photogrammetry. With the computer technology of today, especially using their capability to store, process, and display digital images, it is possible to make advanced collection of 3D spatial data from digital images using non-specialized computer workstations. There has also been a growing interest towards low-cost solutions (Nolette et al., 1991) and end-user systems that can be used in GIS-environment with minimal training (Sarjakoski and Lammi, 1993). The possibility to superimpose graphics on the digital images makes such software powerful for checking the correctness of the 3D spatial database with respect to the photographed situation. And further, the same technology can be used for superimposing plans related to road and building design, and similar.

Hyper- and/or multimedia. This concept was widely popularized, although not invented, along the release of Apple Macintosh HyperCard in the mid 1980s. Hypermedia makes it possible to associate different peaces of information with links, reflection the important relations between a document. When applied to maps, these documents are sometimes called hypermaps (Laurini and Thompson, 1992). The original meaning of the concept multimedia was not so much oriented towards the organization of the document but its content. A multimedia presentation can thus include use of not computer-readable material, as in the early geography-related Domesday project (Rhind et al., 1988).

Electronic meeting systems (EMS) and groupware. These terms are used for systems used to support computerized exchange of information between people working in the same project. The EMS system has a client/server local area network (LAN) architecture with a file server collecting all data generated by participants (Faber, 1995:61). Typical activities supported by commercially available EMS's include: voting (yes/no, multiple choice, 10-point scale, etc.), issue prioritization, criteria evaluation, group writing, electronic brainstorming, project analysis, surveys and questionnaires. Lotus Notes is one of the commercial products that is widely used as a groupware in corporate environments. A computing network as such is often a satisfactory tool for groupwork. Newton et al. report (1994) how networking CAD is used in architecture, engineering, and construction.

Internet and WWW. Internet has set the foundation for open computer networks of today. The packet-switching data transmission and addressing protocols have established a standard that makes it possible to build local and international networks using a single standard. Internet based file-transfer, electronic mail, news groups and listservers have been used since the early 1980s. The specifications as well as the first implementations of server and browser software for the World Wide Web became about ten years later. The essential thing with the introduction of WWW-concept was that now for first time we had a non-proprietary protocol for Internet-based hypermedia application and also a uniform way to access the other Internet services like e-mail and ftp. When writing this paper we can observe that the extent and utilization of WWW has already exceeded the fictions by Nelson (1981) concerning a world-wide hypermedia system, called Xanadu by him.

4. Towards systems to support public participation in spatial planning

The interest towards systems supporting public participation in planning has evolved through several phases and so that emphasis in the works has varied between technological and methodological issues. Research in spatial decision-support systems (SDSS) has already a rather long tradition (see Densham, 1991). Works related to collaborative spatial decision-support systems (CSDSS) concentrated to overcome the limitations of single-user GIS (Armstrong, 1994). As pointed out by Couclelis and Monmonier (1995:92), CSDSS have their root in operations research (OR). The works by Faber et al. (1995) are a good example of an approach in which the architecture of a CSDSS is based on the integration of groupwork-tools and GIS-tools.

Once the technology for hypermedia was available, the interest to use it in the context of spatial planning rose immediately (see e.g. Wiggins and Shiffer, 1990; Fonseca et al., 1995; Raper and Livingstone, 1995). The work by Batty (1995) is among the first visioning the possibilities of WWW-technology for city planning and public participation.

Along the way for seeking a methodology for planning. Couclelis (1991:383) has introduced the concept *spatial understanding support system* (SUSS) that "may be thought as the open set of all potential conceptual and technical tools that may help planners, geographers, and any others with an interest in the space of human practices get a good grasp of what is really going on, and why". The concept was further elaborated by Couclelis and Monmonier (1995) where so called graphic scripts were proposed to be used for structuring the use of various computer based media.

The Public Participation GIS Workshop (July, 1996, see Schoeder, 1996) is a noticeable landmark in the research and development related to the use of GIS to support public participation. A special outcome was the attempt to define functional criteria for public participation GIS (PPGIS).

5. What is missing? 3D, to some extent

In this section we discuss more in detail the use of 3D visualization and digital photogrammetry in the communication of spatial information to non-professional users. The treatment is motivated by a hypothesis that 3D visualization might be one of the most natural ways for communication.

3D visualization. With the contemporary tools for computer graphics we can create more and more *photorealistic* visualizations, with the meaning that the created image looks like a photograph would have been taken. This photograph-like presentation has two important features. Firstly, it is an *subsymbolic* presentation that can be understood *intuitively* without any knowledge of cartography and map symbols. Secondly, because it is a central perspective view, all the structures being next to the viewing point, the observer, appear to be larger and more important. This is in a nice harmony with the Tobler's first "Law of Geography" stating that "Everything is related to everything else, but near things are more related than distant things" (1970:236). With walk/fly-trough animations we can even increase the feeling of reality. When using computer display, there seems to be a need to prefer "space-to-feel" presentations and to avoid complicated graphics, "maps-to-read" (see Bertin, 1983), as much as possible, Figure 1.

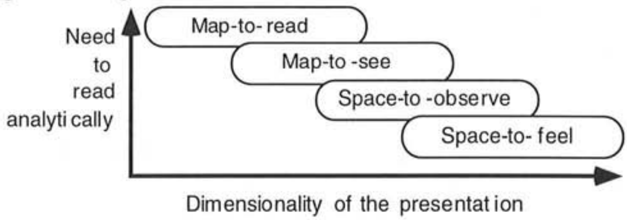

Figure1. The tendency to favor higher dimensional presentations (up to 4D) on a computer display in the visualization of physical environment.

3D digital photogrammetry. In this context we want to emphasize that digital images are a powerful tool for verifying that the visualized 3D model fits with reality. It can also be feasible for the participants to make simple 3D measurements using the images because it is "just click on the mouse".

6. Discussion and conclusions

At the beginning of the paper we discussed the issue how the public-participation approach grow from social and political demand, and the challenges it puts on communication channels. Then we reviewed the development on community-wide networks and found out that they are a nearly exact match to meet these challenges. The enabling technologies and recent research in PPGIS were also reviewed. It was further proposed that 3D modeling and photorealistic visualization and animation should be included in the system to support public participation approach for the sake of "space-to-feel" level experience of urban plans. 3D digital photogrammetry can be used for verifying that the maps and plans fit with the reality.

It is apparent that many technological aspects related the design and implementation of systems supporting public participation in spatial planning have been discussed already in earlier studies. At the same time the technological infrastructure is developing rapidly. Commercially available (geographic) information systems are becoming web-ready. When writing this article, many of the major vendors for GISs have already released tools for web-publishing and/or -accessing spatial data stored in their proprietary formats and databases. It has also been forecasted that the push technology will make a brake-trough within a couple of years (Berst and Hamilton, 1997:73). In contrast to current usage-patters of WWW and television, other media-types would become feasible, including customized newscasts, multimedia-rich web pages, simultaneous video and text, and interactive content.

The tendency seems to be that there is more and more enabling technology available for implementing public participation methodology. Computer and WWW literacy is also growing rapidly. It is apparent that the institutional issues are the hardest ones. How open are planning and decision processes going to be in future? What information is released to the publicity? How to achieve genuine communication between planners, decision makers and citizen? Are the citizens willing to participate? Although some experimental work has been carried in these areas, much more real-life pilot projects and empirical research is necessary.

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This paper is a part of a feasibility study. For that purpose the list of references below includes many entries that have not refereed in the text but which still are related with the topic. The reports of the NCGIA specialist meeting for initiatives 17, 18, 19 should be noted as good sources for further references. The PPGIS homepage offers a forum for participating the discussion (http://ncgia.spatial.maine.edu/ppgis/ppgishom.html).

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DEVELOPMENT OF STANDARDS FOR THE IRANIAN NATIONAL TOPOGRAPHIC DATABASE (INTDB) AT 1:25000 SCALE

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Abstract
The National Cartographic Center of Iran (NCC) is the main civil organization responsible for base mapping activities and supervision at the national level. The maps produced by NCC are used for different developmental projects in Iran. NCC was appointed responsible for base mapping at a scale of 1:25000 in 1988 and the Iranian National Geographic Information System (INGIS) in 1993. Recognizing the importance of a National GIS as a decision making, project management, and design tool, NCC made a fundamental decision to produce the stated maps in digital format as input to a National Topographic Database(NTDB). Following this decision, NCC's production line was upgraded and digital technology was implemented.
The existing conventional specifications were modified to support the digital production line, but due to the characteristics of digital maps and the databasing requirements necessary for development of a national spatial information system, these modifications were not sufficient. Therefore, the Standards Committee for Digital Spatial Data(SCDSD) was formed in 1994 with the objective of developing new standards which would cover the different aspects of digital mapping and spatial databasing.
This report first presents a background on the 1:25000 scale project and the necessity for development of a new standard. The mechanisms used for ensuring attention to user needs are stated and finally a technical overview of the standard's structure is presented.

Introduction and Background

The National Cartographic Center's (NCC) responsibilities encompass the establishment of geodetic and precise levelling networks, topographic and hydrographic base mapping, national atlas, thematic mapping and geographic information production. It is also responsible for supervision of major mapping activities in the country.
One of NCC's major projects is topographic mapping of Iran at a scale of 1:25000. Production of the series in analogue format began in 1990 and approximately 500 sheets had been produced by the end of 1992. Parallel to this, the Islamic Parliament of Iran included a program designated "Design of a National Geographic Information System (NGIS)" in the 1993-94 national budget and mandated NCC for its

execution.(The scale for the NTDB of the NGIS would be 1:25000). Recognizing the importance of digital spatial data for Iran's future information needs, NCC had been planning for a technology change from analogue to digital with emphasis on an in-house approach. Management had decided to change production technology without going through a stage of coexistence of both technologies in the organization. Therefore, the stage was set for the introduction of digital mapping and GIS. A technology implementation team was setup which was responsible for production line design and implementation, personnel training, system customization, supervision of equipment upgrading and start of production. Emphasis in the first phase was primarily on the data acquisition (photogrammetry) and cartography parts of the job (To the extent of producing cartographic maps in the CAD software). The GIS aspects were addressed in the next phase.
Production was stopped during the transition period. New specifications were written based on contents of NCC's specifications for 1:25000 analogue maps and software aspects were introduced. Digital production was started which allowed the interface between different stages to be worked out and operational problems to be solved. Design and implementation of the NTDB in the next stage required development of further specifications. This factor accompanied with short comings encountered during use of the above mentioned specifications were the main reasons for the development of a new standard.

Project Definition

Iran has a land area of approx. 1,684,000 Sq.Km. Its terrain is diverse, consisting of mountain ranges, plains and arid zones. In order to provide geographic information at a scale suitable for developmental, economical, social and cultural planning, the "1:25000 Base Map Program" was initiated. The objective of this program is production of digital topographic maps and a National Topographic Database at 1:25000 scale for Iran. National coverage requires approx. 10000 map sheets. In order to organize the job into logical sections, the country has been divided into 132 blocks, each block containing 96 sheets. (Blocks located on the national border have less than 96 sheets). Data acquisition is by photogrammetry using 1:40000 scale B & W aerial photography.

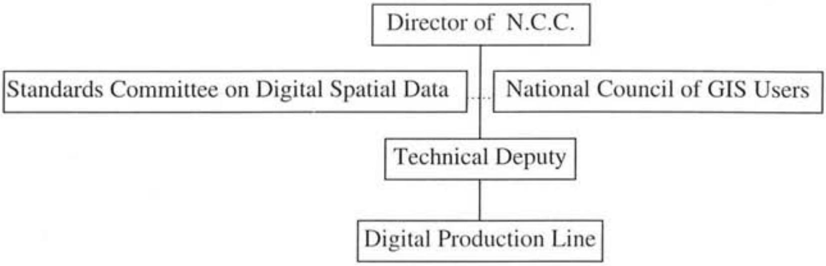
Necessity and Mechanism

As stated in the introduction, after the transition phase in which production technology was changed from analogue to digital, production was restarted using the new specifications that had been prepared. Certain difficulties were encountered in practice:
- Difficulties were encountered during data acquisition due to lack of a conceptual modelling approach for feature classification. There was uncertainty concerning some of the features that were not explicitly stated in the legend.
- Nonuniformity of specifications for a number of features at different stages of production.
- Lack of standards for different aspects of digital spatial data e.g. metadata files.

These difficulties reflected the necessity for development of a new and more complete set of standards. Prior to development of the standard itself, an administrative framework had to be formed in order to ensure that the standard would meet user needs. Experience that had been gained in production was also a valuable asset in developing this standard. NCC established the following bodies as the main parts of the framework:

- Standards Committee on Digital Spatial Data(SCDSD)
- National Council of GIS Users(NCGISU)
- NCC's Digital Production Line(DPL)

These bodies were related according to the organizational chart below.



<u>Standards Committee for Digital Spatial Data</u>
The Standards Committee consists of specialists in the fields of general data acquisition, data-basing, data processing and data presentation who are also involved in digital production. The Committee is responsible for research, development and updating of standards related to surveying, mapping and GIS.

<u>National Council of GIS Users</u>
The NCGISU consists of representatives of relevant ministers and organizations and is chaired by the Director of NCC. In brief, the Council is responsible for national GIS policy, setting the foundation of a NGIS, reflecting user needs and commenting on standards. Ministries and organizations being represented on the Council at the time of developing this standard are as follows:

- Plan and Budget Organization
- Iranian Statistics Center
- Ministry of Agriculture
- Ministry of Energy
- Ministry of Housing and Urban Planning
- Ministry of Industry
- Ministry of the Interior
- Ministry of Jihad-e-Sazandegi
- Ministry of Mines and Metals

- Ministry of Petroleum
- Ministry of Roads and Transportation

Digital Production Line

NCC's Digital Production Line is responsible for production according to approved standards. Difficulties and shortcomings encountered during production are reported as feedback to the SCDSD.

Mechanism for Development

SCDSD interacts with other bodies according to the stages stated below:

1. Project definition and determination of objectives and priorities
2. Gathering and archiving relevant information and documents
3. Studying the obtained documents
4. Preparation of drafts for the standard taking in consideration Iran's criteria
5. Discussion on drafts during SCDSD meetings
6. Submitting drafts and proposals to the NCGISU and departments involved in DPL for comments
7. Gathering, classifying and discussing comments that have been received. Further discussions are done either in the SCDSD or the NCGISU depending on the subject. Some members of the SCDSD participate in the NCGISU meetings.
8. Finalizing the standard
9. Officializing the standard through the Director of NCC

The above stated structure not only ensures attention to user needs but also introduces production experience into the Standard which increases its applicability.
Completion of the tasks, including the time required for receiving comments from the NCGISU, took 23 months. The amount of work done by the SCDSD during workgroup meetings is approx. 5000 man-hours.

Structure of the Standard

Normally, a standard will define the framework on which further specifications and work procedures will be based. This means that the standard is mapped into different software and production methods according to needs. SCDSD recognized this distinction, but also realized that a joint document would be required for production that would address both aspects. Therefore, the decision was made to develop a standard that was also mapped into NCC's chosen software. The software chosen was based on an evaluation project conducted by NCC specialists.

Contents of the Standard

In general, the standard consists of four volumes and an appendix which are organized as follows:

Volume One---General - Introduction and general information concerning the standard
- Objectives
- Reference system and datum
- Metadata

Volume Two---Data Acquisition(Photogrammetry)
- Feature list
- Feature specifications
- Symbols

Volume Three---National Topographic Database
- Feature list
- Feature specifications
- Attribute specifications
- Symbols

Volume Four---Cartography
- Feature list
- Feature specifications
- Symbols

Appendix
- Conceptual model
- Data accuracy
- Cartographic sheet layout
- Flow diagram for features at different stages of production

Volumes two, three and four consist of a set of forms; one for each feature at that stage. Each form supplies information concerning data characteristics and procedures.

1. References Systems and Datum

Information concerning the reference system ,projection system and the height datum being used for the 1/25000 program already existed but they were scattered throughout different reports and books. The objective of this section is to clearly supply important parameters and relevant information in a centralized form.
The reference system being used for the 1:25000 program is WGS-84. The projection system is UTM and orthometric heights are referred to mean sea level(MSL).

2. Metadata

The Committee distinguishes two types of metadata, "Internal Metadata" and "Metadata for Users". "Internal Metadata" refers to information which is important to a certain department in managing its data and workflow. e.g.: operator name, date of task completion, task duration, problems encountered, etc.
Due to diversity of this information and its dependence on each department's managerial aspects, this type of metadata is NOT addressed in the Standard. The second type, meaning, "Metadata for Users" has been addressed. This metadata consists of information which will allow users to identify the data and to determine its fitness for use for their application. In general, the content of the metadata standard consists of:
- Project Identification Information
- Dataset Identification Information
- Data Sources and Their Dates
- Name of the Standard Used for Production of the Data

- Information Relevant For Data Transfer
- Coordinate System and Projection System
- Quality and Accuracy
- Geographic Extent of the Dataset
- Explanations on Certain Feature Types
- Legal Aspects
- Information Related to the Metadata Itself

For each of the above stated titles, further subtitles are presented along with their "definition", "type", "domain", "format" and "notes". The aim is to create uniformity in the file that will assist the user in automatic searches. This is advantageous even when the metadata are organized in a regular ASCII file.

3. Data Acquisition

Data Acquisition is by means of photogrammetry. Aerial photography is at 1:40000 scale using wide angle aerial cameras. Planimetric and altimetric ground control points(GCP) for aerial triangulation are measured by GPS and levelling respectively. Where levelling is not possible, GPS is used for height determination. These measurements are based on the Iranian geodetic and precise levelling networks.

Annotated photographs prepared in the field assist the operator in identifying the required features during stereo-restitution. Considering the number of features that have to be interpreted by the stereo-restitution operator, features have been aggregated into groups in order to facilitate the task. In this way the operator can concentrate more on the geometry and less on detailed interpretation. Features have been grouped in this stage based on similarity in type and geometry. (e.g. watch towers, lighthouses, control towers and communication antennas are compiled as simply "tower").

Feature grouping in the data acquisition part of the standard does not necessarily follow the NTDB classification because it is based to some extent on geometry and the method of compilation. (e.g. the feature "cape" is in the group "Large Water Bodies" because its limit is determined by compiling the water that it protrudes in). Further on in the production line, aggregated features are extended to more detail using the field checked annotated photographs.

4. Conceptual Modelling for the NTDB

As a first step, features that would be included in the topographic database were selected from existing standards and maps with the objective of general topographic mapping in mind. The Committee's knowledge of the terrain was used to modify and adapt the list to Iran's criteria.

The second step was to determine feature attributes. Due to the extent of attributes that could be specified, a minimum level of detail required for mapping was determined and further detail was left to be announced by the NCGISU.

Feature classification was the third step. Through comparison of existing feature classification schemes in different standards and based on research work done by SCDSD members concerning a suitable model for Iran, the SCDSD reached a preliminary classification scheme. The conceptual model was designed according to the object oriented paradigm, but with the ability to be implemented using relational

methods. The feature list, feature attributes and conceptual model were submitted to the NCGISU for comments and approval. These went through a number of refinements by the NCGISU before being finalized.
Since conceptual modelling was being done for the purpose of a NTDB, a general topographic view was adopted instead of any certain application view. For this reason, features related to certain applications were not brought under one class. For example, bridges were not classified as part of "transportation" as in some standards, but rather as a "structure". Further classification was achieved by defining subclasses. For example, bridges were brought under the "Transportation Structures" subclass, but this was done to facilitate querying the database.

The Iranian National Topographic Database has nine superclasses:
- *Buildings;* Although technically buildings are a type of structure, a distinction is made here between them. Buildings refer to constructions having walls and a roof which are used for dwelling or other activities e.g. a house or hospital.
- *Structures;* Structures refer to constructions not having walls and a roof in the sense of a building. e.g. a tower or a dam.
- *Roads and Railroads*; Routes on the surface or under the surface of the earth for the passage of vehicles, trains, humans and animals.
- *Vegetation*; Vegetation encompasses both the existence and non-existence of plants as natural land cover. With this definition areas unable to support plants due to their climate or soil type are also classified under vegetation. e.g. sand dunes and salt flats.
- *Hydrography*; All locations, either natural or man made, covered perennially or seasonally with water. Non-agricultural areas in which water dominates soil are also included in this class.
- *Hypsography*; Natural, man made or conventional features representing the shape or topography of the earth's surface.
- *Delimiters*; The limit of an area having a certain usage or of political importance. This superclass represents complex objects such as airports, refineries and provinces.
- *Utilities;* A feature used for storage, transmission or related support services concerning electricity, water, telephone, oil or gas.
- *Control Points;* Control points are physical or non physical marks on the earth's surface with known planimetric and/or altimetric coordinates.

5. Cartography and Data Presentation

The complete digitalization of the cartographic process was postponed to future development phases of NCC's production line. In the first phase the task was limited to production of maps in the selected computer aided design (CAD) package. Therefore, taking in account the characteristics of printed maps and the needs of the software environment, symbols have been designed in two different forms.
- For presentation on screen (Softcopy)
- For offset printing (Hardcopy)

Cartographic symbols and symbology were designed independent of software. Software related characteristics were then determined to produce the nearest fit. Legends of conventional maps, NCC's 1:25000 conventional map specifications,

digital cartography specifications, semiology, user needs, software limitations and the culture of Iran were considered during cartographic design. Another factor to be considered was the possibility of implementation in different CAD packages. For the purpose of manual color separation in semi-digital offset printing, the cartographic elements of each sheet have been designed in such a way that at the end of the cartographic process we will have four separate files. Each file is for one of the colors blue, brown, green and black which are registered with each other.
Another problem in cartographic design was the Persian fonts. Due to the characteristics of these fonts, some cartographic procedures and functions were not accessible.(e.g. making a text bold or italic without changes in its width). Therefore, some procedures have been simulated. This simulation is not perfect but the committee has tried to simulate those procedures in a way that it would have the right effect on the users as it is tasked in cartographic functions.
During the cartographic stage features in the NTDB are further extended to more detail using the attributes that have been linked to them. (e.g. Perennial and seasonal rivers are distinguished using the attribute information linked to the feature "river").

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THE SWEDISH CORINE LAND COVER PROJECT

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Abstract

For planning and execution of environmental policy information on the environment is needed. This paper describes the CORINE Land Cover product, what it is, what it can be used for and how it is produced. Some of the important stages (updating of thematic masks, segmentation and generalisation) in the production are described more detailed.

EU's CORINE Land Cover

The CORINE (Co-ordination of Information on the Environment) programme was initiated within the EU in 1985. It has the aim of building up databases on the condition of and changes within the environment. These provide an overview that is up-to-date and comparable between countries. In the first instance, the programme aims to simplify the planning and execution of the EU's environmental policy.

The final product of CORINE Land Cover (CLC) consists of a geographical database describing vegetation and land use in 44 classes with a minimum map element of 25 hectares. The CLC database will be updated every 5 to 10 years. The land-cover information is delivered from satellite data in combination with for example, map information.

The EU's environmental organisation, the European Environment Agency (EEA), has primary responsibility for the CORINE Land Cover project. Figure 1 shows the production status of CORINE Land Cover in Europe.

Land-cover mapping in Sweden

Discussions have been ongoing since 1993 about Swedish participation in the CORINE Land Cover project. At the same time technical development work has been carried out at the Swedish Space Corporation on behalf of the Swedish Environmental Protection Agency. The main principle is that Sweden should produce not only a product that meets the EU's needs, but also at the same time generate a more detailed product that is better suited to the national requirement. Some of the central points in the production of the land-cover databases are:

- short production time for the national coverage
- user requirements provide basis for choice of national sub-classes and minimum map element
- the products should be able to be updated continuously.

Figure 1: Production of CORINE Land Cover, December 1996

<u>Production flow</u>

The production of both the Swedish and EU land-cover databases builds on data from three main sources:

- digital satellite data (complete coverage, up-to-date image data for classification and interpretation).
- digital geographical data and map information (the best ancillary data)
- test-area data, including co-ordinates, from the National Forest Inventory (objective, detailed reference measurements for calibration of satellite data).

The major part of the work consists of classifying and interpreting the satellite data in combination with other information. The classification and interpretation can be carried out in parallel since the most suitable method is used to process different classes. For specific classes, for example arable land and dense urban areas, the information is more or less directly extracted from the National Land Surrey's geographical databases.

The subsequent stages of work involve combination of the different elements into one database and then generalisation. The aim of the latter is to generate products with specified minimum map elements for both the Swedish and EU products. In addition to these stages there are quality assurance activities with visual control, editing and assessment of the thematic accuracy. The input data and stages of work to produce the main products are shown in Figure 2.

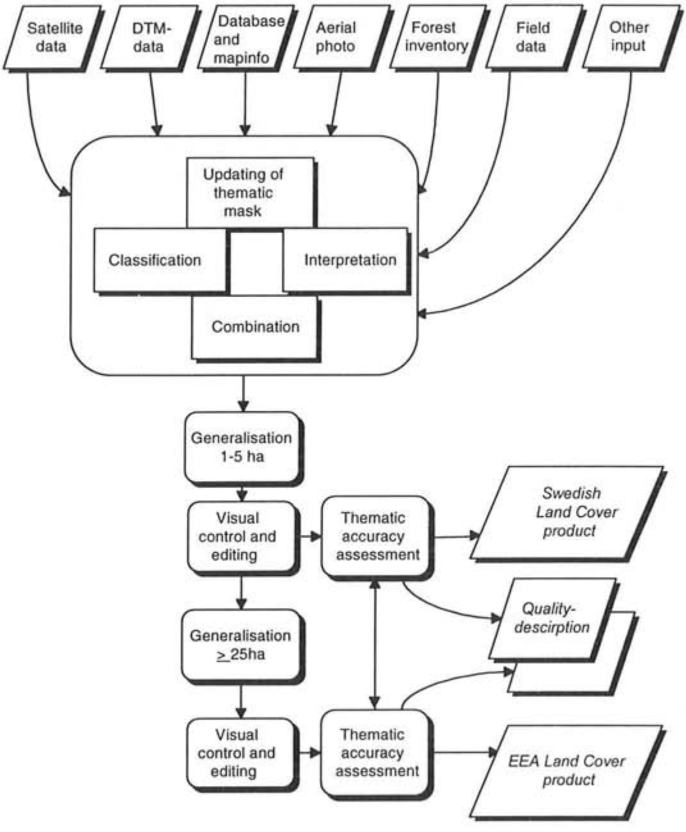

Figure 2: Input data and stages of work to produce the main products

Products

Main products

The main products consist of two CLC databases covering the whole of Sweden - one according to national needs and one to EU requirements. Appended to the main products is a quality description which includes metadata on the input data, the description of the input data processing, and the product's geometric and thematic accuracy.

The Swedish product contains information on vegetation and land use in about 50 classes and is foreseen to have a minimum map element of between 1 and 5 hectares. The EU version contains information in 33 classes (i.e. 33 of the 44 possible classes occur in Sweden) with a minimum map element of 25 hectares. Today's requirement for thematic class accuracy is better than 85% total class accuracy for classes down to the third class level. The end products are digital, but plotted/printed maps can be produced as by-products.

Upon the revision of the product every 5 to 10 years information on changes in vegetation and land use will be kept, thus extending the possible uses. A product showing changes for instance can be used in the monitoring of special classes and special areas, or in climate and environmental models where information on changes in land-cover area and class are of significance.

By-products

From the primary production flow several by-products could be produced at marginal cost. Some of these by-products are:

- Change images
- Revised and new map masks
- Thematic estimates
- Land-cover classification in 25-metre squares
- Statistical products

Which of the by-products come to be produced depends on the user needs. When by-products of interest are identified and specified, the production method must be changed as necessary. In some cases further method development will be needed.

Stages in the production process

The following stages in the production process are described in detatil: updating of thematic masks, segmentation and generalisation.

Updating of thematic masks

Thematic masks primarily from topographic maps are used in the production process to ensure more correct classification of the satellite image. Classification within a specific mask forces the pixels inside to belong to the corresponding category. The masks that are planned to be used in the production are forest, water, swamp and urban area masks. In the following only updating of the forest mask will be discussed. As the common topographic maps in many cases are old and with bad geometry there is a need to update them both geometrically and thematically. This is a rather difficult task since some features from different categories have very similar spectral signatures, e.g. water and dense coniferous forest or clearings and fields. Besides that, the geometry of the satellite image varies. The geometrical error can amount almost 25 to 30 metres.

In the test area there exists both old topographic maps, on which the methods are tested, and a new map which is considered the ground truth and is used for evaluation. The method evaluated for updating the masks includes the following steps which are described in more detail below:

- Mask filtering
- Classification of the satellite image
- Segmentation of the satellite image
- Generation and thresholding of the "distance image"
- Rule-based alteration of masks

Some masks are scanned originals from the topographic map. Since the older maps are cartographic products, point symbols have to be removed from the mask and masked-out roads have to be filled out. These tasks are accomplished with common image filtering techniques.

Classification of the satellite image is performed as a Maximum Likelihood classification with an extra option to store an image containing the Mahalanobi distances.

A split-and-merge and region growing segmentation algorithm is used to create homogenous segments in the image. For every segment a majority class is computed according to the classification.

For each pixel, the distance (Mahalanobi distance) to the nearest class signature is computed and stored as a separate raster image. After that a histogram is computed for each class based on the distance image. Thresholding in those histograms keeps the pixels that are most probable to be correctly classified. This method is working quite well for some classes, but not for others.

In the last step a rule-based system is used to decide whether to alter the mask border or not. The rules are built on criteria like:

- A segment classified as forest with 90% confidence that lies outside the forest mask should be added to the mask.

- A segment totally inside the mask, classified as "not forest" with 90% confidence should be removed from the mask.
- A homogeneous segment that crosses the mask border could either add on the mask or be removed from it, depending on classification.
- A heterogeneous segment that crosses the border of the mask should be sub-sampled and reclassified.

Segmentation

The segmentation algorithm evaluated in this project is of the split-and-merge type with subsequent region growing. It was developed at the Swedish University of Agricultural Sciences.

Segmentation as a part of the production process is evaluated both in the generalisation process, in the process of updating thematic masks and in the classification process. Considering the classification process a number of variants were evaluated. Each variant starts with segmentation of the satellite image to create homogeneous regions, but then they differ:

1. Classification of the spectral mean values inside each segment. To use the mean value reduces spectral variance and implies that only one class is found inside a segment.
2. Computation of the majority class, from a pixel classification, inside every segment. As an option, a priority list that favours certain classes, is used.
3. Same method as number 2 but in combination with some type of probability image, in this case the Mahalanobi distance image, which is automatically generated during the classification.

Generalisation

The generalisation process should transform a pixel-based map into a map with a minimum mapping unit of 1, 2, 5 or 25 hectares. The principle is to eliminate all areas below the minimum mapping unit (1, 2, 5 or 25 hectares) by merging them with neighbouring areas. At each step of the processing, the areas exceeding the size limit are left unchanged. Small areas are merged with neighbouring areas of the same class, or failing this, of the most similar class. If there are no neighbouring areas of a similar class, a small area is divided among the neighbouring areas, regardless of class.

An important principle is that an area's shape and class can only be changed during the generalisation process in accordance with decision rules based upon the biological or geographical context. Priority tables describing class priority and class similarity are used to control the merging of areas. To assess the generalisation method at each stage the results are compared with the input data.

The generalisation is implemented in Arc/Info's GRID module and takes place in five stages:

- Pre-filtering
- Merging small areas with neighbouring areas of the same class
- Merging small areas with adjacent areas of a similar class
- Division of small areas which have no neighbouring areas of a similar class
- Smoothing of area boundaries

Pre-filtering is done to speed up further processing by elimination of very small areas. The largest proportional changes take place during this step. Therefore three different methods of pre-filtering has been evaluated: pre-filtering to 0.6 ha, 0.25 ha or using a segmentation. Overall the statistics show that the 0.25 pre-filtering is the best of pre-processing methods tested, but further improvements have to be made.

For all small areas it is tested whether there are areas of the same class nearby, in this case considered to be separated only by one pixel (25 metres). This process is performed class by class, with the most "important" classes first.

In this step each area under the minimum mapping unit is merged with a larger neighbouring area belonging to the most similar class. If none of the neighbouring areas are considered similar enough, the area is not merged. A priority matrix is established to define, for each class, which classes that are most similar. An example of the priority matrix is shown in Figure 3.

CORINE Land Cover class	Code	31111	31112	31211	312121	312122	31213	31311	31312
Older broad-leaved forest, not on mire	31111	1	490	390	380	360	400	450	440
Younger broad-leaved forest, not on mire	31112	490	1	0	0	0	0	0	0
Dense older coniferous forest, not on mire	31211	330	320	1	480	470	450	380	370
Sparse older spruce-dominated coniferous forest	312121	330	320	470	1	490	450	380	370
Sparse older pine-dominated coniferous forest	312122	320	310	460	480	1	440	380	370
Younger coniferous forest, not on mire	31213	330	340	480	470	450	1	370	380
Older mixed forest, not on mire	31311	470	460	450	440	340	430	1	490
Younger mixed forest, not on mire	31312	460	470	440	430	330	450	490	1

Figure 3: Priority matrix used for generalisation. A weight of 500 represents the most similar class.

After the above processing, certain areas will remain that are under the minimum size and have no neighbours of a sufficiently similar class. These areas are eliminated by dividing them among the surrounding areas. The water classes are not allowed to take part in this subdivision, so a small areas are divided among the non-water classes.

In order to improve the cartographic appeal of the resulting maps, the boundaries of mapped area are smoothed. The intention above all is to remove narrow protrusions and indentations from all areas, regardless of size or class. Technically this is achieved by expanding and again contracting the areas in such a way that smaller areas are retained as far as possible.

Generalisation for the European product

For the European product the national sub-classes have to be combined into European classes and some of the heterogeneous classes have to be interpreted separately (complex cultivation patterns).

Results and conclusion

The work on segmentation and mask updating is still going on, but results and evaluation of the methods described earlier in this paper will be published in reports during spring 1997.

The use of segmentation within the mask updating process and for classification seems promising. Some examples have been produced and visual evaluation indicates that segmentation can be very useful.

To assess the generalisation process the composition of the respective classes has been evaluated. Often the generalised classes and the respective classes in the input data are very much alike. Figure 4 shows what the generalised class "older broad-leaf forest" consists of. The result for all classes indicates that the priority tables used in the generalisation process work well. Overall the statistics show that the 0.25 ha pre-filtering is the best of the pre-processing methods tested with the 1 ha generalisation. The total for correct classification in the 1 ha generalisation is 79%.

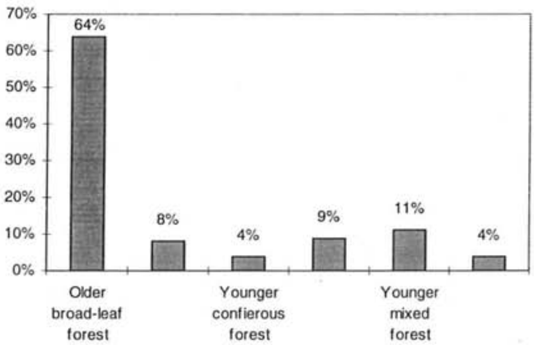

Figure 4: Composition of the class "older broad-leaf forest" after generalisation to 1 ha.

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EDUCATION AND TRAINING IN CARTOGRAPHY "A KENYAN CASE"

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Introduction.

Cartography as known in many places as an art science and technology of map making. Education and training in this area has undergone a dynamic change all over the world and Kenya is no exception. Education brings out the idea of leading out to new knowledge and incorporating ideas to grow and develop. Training is being skilled and specialised in one or several areas. This requires education and training. The management of education and training if poorly done causes difficulty, and Education cannot be equated to schooling as it takes three forms in itself. That is formal non formal and informal. Formal is carried out in well structured instructions for example schools, colleges, universities e.t.c. Non-formal is where activities are carried out to educate others e.g. Agriculture, Cookery e.t.c., these are usually outside the structures of formal education. Informal is where learning is continuos and is done almost unconsciously for example a child learning from the mother, friends, experience and the environment.

Cartography takes all these forms and ends with training.

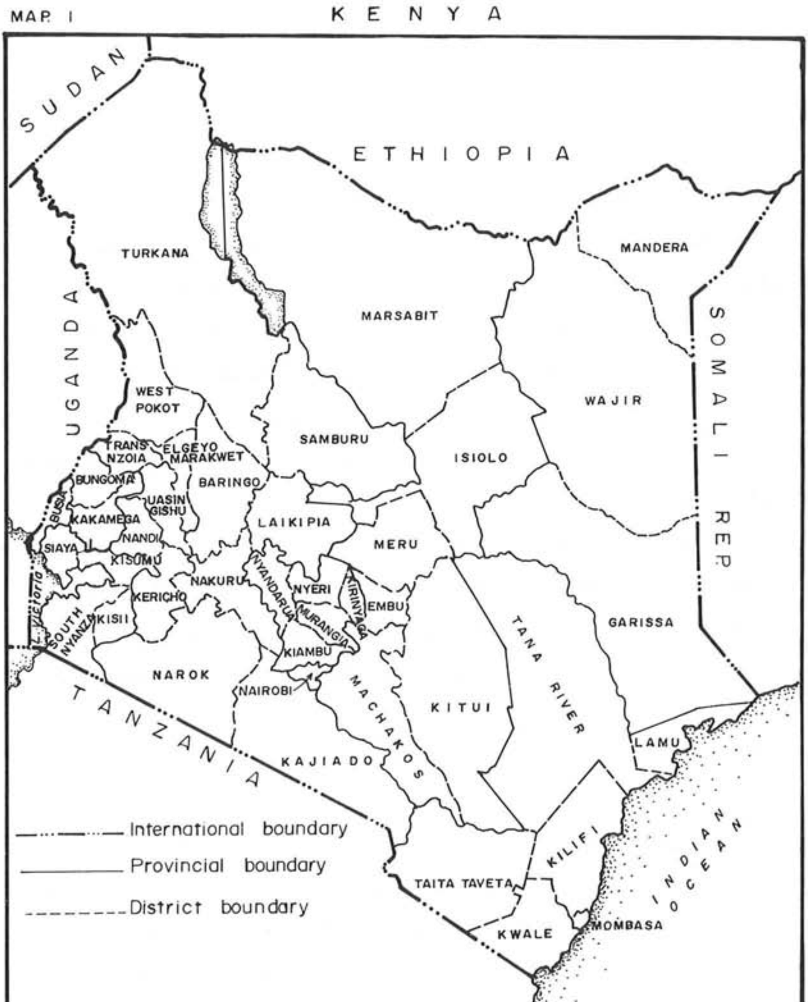
Historical backing of Kenya.

Kenya is a country of 225,000 sq. miles with a population of about 27, 000,000. It has the rift valley which runs through the country, from Ethiopia to Tanzania. It is a multi-racial society of over thirty tribes, it has several National parks having many different animals. It is basically an agricultural country with several cash crops. See map 1.

Historical Background of the Educational Structure.

The new structure of western education was introduced in Kenya by missionaries around the middle of the nineteenth century, this found when traditional education had

MAP. I


KENYA
SUDAN
ETHIOPIA
UGANDA
SOMALI REP.
TANZANIA
INDIAN OCEAN
L. Victoria
TURKANA
MARSABIT
MANDERA
WAJIR
WEST POKOT
SAMBURU
ISIOLO
TRANS NZOIA
ELGEYO MARAKWET
BUNGOMA
BARINGO
BUSIA
UASIN GISHU
KAKAMEGA
LAIKIPIA
NANDI
SIAYA
KISUMU
MERU
NAKURU
NYANDARUA
NYERI
KIRINYAGA
EMBU
KERICHO
SOUTH NYANZA
KISII
MURANGA
KIAMBU
GARISSA
TANA RIVER
NAROK
NAIROBI
MACHAKOS
KITUI
LAMU
KAJIADO
KILIFI
TAITA TAVETA
KWALE
MOMBASA
International boundary
Provincial boundary
District boundary

played a vital and effective role. Traditional education fitted children into their society and taught love and respect for their families, clans, tribes, religions and traditions. As the western education continued in popularity the structure of education became more organised.

The Structure of Education in Kenya.

Formal education begins with the three years in baby class, nursery, and pre-unit. The rest of eight years are spent in primary school, the following four years in secondary school and the last four years at the university. That is the 8-4-4 system. There are training institutions which one can join after eight years of primary education, if they do not continue to secondary school or after secondary education if they do no join university. There are postgraduate programmes as well as masters and Ph.D. programmes; for the students who continue to the university.

Historical Background of Cartography

It is well known that cartography dates back to time immemorial but cartography in Kenya is a very recent development as it started with survey of Kenya which is a department in the ministry of lands and settlement and later the Kenya Polytechnic, as the need for the understanding of maps increased the subject was introduced at the industries and more bodies are taking it up as the integration between itself and other subjects continued

The idea that houses maps and the use of maps was introduced in Kenyan education system as early as in the first eight years of primary education, here it is taught as part of Geography that is map reading. They use the maps without knowing how and who makes them. This continues well into secondary schools where it is also part of Geography, "map interpretation" here the maps is taught. If the student continue on to university the subject is taught as a unit within the Geography department. If one drops at secondary level, and wants to continue with maps, they can join The Kenya Polytechnic which is the only institution which teaches cartography as a pure subject, it takes a period of three years to graduate. The survey of Kenya also trains its own staff where they sit for internal exams and achieve grades for promotional purposes. This institution is not open to other people who are not their employees.

From the above brief account we realise that it has not been given the attention it requires to develop as in other subjects. It is a subject which has been restricted to few institutions.

The Kenya Polytechnic

The Kenya Polytechnic is the only institution which has offered cartography as a pure subject until recently when the Japanese set up another college, this needs to be congratulated.

At this college one trains for a total of 3 years training. This comprises of 2 1/2 in college and six month of attachment at any of the institutions which employs cartographers. The subjects taught are Math, Surveying, Photogrammetry, Geography. Air survey, Current affairs and Cartography both theory and practical. The college admits thirty students. This number has been increasing in the last five years showing a developing interest. People who register for this course are people who are already in employment. Work is rigorous with plenty of practicals, as the students are taught both theory and praticals and applications. The most difficult aspect to develop is the skill as realised by the students. At the end they graduate with a diploma in technical education. Most of the teaching staff are drawn from former geography teachers or members of the survey of Kenya. Survey of Kenya also sponsors the largest number of students almost three quarters of all the admissions. The students are normally given a scholarship and absorbed by the survey of Kenya who is the largest employer of cartographers. Other institutions sponsor their own people who are usually very few.
Since most of the teachers are drawn from people who trained sometimes back it is difficult to improve the quality of education. The Polytechnic still teaches the old methods of drafting the integration of this subject with others of the kind of

photogrammetry and remote sensing is something in the future. This has caused the strongest draw back in the development of this subject. The instruments used are of the old type, the classrooms miss proper technical arrangement, the future looks very dim as this development lags behind.

Constraints in the development of Cartography.

-Manpower :-

Due to the availability of manpower which is not well trained in the latest technology, it becomes difficult to improve the products who are the students.

-Poor planning and Management:-

Education and training in the courses offered, time allocated and the running of the courses has contributed very much to the poor performance.

-Policing:-

Over several years students have been encouraged on formal education which promised higher wages and better job positions, unlike the technical subjects which require a lot of skill and the jobs are poorly remunerated.

-Equipment:-

Most of the equipment used in education and training are very expensive and have to be imported, due to these prohibitive costs, the learning institutions can buy only a few for training.

Due to the prohibitive equipment costs students are forced to share hence creating a lot of learning inconveniences and freedom of use.

Employment :-

Employment in this area is rare and undertaken by only very few specialized institutions.

The entry requirements in this subject is very strict, so students choose the subject very sparingly.

-Loans:-

There are no well set loan facilities for the cartographers to set up small businesses, if these were set up then they would employ themselves.

-Institutions:-

Since there is only one institution which offers diploma many students choose other areas where they can go further in their education locally since the costs for training outside the country is so expensive.

-Teaching aids:-

The teaching aids are of the old type and therefore when the cartographers hear of the latest technologies they wonder as to where they are in view of the their counterparts world wide.

The lack of proper library and reading materials has been a very serious drawback.

Lack of association with other international organisations e.g. ICA, which could improve information flow of the latest developments, has been lacking.

Conclusion.

In conclusion I am sure that the education and training in cartography can improve and hence contribute to the development of this country more if the following suggestion are looked into :-

Employment

(i) The employment market should be improved by encouraging the cartographers to open their own mapping centres. This can only be achieved if those who desire can get access to proper loaning system.

Teaching aids

(ii) There should be free flow of education and training materials, this will enlightened people on what they have what they can have and how they can develop and improve education and training.

(iii) Information on teaching aids should be made easily available, this will encourage people to reach out more, it will also make education and training much more easy and the quality will improve.

(iv) Conferences should be made more accessible cost wise, they should be held in Africa too.

(v) Free interaction and exchange of expertise can bring new ideas and create realization where there is lack of knowledge. So exchange programs should be encouraged.

(vi) The subject should be introduced much more clearly, this will enable students to make rational decisions.

(vii) Education and Training needs a lot of hours to do a good piece of work so time allocation should be improved drastically, to give time to skill development in all institutions.

With the above few remarks Education and training in Cartography has been left way behind in Kenya and for us to improve we need to work hand in hand with the others in the same discipline.

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MAP COLLECTION IN THE DEPARTMENT OF CARTOGRAPHIC EDITIONS OF THE RUSSIAN STATE LIBRARY (RSL) AS A SOURCE OF STUDYING HISTORY OF RUSSIAN CARTOGRAPHY

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e-mail: irgb@glas.apc,org

The Russian State Library (RSL) has begun since 1995 to work over a series entitled "Cultural Heritage of Russia" which is financially supported by the Oneksim Bank.

The first issue of the series is a book entitled "Russia in Maps: a History of Geographical Study and Cartography of Our Motherland" (1996).

The book has been based on the collection of the RSL Department of Cartographic Editions which is one of the largest and fullest collections in Russia and is closely connected with the collection of Count N.P.Rumyantsev.It consists of about 500 maps and atlases and includes the world-known "Draught Book of Siberia" by Semyon Remezov (1701)- a memorial of Russian pre-Petrovian cartography.

For a long time ancient Russian maps of the 18th-19th centuries have not been introduced into scientific practice.

They were considered classified together with other modern topographic and geographic maps of the scale larger than 1: 2500000.

Thus, such maps were available only to a narrow group of experts who had permit to work with classified materials. Publication of such materials was completely banned. Only their fragments and legends to them were permitted to be published.

As a result, the collections of maps and atlases of the largest Russian libraries,including the Russian State Library, were not available to wide circles of readers. In this respect, our country lagged behind many countries of the world where cartographic departments at libraries play, in fact,the role of research centers.They study and publish in a facsimile form ancient cartography memorials as most significant components of history of civilization and valuable sources of historical information.

Our compatriots have had until recently no access to such materials.It was only in 1992 that an illustrated album entitled "Ancient Engraved Maps and Plans of the 15th-18th Centuries" was published. It was compiled by N.A.Borisovskaya on the basis of the collections of the A.S.Pushkin State Museum of Fine Arts. The album presents maps as a special genre of art, a kind of scientific illustrations, a sample of engraving mastery.

The publication of this album has given an impetus to the staff of the RSL Department of Cartographic Editions to initiate scientific study of its collections.

A suggestion has been made to publish a book "Maps of Russia" on the basis of the RSL collections. It would make possible to introduce handwritten and printed maps into scientific practice. They form the basis of this book.

The text of the book and the personalia of painters,engravers, publishers, travellers have been prepared by A.V.Postnikov.Illustrations to the text and legends to the maps have been made by N.E.Kotelnikova and L.N.Zinchuk, staff members of the Department.The book contains 131 maps, some of them have not been published before. Among them are maps of the Baikal Lake compiled by P.K.Frolov and N.E.Karelin.
They indicate, for example, depth measurements of the Baikal Lake (1100-1234 m) which are close to the present-day ones.

The RSL collections include two review handwritten maps connected with designing and construction of hydrotechnical installations. They were signed by Brigadier-General Molletsky in the town of Augustov. These maps may be referred to 1825 and 1828. The map of 1825 has the scale of 1:168 000. It contains only components of channel relief. That of 1828 is a multi-color handwritten original with the scale of 1:84 000 which was made with a great artistic taste.

Besides those two,the book includes printed maps of the 18th-19th centuries.

The book opens with a historical review of development of cartography in Russia. Geography and cartography played a very significant role in the development of our country which, in the course of its history,except the most recent period, continued to expand its territory over adjacent vast uninvestigated areas.The first documented mentioning of cartographic work in Russia relates to draughts of disputable lands. Such a document was pasted in a manuscript entitled "A Draught of Lands Adjoining the River of Solonitsa" which is kept at the RSL Manuscript Department.

The next chapter of the book deals with first maps of Moskovia. Descriptions of various territories, draughts made by official persons, travel notes and commentaries,delineating draugts were kept at official departments (the prikazes) of the Russian state. No Russian-made maps of that period are available, however we have at our disposal numerous foreign-made maps of Russia, which indicate that Russian-made maps and descriptions were used as an original source.

Besides review maps,a large number of sufficiently large-scale regional draughts of individual towns and fortresses, roads, parts of land were made in the 17th century. V.S.Kusov deals with this problem in detail. According to him, 1040 Russian-made geographic draughts have been kept up to now. An idea of how these documents looked like can be had from a 19th century copy of a 17th century draught which is kept at the RSL Department of Cartographic Editions.

The next period of Russian cartography began since the time of Peter the Great and continued during the 18th century.As far as the first teachers of Russian geodesists at that time were Englishmen Fargwarson and Gwyn, the British topographic and geodesic school exerted a very great impact upon the formation of the Russian topographic school.

The work of that period resulted in publication of the "Atlas of the Russian Empire".By 1734, 37 maps were issued and prepared for publication. Several maps from this Atlas are available at the RSL Department of Cartographic Editions, and they have been included into the book.

At the second half of the 18th century, the Russian Empire began to penetrate into Kazakhstan and Central Asia.

At our Department we have a rare cartographic source of that period: "A Draught Based on Information About Khiva", compiled by Velichko, Director of the Orenburg Customs Office.

At the time of Ekaterina II, land-surveying works were under way. Many regional and district draughts were made, some of them are extremely valuable and have been included into the book.

A significant achievement of the Petrovian geographers was the survey and mapping of the Baltic and Caspian seas.

The late 18th century saw the process of surveying and mastering of North America, including the Alaska peninsula, the isles of Umnak and Unalashka.A number of individual maps and atlases appeared, which reflected results of round-the-world expeditions.

The final chapter of the book deals with Russian cartography of the 19th and 20th centuries.At that period military topography came to the forefront of attention.That was, to a great extent, due to the war of 1812 after which the role of military topographers significantly increased.Their work was of large scientific and practical significance. The book is full of maps and map fragments of the period.

In general, the book gives an integral idea of development of Russian cartography along with development of the Russian state.

The book discovers and introduces into scientific practice new names of cartographers and geodesists who were unknown or little known to the scientific public, as well as unknown maps.

Besides, the series "Cultural Heritage of Russia" carries on the great traditions laid down by Count N.P.Rumyantsev whose collection forms the basis of the Russian State Library.

CROATIAN CARTOGRAPHERS

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Abstract

The paper describes first steps in the realization of the project titled *Croatian cartographers* which has started at the University of Zagreb, Faculty of Geodesy. The project is supported by the State Geodetic Administration of the Republic of Croatia. It is planned that the work will be going on for three years.

1. Introduction

Every nation needs systematically elaborated and published bibliographic data about all the people who contributed in the development of its material and spiritual life during many centuries-old historical advancement. Some nations still have such manuals, while several others are just preparing theirs. It is known that such work is a very complex one and can sometimes last for a number of decades.

Under the term *Croatian cartographer* we understand Croats or people having Croatian origin, who have lived around the world and worked in cartography, then people belonging to other nations or nationalities but born in Croatia, regardless where they lived, as well as foreigners who lived and worked in Croatia giving their contribution to cartography.

We have to face with the fact that our choice will not be the best one for everybody. Perhaps some names will be omitted. On the other hand, a few names which are not so important, and which could be neglected, will be probably included.

2. More important organizations engaged in cartography in Croatia

Državna geodetska uprava (*State Geodetic Administration*)
Ministarstvo obrane Republke Hrvatske (*Ministry of Defense of the Republic of Croatia*)
Državni hidrografski institut u Splitu (*State Hydrographic Institute in Split*)
Zavod za kartografiju Geodetskog fakulteta Sveučilišta u Zagrebu (*University of Zagreb, Faculty of Geodesy, Institute for Cartography*)
Geografski odsjek Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu

(*University of Zagreb, Faculty of Natural Sciences and Mathematics, Department of Geography*)
Nacionalna i sveučilišna biblioteka u Zagrebu (*National and University Library in Zagreb*)
Hrvatski državni arhiv (*Croatian State Archive*)
Hrvatski povijesni muzej (*Croatian Historical Museum*)
Muzej Grada Zagreba (*Museum of the Town Zagreb*)
Kartografski odjel Leksikografskog zavoda "Miroslav Krleža", Zagreb (*Lexicographical Institute Miroslav Krleža, Department of Cartography, Zagreb*)
Kartografija-Učila, Zagreb (*Cartography-Teaching Aid, Zagreb*)
Školska knjiga, Zagreb (*School Book, Zagreb*)
INA-industrija nafte d.d., Sektor informatike INFO, Služba GIZIS (*INA-oil industry, Section for informatics INFO, GIZIS Service*)
Kartografski laboratorij Križovan, Zagreb (*Cartographic Laboratory Križovan, Zagreb*)
Gradski zavod za katastar i geodetske poslove, Zagreb (*Town Office for Cadastar and Geodetic Affairs, Zagreb*)
Zavoda za fotogrametriju d.o.o., Zagreb (*Photogrammetric Company, Zagreb*)
Geodetski zavod, Rijeka (*Geodetic Company, Rijeka*)
Geodetski zavod, Split (*Geodetic Company, Split*)
Geodetski zavod, Osijek (*Geodetic Company, Osijek*)
GEOFOTO, Zagreb (*GEOFOTO, Zagreb*)
GISDATA, Zagreb (*GISDATA, Zagreb*)

3. Sources of bibliographical data on Croatian cartographers

1. Professor's notes, textbooks and monographs written for studying cartography at the Faculty of Geodesy, University of Zagreb, and its predecessors

Professors: Nikolaj Abakumov, Branko Borčić, Franjo Braum, Anton Fasching, Nedjeljko Frančula, Stjepan Horvat, Ivan Jagnić, Mato Janković, Vladimir Kirin, Marije Kiseljak, Ivan Kreiziger, Antun Krček, Paško Lovrić, Slavko Macarol, Ivan Novak, Mijo Philipovich and Vladimir Vranić.

2. Masters and doctoral theses on cartography made at the Faculty of Geodesy, University of Zagreb

M.Sc.: Frangeš S., Horvat S., Jakopec V., Kosek M., Lapaine M., Malić B., Nikolić M., Okić A., Pleić S., Racetin F., Solarić R., Sošić A., Vučetić N., Zdjelar D.

Ph.D.: Brukner M., Buder I., Lapaine M., Peterca M., Podpečan A., Racetin F., Zdenković M.

3. Proceedings of the Faculty of Geodesy, University of Zagreb

The first volume of the Proceedings appeared in 1965. Twelve publications contain articles from the field of cartography.

4. Articles on cartography published in journals

In Croatia there is no journal with exclusively cartographic subjects. The articles from the field of cartography are mostly published in the geodetic periodical. In Zagreb there is the geodetic journal *Geodetski list* being published continuously since 1947. Till the end of 1996 there were more than 160 articles from the field of cartography published in it.

5. Books

Plenty of cartographic material on Istra and the entire Adriatic Coast has been elaborated by Lago and Rossit (1980), Kozličić (1995), and Lago (1996). The monograph *Descriptio Croatiae* (Marković 1993) is the result of a thirty years long work of the Academy member Mirko Marković, of his long lasting efforts to gather and process the material. Descriptio Croatiae is the most integer and the broadest review of the cartography of Croatia and of the Croatian cartography till the end of the 19th century. It comprises the majority of what has been scattered around in numerous articles and studies in different journals and proceedings less approachable to the majority of readers. This work shortens the tiresome job of searching through and looking for the topics, maps and their authors to all the readers.

6. Map exhibition catalogues

The historical archives of Split has prepared in 1992 a unique exhibition of cadastral maps with a beautiful catalogue the *Treasures of Croatia* from the archives for Istria and Dalmatia. In 1993 the Museum for Arts and Craft in Zagreb prepared a great exhibition *The Border of Croatian on the Maps from 12th till 20th century* with the beautiful reproductions of 88 maps. In autumn 1994 the exhibition *Older Geographic Maps in the University Library in Split* has been made in Split, accompanied also by a very nice catalogue.

The exhibition under the title *Zagreb on Surveying-Cadastral Maps and in Land-Registers* was held in the Arts Pavilion in Zagreb at the end of 1994. The representative catalogue was published for the exhibition containing a lot of valuable articles and reproductions.

The last exhibition of maps *Plans and views of Osijek* was held in Muzej Slavonije Osijek in 1996. There were 143 exhibits presented with panoramic views, cadastral plans, topographic maps including new maps made on the basis of satellite images.

4. Map projections in Croatia

Croatian eminent individuals bring evidence the scientific tradition of Croatian people dating as far as the 12. century. Some of them contributed to the science in such a way, that their achievements introduce new periods in the development of science. These are, for example, Herman Dalmatin in the 12. century and Josip Ruđer Bošković in the 18. century which can be looked upon as the forerunners of the Croatian geodesy and cartography.

During the last and at the beginning of this century, there was the cadastral survey carried out at the territory of the Republic of Croatia and the plans made in several coordinate systems. We regard all these systems as old. Since the plans made in old systems are still being used, it is becoming necessary to establish the connection between these systems and the systems of Gauß-Krüger projection. The old survey was made by the experts under the authority of institutions that were resident in the administrative centres of that time (Vienna, Budapest), so that very few data has been kept until the present time which may indicate how these jobs were performed. The old coordinate systems at the territory of Croatia are so-called: Kloštar-Ivanić, Budapest, Vienna, Krim and the oblique conformal cylindric projection. The insight into the origins of the old systems and their characteristics have been worked out in several articles (Filkuka 1922, Sirks 1936, Čubranić 1947, Borčić 1954). The book *Technische Anleitung zur Ausführung der trigonometrischen Operationen des Katasters* by J. Marek from 1985 is of a special importance in this respect.

Borčić and Frančula have worked with their collaborators on the issue *Determining the Elements of Transformation between Projections and Coordinates Systems of the Old and New Land Survey at the Territory of the SR Croatia* in the period between 1962-66. The basic results of the extensive research made, were published in the publication *Old Coordinate Systems at the Territory of the SR Croatia and their Transformation in the Systems of the Gauß-Krüger Projection* (Borčić, Frančula 1969). Frančula has later on worked specially on the double oblique conformal cylindrical projection (Frančula 1972).

Although important research on map projections at the territory of Croatia were made in the last and at the beginning of this century, it seems that there is still material to be studied. For example, there are *Mitteilungen des k. k. Militär-Geographischen Institutes* that used to be published in Vienna, in which there were also published relatively detailed articles by H. Hartl about map projections (1886, 1896).

David Segen (1859-1927) obtained his PhD at the Faculty of Philosophy in Zagreb in 1889 as the first doctor in the field of mathematics at the University of Zagreb. He staid there to hold a course of lectures, like *Perspective Graticules (Perspektive mrežotine kartografijske)*. He wrote a comprehensive article titled *About drawing graticules for geographic maps (O crtanju mreža za geografijske karte)* which was published in Izviešće o Kr. velikoj realci u Osieku (Report about the Royal Big Junior High School in Osijek) in the school year 1880/81. Apart from that, he published the article in the Teacher Gazette (Nastavni vjesnik) titled *Basics of Relief Perspective*.

Marije Kiseljak (1883-1947) lectured *Mathematical Theory of Cartography* (1922-23) and *Cartography* (1923-25) at the Geodetic and Engineering Department in the Technical High School in Zagreb.

Vladimir Vranić worked as a professor in *Mathematical Cartography* at the Geodetic Department of the Technical Faculty from 1945. His work *About the derivation of formulas in spherical trigonometry by means of stereographic projections* (1927), translated into German *Über die Ableitung der Formeln der spherical Trigonometrie mit Hilfe der stereographischen Projektion* (1928), is important for the our history of map projections.

Željko Marković (1889-1974) was the head of Mathematics for a long time at the Technical Faculty in Zagreb. He did not teach Cartography, but it is very important for us, that in his manuals in Higher Mathematics, he worked out in details the conformal projections, especially referring to conformal projections of a sphere and ellipsoid in cartography (Marković 1965).

I would also like to mention that Vilko Niče (1902-1987) in his *Perspective* which had a few editions, worked on the perspective projection of the globe among other things, and in the chapter on central projections applications he elaborates the stereographic and gnomonic projection.

Tomo Jakić (1879-1966) from Požega was the professor of Mathematics and Physics in high schools in Požega and Zagreb. In the *Teacher Gazette* which was issued in Zagreb, he published a very extensive article titled *Drawing of Graticules for Geographic Maps*. The article was published in four sequences at altogether 52 pages.

Artur Franović-Gavazzi (1861-1944) was the most outstanding geographer in Croatia at the turn of the century. His booklet on 66 pages under the title *Map Projections* is of great significance for the Croatian history of map projections. Together with other manuscripts of his lectures at the University, it was reproduced and published in the thirties by the Academic Geographic Club in Zagreb (Gavazzi 1933).

In this century, the activity of a great number of our geodetic experts can be noticed who did not have map projections as the basic field of their interest, but have still left written evidence in this part of cartography as well. I am stating them in chronological order: V. Filkuka (Projections of land survey in Croatia and Slavonija, 1922), N.P. Abakumov et al. (Projections of cadastral survey in the Kingdom of SHS, 1928-29), N. Čubranić (Projection systems in Croatia, 1947, Table for the length reduction in Gauß-Krüger Projection, 1948), E. Adamik (Reduction of direction and distance in the Gauß-Krüger Projection, 1948), L. Randić (About the Construction of Verticals in Stereographic Projection, 1953), M. Bolt (Transformation of Coordinates between Neighbouring Coordinate Systems of Gauß-Krüger Projection, 1974), Z. Narobe (Simplified way of Computing Meridian Convergency for the Purpose of Gyroscopic Orientation, 1975), R. Solarić (Computing of Point Coordinates in Mercator Projection by Applying Pocket Computer, 1980) and M. Cigić (Transformation of Coordinates from the System of the Old Survey into the Systems of Gauß-Krüger Projection and Vice Versa, by Applying Pocket Computer, 1981).

The Institute for Cartography at the Faculty of Geodesy, University of Zagreb has been founded by the Act of the University of Zagreb on 22 May 1956 at the Geodetic Department of the Technical Faculty in that time. The foundation of the Institute for Cartography has been proceeded by the establishment of the Department for Cartography in 1951 after Branko Borčić had been elected an associate professor, and gradual formation of Cartographic Laboratory initiated by Ivan Kreiziger in 1948 already.

A remarkable teaching activity existed in the field of cartography even before the Department for Cartography had been founded. However, from its foundation, and especially from the establishment of the Institute for Cartography, a significant scientific and professional activity was also developed. The Library of the Institute is very rich numbering about 5000 items. The Institute receives regularly 27 journals. The collection of maps contains about 8000 maps and 170 atlases.

At the Faculty of Geodesy, University of Zagreb, there is a longstanding continuity in the teaching of map projections and geodetic drawing. The map projections were lectured by eminent professors: Marije Kiseljak, Vladimir Vranić, Anton Fasching, Nikolaj Abakumov, Franjo Braum, Mato Janković, Branko Borčić, and up to now Nedjeljko Frančula.

Stjepan Horvat (1895-1985) lectured Geodetic Cartography in the 30-ties of this century within the frame of the courses Geodetic Surveying, and State Survey. He has been almost forgoten and unknown until recently, because he was forced to emigrate after the World War II. His works are very important for the history of map projections, regarding their contents and their volume. If we would count his papers only in the field of geodesy and cartography, we would obtain the number larger than hundred, with altogether more than 2000 pages.

Antal (Antun, Anton) Fasching (1879-1931) was one the most educated Hungarian geodesists. He wrote about 70 papers and books. He lectured Higher Geodesy, Cartography, Geodetic Surveying and Photogrammetry in Zagreb in the period from 1923 to 1928. Apart from his teaching activity, his research on solving the question of state projection selection is very significant.

Nikolaj Pavlovič Abakumov (1882-1965) was elected a full professor in 1927 at the Geodetic Department of the Technical Faculty in Zagreb, where he lectured Geodetic Surveying, Higher Geodesy, Spherical Trigonometry, Practical Astronomy, Applied Astronomy, Positional Astronomy, Photogrammetry, Cartography, Mathematical Cartography, Applied Cartography and Geophysics at the end of 1950. I would also like to mention, that Borčić quoted the lectures of professor Abakumov at the Technical Faculty in Zagreb in the references of his manual Mathematical Cartography.

Branko Borčić (1908-1977) made his doctoral thesis in 1964 at the Fakulteta za gradbeništvo in geodezijo u Ljubljani (Faculty of Architecture, Civil Engineering and Geodesy in Ljubljana) titled *Mathematical Base for the World Map at the Scale 1 : 1 000 000*. From 1951 he was the assistant professor at the Technical Faculty in Zagreb, where he habilitated in 1956 with his work *Contribution to the Solution of Coordinate Transformation between Neighbouring Coordinate Systems in Gauß-Krüger Projection*. From 1960 he was a full professor at the Faculty of Architecture, Civil Engineering and Geodesy in Zagreb. He wrote about the issues of mathematical and geodetic cartography and published a lot in Geodetski glasnik (1939-40), Geodetska služba (1951), Geodetski list (1955, 1960, 1975), Građevinar (1958). His manuals on map projections and Gauß-Krüger projection have been used in Croatia for years as the only manuals of this kind.

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DYSCOVER
A WORLD OF SPECIAL MAPS FOR SPECIAL PEOPLE

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Introduction

Dyscover is a unique, concept-mapping project. It was started in 1995 by two cartographers whose own children have specific learning difficulties. It has combined a variety of previously unrelated special needs topics to create a bespoke cartographic package.

Aims

Maps have the functional ability to address highly complex issues such as the perception of spatial awareness. At the same time they provide the user with a wealth of fundamental, lower-level information such as routes, location etc. This data must be presented in a format which the user can understand. Cartographers rarely consider the specific needs of people who lack their own abilities. How can they? They can neither perceive nor truly appreciate the difficulties which some people face when presented with map products.

All children have some difficulty in communication and motivation but the degree of difficulty varies. Cartography and map products can be one way in which we can help the special needs child to understand his own immediate surroundings as well as the world in which he lives.

Maps for the special needs customer may lack convention and even flout normally accepted design principles but, in essence, they still attempt to convey a message of spatial reality into the mind of the user. How this is achieved should not be hindered by the cartographer. Rather he should facilitate the user to discover their potential.

Map designers do not take into account simple changes which may enable entirely new sectors of the community to make valid use of their work. It is important that these issues are addressed at the start of each original compilation task undertaken.

All maps aim to provide a unity between objects, words and images in an adequate fashion. The fact that maps have been inaccessible to a percentage of the population, based purely on our inability to use a "courteous translation", is tragic. During those early, formative years cartography can provide an essential resource, not only in support of education, but in teaching additionally valuable life skills and maintaining learning momentum.

Dysfunctions

Our research and work has identified, we believe for the first time, common problems of dysfunctional children, some of which can be assisted through a multi-sensory approach to mapping. By dysfunctional we mean those who suffer the hidden handicaps of Dyslexia (Reading and writing), Dyspraxia (Co-ordination), Dysgraphia (Writing), Dyscalculia (Mathematics) and Dysphasia (Speech).

We feel common links exist between these groups and therefore they should not be treated in isolation. Problems with spatial awareness is one such commonality. Normally maps, as representations of spatial data, would be of great assistance but, for people suffering any of these conditions, conventional mapping can be very confusing or even frightening!

Our study of Irlen or Scotopic Sensitivity Syndrome (I/SSS) made us realise that not all people perceive things in the same way. This condition was first described by Helen Irlen in 1983. She is an American educational psychologist with many years experience of pupils with various learning difficulties. I/SSS is reported to affect up to 20% of the population. It results in an under-achievement at school and in the workplace.

It is a perceptual dysfunction occurring within the brain, creating distortions to the printed page. It manifests itself in many ways and creates such abnormalities as pages of text moving, letters and lines swirling into a mass, words jumping about and letters transposing themselves. If this happens to written text, we concluded, it must also affect the appearance of maps.

There are five main factors that must be taken into account before we consider individual map specifications. In order to understand the basic problems we are trying to overcome it is important to understand the perceptual problems that these children may suffer.

1. Light Sensitivity: certain glare and brightness cause the sufferer dizziness, restlessness, headaches and nausea. As reading is a visually intensive activity they quickly tire. These individuals usually prefer to work or read in a dimmer light. Here we must carefully consider the colour and quality of modern papers.

2. Inadequate Background: combine the glare of white paper with modern printing inks and consider the high contrast achieved. It is assumed a high contrast is best for reading because the text is allowed to dominate the page with little interference from the background. For people with I/SSS this contrast is insufficient. Letters and lines begin to lose their distinctiveness and become distorted. Some even appear the same. Lower case letters can visually lose their ascenders and descenders.

3. Poor Print Resolution: this can be dependent on the type style, point size and the spacing between the letters or numerals. The person perceives text that pulsates, shimmers and dances across the page. It can even be seen to run off the page and disappear completely. Tracking and comprehension are lost.

4. Restricted Span of Recognition: this occurs when the sequencing and processing of groups of letters, numerals, musical notes etc. is found to be difficult. Hyphenated words create a problem - especially if on two lines.

5. Lack of Sustained Attention: co-occurring with the problems listed above, it is the lack of ability to concentrate for long periods of time.

Colour Preferencing

Many of these symptoms can be relieved by the use of specific colours. The individual benefits from viewing a page through a coloured plastic overlay or coloured lenses. The coloured tints modify the wavelengths of light reaching the eyes. It reduces individual, problematic wavelengths in order to stabilise the page. The clinical "Colour Preference" will be unique to each person. It is selected by means of precise testing by a trained diagnostic technician.

Design

Careful design is essential for the special needs child and should be media independent. These days cartographic design seems to be limited by the ability of the available software and clipart rather than the skills of the cartographer.

Creativity should not be restricted by technology. Yet it is allowed to influence so many large cartographic houses. Here the compilation task is governed by the machinery and not the cartographer's design capability. A map should be designed with an emphasis on communication. It should neither be hindered by adherence to fashion nor constrained by aesthetics. The cartographer's own perception of a pleasing product must come second to the transfer of information to the mind of the user.

Cartography has become too much a precise science and less functional. The initial specification for each of our maps is customer-dependant taking into account learning difficulty, age, educational level, perception, spatial awareness etc. These factors become the fundamental design parameters to ensure map functionality. Clutter and ambiguity demand unnecessary attention. Thus we begin with the most complex and strip it down to its bare essentials. In this way we ensure that the individual customer receives the required data in a format he can read and understand.

General mapping products are increasingly aimed at a much wider and more complex audience. Large print runs offset high production costs. In order to maximise sales return, extra detail is often added to widen the appeal/usage. This over compromise can create dreadful products which fail to satisfy any single user group.

Yet here we are talking of a one-off product which may be adapted in the future for someone else but which will never be repeated wholesale. The versatility of on-screen compilation allows us to create such flexible products. If this involves exaggerating colour, lines, symbols etc. then we must explore those areas.

Communication is the key and no matter how exact the position of an island, how technically correct the statistics of the data, how perfect the registration of the colour masks - if the map communicates nothing it is useless. The cartographer has failed.

Method

Each map we produce has an individual purpose and function. A logical sequence of research, design and compilation is required for such bespoke products. We need to research individual user requirements before embarking on the compilation of a specific map. Our ultimate product needs to be effective and efficient in its delivery of information.

Projects to date

Sophie's Map

Sophie was 7 years old when we designed a simple map, mounted on stiff board, to guide her to her Grandmother's house. A short journey but, for a Dyspraxic child with little spatial awareness, a nightmare. Sophie has processing dysfunctions and is unable to access available map products. Having investigated colour preferencing, we established that she has a clinical colour preference for black on scarlet red. Traditionally, red is the colour reserved only for the most important features on a map.

The map includes a series of coloured pegs to indicate major road junctions which are related to time. At any one time, by moving a coloured peg from the "scale" bar to the next position on the map, Sophie is made aware of her relative position and the time/distance from home. She is also reminded of the direction she has to travel.

The map content was kept unambiguous and as simple as possible. Thicker lines indicate the major roads and the use of a stipple route strip ensures Sophie can follow her progress using her finger. The line work was kept clear of other detail where possible.

A sans serif upright font was employed to reduce the amount of scanning the brain has to undertake. Italic or fancy fonts were avoided for the same reason. All text was kept clear of the line work to avoid blurring and subsequent confusion.

Symbols were designed noting the landmarks she finds useful and thus a key was avoided. Symbols are not boxed-in as the additional line work would offer no further useful information.

As a result Sophie is, for the first time in her life, able to use a map effectively and follow a route using her finger.

Matthew's Atlas

Matthew is 14 years old and Dyslexic. He has been tested by an Optometrist using a Cerium Intuitive Colorimeter and, as a result, he now wears green, non-prescription lenses for reading and writing tasks which remove the glare from the paper. Due to Matthew's Dyslexia he finds complex design issues difficult to unravel within his own mind. Excessively detailed maps cause him to turn away rather than to investigate further. He needed a series of maps, i.e. an atlas, to help him with his current school work, studying South America.

The basic concept for the atlas was to take the complex base data and to physically separate it into layers. These may be reassembled, in any combination, to meet his needs at any point in time. The effect is to produce a series of simple overlays which are,

individually, easier for the brain to scan and interpret. Any unnecessary information which may clutter the display is removed to improve clarity and understanding. Matthew is then able to work within the limits of his own perceptual field and mental agility.
The series of overlays were produced on clear acetate to fit a base map. These were registered onto specifically placed pins so they cannot be inversed or reversed.
They can be updated as required to meet educational demands. A grid overlay was supplied for reference during lessons. This enables Matthew to find a particular feature which he may be unable to identify by name. It also works to divide the map into smaller, more manageable areas.
In the design phase, over-simplification is a temptation which must be considered e.g. the complex drainage system of South America is vital to it's vegetation and environment. Thus it has to be shown as an intricate and extensive pattern.
As a result of the Atlas, Matthew was able to study a country at his own pace and in a way which suited him best.

Antony's map
Antony is a 13 years old blind boy who attends the West of England School for the Visually Impaired at Exeter. We decided to survey the school's new Sensory Garden and produce a tactile map for the children. This was a different field of cartography for both of us and so we have had to learn a lot along the way. Antony became our guinea pig with reference to testing our map. He pointed out anomalies and discrepancies which we are now including in the final product. It was interesting to note that he did not like some of the symbols and line widths we had used in accordance with the books on Tactile symbolisation we had read. In fact, he preferred symbols we had independently designed. His ability to read the map effectively made us quickly realise that a tactile approach would be relevant to a child with poor motor control/co-ordination regardless of their ability to see. We were able to observe the way he handled the map in order to orientate himself and watched with interest as he employed a piece of Blu-tack to record his next point of call. These are methods we feel could be trialed with sighted, dysfunctional children.

"Dysplay"
We are aware of the particular importance of typography for those we wish to help.
Through our research, we have identified important typographic design controls which would very much aid the perception threshold of dysfunctioning children. These criteria are not very exotic but, combined with the other elements of our map designs, dramatic improvements in visual processing can result.

The R.I.M. factor
The perceptual distortions suffered by these children are often transitory, random and inconsistent. The most common problems experienced are ROTATION, INVERSION & MIRRORING. These have led us to investigate the "R.I.M. factor", as we have called it.
Some letters are known to be affected more than others. b's, d's, p's and q's are notorious.

They fail to retain a unique identity and are readily transposed.
After examining over 3,000 existing typefaces we failed to find a character set that fulfils all of our criteria. Faced with this problem we set about designing our own unique font. "Dysplay" has been designed to assist with the exclusive recognition of these characters in particular. We do not attempt to eliminate the distortions, merely reduce the resultant confusion by creating letter forms which withstand a high degree of R.I.M. transformation.
"Dysplay" has been designed on altsys "FONTOGRAPHER 3.5" software as a True Type Windows-compatible font. Bitmap, Postscript and Type 1 files have also been constructed as standard options. By linking the font metrics to Digital Braille dynamics we can easily substitute font styles to create tactile images from identical base data without re-defining the text positioning.

The need for colour preferencing in schools

The relevance and implications of colour preferencing to school children is of paramount importance. At present the educational format is possibly inappropriate to some children's ability to see and comprehend lessons. A simple change e.g. photocopying information onto different coloured paper may enable them to concentrate for long enough to learn alongside their peers. This could relieve them of a great deal of pressure and internal anguish.
The Ordnance Survey produce educational CD-ROMs such as "Discover York" and "Discover London". These packages are ideal learning tools and give a "hands on" approach - fulfilling part of the U.K. National Curriculum I.T. requirement. However, the brightness of the colours used and their appearance on the screen could have a bizarre and negative effect on some children. The ability to change the background colour or simplify the content does not exist within the CD package. Therefore, this format only provides an interactive approach to developing map skills for those who can see and understand it.

Conclusion

This holistic and multi-sensory approach can enable a child to explore his own ability as well as facilitate map appreciation/reading for the first time.
Through the enhanced use of colour, clear text, simplicity, touch etc. we can produce map products to suit the individual needs.
We have no desire to produce a wonderfully complex, visually pleasing, multi-layered map for all to stand in awe of. We aim to meet the minority. We aim to produce a simple graphic which will introduce the dysfunctional child to his own spatial awareness and open the visual doors to the 2-dimensional world of maps.
We have had to turn the well tried and tested methods of modern cartography upside down to achieve these end results.
The excitement of our work to date has been in the design and development of products which seem to ignore normal, acceptable cartographic practice. The reward is in seeing those products successfully put to use by the children for whom they were created.
The possibility of producing individually tailored maps in limited print runs is at our

fingertips with the availability of mapping software packages and high quality laser printers. This technology provides the cartographer with the versatility required to give a significant minority of the population the facility to see a map for the first time by supplying it in a sympathetic format. In our language based society, maps can communicate vast quantities of data in visual format.

This concept is becoming increasingly viable. We must respond by attempting to alleviate the confusion current products create. To the trained cartographer the end results may be bizarre but each map will be compiled to meet the highly specific needs of an individual.

We cannot cure any of the "Dys" functions with our products but we can attempt to make learning a less stressful experience.

Traditionally, maps have always been expensive to produce. In order to maximise return in this investment, cartographers have sought to ensure their maps have as wide a market appeal as possible. Similarly, some potential customer markets have been ignored due to their minority status. In general, customer needs have not even been assessed where the potential market is already known to be too small to support the initial investment. The "Special Needs" sector is one such market area. This market group has the added problem of being difficult to scope.

With the advent of very flexible software packages and the tumbling reproduction costs, the climate now exists to tackle these minority markets.

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THE ACCURACY CRITERION OF TRANSFORMATION SPACE IMAGES INTO CARTOGRAPHIC PROJECTION

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Abstract

In the paper mathematical model for estimation accuracy of the transformation space images into cartographic projection with application approximating polynom is given.

1. Introduction

The transformation of the space images into the given cartographic projection can be realized with application of a various approximating functions. The offered mathematical model permits to predict:

— influence of initial information errors on the transformation accuracy;
— influence of unconsidered terms of approximating functions on the accuracy of the transformation of the space images into cartographic projection.

2. Initial mathematical model.

The power algebraic polynoms are considered as of approximating functions, but the principle that is in the basis of the model can be applied to other kinds of approximating functions.

Accept that the transformation is described by model:

$$A\,U_{kl} + L^{\circ} + A_p\,U_{k'l'} + \Delta = V, \qquad (1)$$

where A - matrix, and it's elements

$$a_{ij} = x_i^{k_j}\ y_i^{l_j}\ ; \qquad (2)$$

x_i, y_i — coordinates of i-th point on the space images;
$i = 1,\dots, n$ (n — quantity of the points, which are used for approximation);
$j = 1,\dots, m$ (m — quantity of approximating polynom terms);
U_{kl} — vector of most probably values of approximating polynom coefficients;

$(L^\circ + A_p\, U_{k'l'} + \Delta) = L$ — vector of the measured values of coordinates (abscissa or ordinate) of the space image points in the given cartographic projection, here:

$(A_p\, U_{k'l'})$ — vector of unconsidered polynom terms;

Δ — vector of the true errors of the initial information;

L° — value of the vector L on condition, that

$$A_p\, U_{k'l'} + \Delta = 0; \qquad (3)$$

V — vector of residual deviations.

Minimizing of $(V^T V)$ gives :

$$U_{kl} = -\,(A^T A)^{-1} A^T (L^\circ + A_p\, U_{k'l'} + \Delta). \qquad (4)$$

From this expression the distortions of the vector U_{kl} under the influence of vector Δ and $(A_p\, U_{k'l'})$ are :

$$\delta U_1 = -(A^T A)^{-1} (A^T \Delta) \qquad (5)$$

$$\delta U_2 = -(A^T A)^{-1} (A^T A_p\, U_{k'l'}) \qquad (6)$$

The vectors δU_1 and δU_2 permit to construct models of approximation accuracy prediction.

3. The model of the prediction of the vector Δ influence on the approximation results.

The elements of the distortion vector δU_1 are characterized by the covariation matrix K_U, which has such form according matrix A structure :

$$K_U = \mu^2 \begin{bmatrix} Q_{\xi 11} & \frac{1}{c} Q_{\xi 12} & \cdots & \frac{1}{c^{(k_m + l_m)}} Q_{\xi 1m} \\ & \frac{1}{c^2} Q_{\xi 22} & \cdots & \frac{1}{c^{(k_m + k_2) + (l_m + l_2)}} Q_{\xi 2m} \\ & \cdots & \cdots & \cdots \\ & & & \frac{1}{c^{2(k_m + l_m)}} Q_{\xi mm} \end{bmatrix}, \qquad (7)$$

where μ — standart of weight unit,

$Q_{\xi ij}$ are the elements of the matrix

$$Q_\xi = (A_\xi^T\ A_\xi)^{-1}, \qquad (8)$$

here A_ξ — matrix, and it's ij - th element is

$$a_{\xi ij} = \xi_i^{k_j} \cdot \eta_i^{l_j}, \qquad \xi_i = x_i / |c| ; \qquad \eta_i = x_i / |c| \qquad (9)$$

$|c|$ — the modulus of the maximum value of the point abscissa (ordinate) on the approximation area.

After the approximation the vector δU_l causes a residual deviations V_{li} which are characterized by the covariation matrix according to (7)

$$K_V = \mu^2 \ (A_\xi \ Q_\xi \ A_\xi{}^T). \tag{10}$$

As approximation is implemented with using of the power algebraic polynoms, the mathematical correlation appears among the vector V_l elements. On these conditions, the matrix Q_ξ which is a normalized covariation matrix of the residual deviations for separate terms of the approximating polynom for points with coordinates $|x|=|y|=c$ has a predominant importance for the prediction.

Then value of a dispersion the residual deviation for this point is

$$D_{vi} = \mu^2 \sum_{i=1}^{m} \sum_{j=1}^{m} (Q_\xi)_{ij} \tag{11}$$

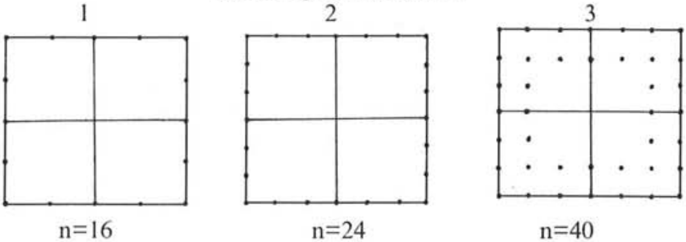
Using the elements of this matrix with various quantity of the control points and with various geometric schemes of the location ones it is possible :

— to determine the dispersion value of the residual deviation with the given precision of a determination of the approximating polynom separate terms.

— to find the optimum scheme of the points location on the space images for given kind of the approximating polynom.

The numerical values of the matrix Q_ξ elements for the polynom of 3th power with various schemes of the points location are given lower:

schemes points location



for schem 1

$$
Q_\xi = \begin{bmatrix}
a_0 & a_1x & a_2y & a_3x^2 & a_4xy & a_5y^2 & a_6x^3 & a_7x^2y & a_8xy^2 & a_9y^3 \\
0.90 & 0 & 0 & -0.61 & 0 & -0.61 & 0 & 0 & 0 & 0 \\
0 & 2.57 & 0 & 0 & 0 & 0 & -2.27 & 0 & -0.67 & 0 \\
0 & 0 & 2.57 & 0 & 0 & 0 & 0 & -0.67 & 0 & -2.27 \\
-0.61 & 0 & 0 & 0.56 & 0 & 0.33 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0.17 & 0 & 0 & 0 & 0 & 0 \\
-0.61 & 0 & 0 & 0.33 & 0 & 0.56 & 0 & 0 & 0 & 0 \\
0 & 2.27 & 0 & 0 & 0 & 0 & 2.21 & 0 & 0.38 & 0 \\
0 & 0 & -0.67 & 0 & 0 & 0 & 0 & 0.57 & 0 & 0.38 \\
0 & -0.67 & 0 & 0 & 0 & 0 & 0.38 & 0 & 0.57 & 0 \\
0 & 0 & -2.27 & 0 & 0 & 0 & 0 & 0.38 & 0 & 2.21
\end{bmatrix},
$$

$$D_v = 0.9\mu^2$$

for schem 2

$$
Q_\xi = \begin{bmatrix}
a_0 & a_1x & a_2y & a_3x^2 & a_4xy & a_5y^2 & a_6x^3 & a_7x^2y & a_8xy^2 & a_9y^3 \\
0.72 & 0 & 0 & -0.50 & 0 & -0.50 & 0 & 0 & 0 & 0 \\
0 & 1.93 & 0 & 0 & 0 & 0 & -1.69 & 0 & -0.62 & 0 \\
0 & 0 & 1.93 & 0 & 0 & 0 & 0 & -0.62 & 0 & -1.69 \\
-0.50 & 0 & 0 & 0.45 & 0 & 0.29 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0.12 & 0 & 0 & 0 & 0 & 0 \\
-0.50 & 0 & 0 & 0.29 & 0 & 0.45 & 0 & 0 & 0 & 0 \\
0 & -1.69 & 0 & 0 & 0 & 0 & 1.62 & 0 & 0.40 & 0 \\
0 & 0 & -0.62 & 0 & 0 & 0 & 0 & 0.48 & 0 & 0.40 \\
0 & -0.62 & 0 & 0 & 0 & 0 & 0.40 & 0 & 0.48 & 0 \\
0 & 0 & -1.69 & 0 & 0 & 0 & 0 & 0.40 & 0 & 1.62
\end{bmatrix},
$$

$$D_v = 0.7\mu^2$$

for schem 3

$$
Q_\xi = \begin{bmatrix}
a_0 & a_1x & a_2y & a_3x^2 & a_4xy & a_5y^2 & a_6x^3 & a_7x^2y & a_8xy^2 & a_9y^3 \\
0.16 & 0 & 0 & -0.12 & 0 & -0.12 & 0 & 0 & 0 & 0 \\
0 & 0.50 & 0 & 0 & 0 & 0 & -0.47 & 0 & -0.17 & 0 \\
0 & 0 & 0.50 & 0 & 0 & 0 & 0 & -0.17 & 0 & -0.47 \\
-0.12 & 0 & 0 & 0.19 & 0 & 0.05 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0.1 & 0 & 0 & 0 & 0 & 0 \\
-0.12 & 0 & 0 & 0.05 & 0 & 0.19 & 0 & 0 & 0 & 0 \\
0 & -0.47 & 0 & 0 & 0 & 0 & 0.57 & 0 & 0.03 & 0 \\
0 & 0 & -0.17 & 0 & 0 & 0 & 0 & 0.32 & 0 & 0.03 \\
0 & -0.17 & 0 & 0 & 0 & 0 & 0.03 & 0 & 0.32 & 0 \\
0 & 0 & -0.47 & 0 & 0 & 0 & 0 & 0.03 & 0 & 0.57
\end{bmatrix}.
$$

$$D_v = 0.6\mu^2$$

So this model for the prediction uses matrix Q_ξ instead of covariation matrix K_v. By this such advantages as simplicity of determination and reliability are reached.

4. The model of the prediction of the unconsidered polynom terms influence on the approximation results.

Imagine the distortion vector δU_2 as a function of a polynom unconsidered terms for the point with the coordinate $x = y = |c|$, which is on the edge of zone of the approximation area. Then :

$$\delta U_2 = G_U \cdot \delta_{k'l'}, \tag{12}$$

where
$$G_U = -(A^T \cdot A)^{-1} \cdot (A^T \cdot A_{p\xi}), \tag{13}$$

$$\delta_{k'l'} = [\delta_1 \ \delta_2 \ \dots \ \delta_h \ \dots \ \delta_p]^T, \tag{14}$$

here p — quantity of polynom unconsidered terms,

$$\delta_h = U_{k'l'(h)} \cdot c^{(k'_h + l'_h)} \tag{15}$$

$A_{p\xi}$ — the matrix of the coefficient with δ_h, where

$$\alpha_{p\xi(ih)} = \xi_i^{k'h} \cdot \eta_i^{l'h} \tag{16}$$

The residual deviations V_2 caused by vector δU_2 is

$$V_2 = (A_{p\xi} - G) \cdot \delta_{k'l'} \tag{17}$$

where
$$G = A_\xi \ (A_\xi^T \cdot A_\xi)^{-1} \cdot (A_\xi^T \ A_{p\xi}). \tag{18}$$

As the elements of matrix A_ξ and $A_{p\xi}$ are the function of the image points coordinates, the elements of matrix G and $(A_{p\xi} - G)$ can be beforehand determined for various points quantity and the schemes of the location ones. And here the matrix $(A_{p\xi} - G)$ elements show what share of the h[th] polynom unconsidered terms (15) remains on the control points after the approximation.

Therefore even with uknown values of the vector δ elements using comparison of values $(A_{p\xi} - G)$ for various schemes of the points location and various approximating polynom power it is possible to find:

- the optimum scheme of the points location with the approximation for given polynom power;
- the optimum power of the approximating polynom for the given cartographic projection;
- the expected value V_2 (in the shares from δ_h) for the given scheme of the points location and for the given polynom power.

The analysis of the structure of the matrix G_U and G (expresion (13) and (18)) shows that the basis of this prediction model is a finding of the matrix $G_{u\xi}$, which is:

$$G_{U\xi} = (A_\xi^T \cdot A_\xi)^{-1} \cdot (A_\xi^T \ A_{p\xi}) \tag{19}$$

The matrix $G_{U\xi}$ elements give possibility to analyse how does each term of the approximating polynom reduce the unconsidered terms of the higher powers.

For any points it is

$$G_{U\xi\,(jh)i} = G_{U\xi(jh)} \cdot \xi_i^{k_j} \cdot \eta_i^{l_j} \tag{20}$$

The numerical values of the matrix $G_{u\xi}$ for the unconsidered terms of the 4-th power are given lower:

for schems 1,2 for schem 3

$$G_{u\xi}=\begin{bmatrix} xy^3 & x^2y^2 & x^3y & x^4 & y^4 \\ 0 & -0.99 & 0 & -0.05 & -0.05 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 1.0 & 0 & 1.07 & -0.08 \\ 0.83 & 0 & 0.83 & 0 & 0 \\ 0 & 1.0 & 0 & -0.08 & 1.07 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad G_{u\xi}=\begin{bmatrix} xy^3 & x^2y^2 & x^3y & x^4 & y^4 \\ 0 & -0.37 & 0 & -0.20 & -0.20 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0.58 & 0 & 1.13 & 0.07 \\ 0.78 & 0 & 0.78 & 0 & 0 \\ 0 & 0.58 & 0 & 0.07 & 1.13 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\Sigma \quad 0.83 \quad 1.01 \quad 0.83 \quad 0.94 \quad 0.94 \qquad \Sigma \quad 0.78 \quad 0.79 \quad 0.78 \quad 1.00 \quad 1.00$$

So the developed approach to the accuracy estimation of the transformation of the space images into the given cartographic projection solves the problem of the accuracy and efficiency prediction for this transformation.

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THE USE OF SATELLITE IMAGERY IN VEGETATION STUDIES AT HUMID TROPICAL AREAS WITH GREAT DECLIVITY

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Introduction

The village of Picinguaba in the munipality of Ubatuba, State of São Paulo, Brazil, is in the midst of the coastal tropical rain forest with traditional forms of land use. This area has a reasonable amout of documentation from other remote sensors such as aerial photos. It has a special classification, being an area of environmental conservation.

Area Description

The study area was defined within the political boundaries of Picinguaba. It's area comprizes 7942 ha. and is within the Ocean Moutain Range State Park. It is located in the northern portion of the Ubatuba municipality, between 23 and 24°S, 44 and 45°W.

One of the most important reasons for choosing Picinguaba was the scale of this test area. It adequatelly represents the slope of the Ocean Moutain Range, with altitudes from sea-level to 1200 m. In an ocean-mountain terrain crossection, vegetation variations can be seen due to the altitude gradient, soils variations, land use among other factors.

The social caracteristics of this test area, associated to its geographical coverage constitute determining factors for it's choice. The village of Picinguaba was incorporated into the Ocean Moutain Range State Park in 1979 and has 60% of it's area located in the northern shores of the State of São Paulo coast. The State law n° 10251, from 1977, created the Ocean Moutain

Range State Park with the objective of assuring the preservation of the fauna and flora, natural beauty, and to discipline it's usage for scientific, educational and recreational purposes.

Methodology

The image used in this study is from LANDSAT TM. It is a multispectral image composed of channels TM3, TM4 and TM5. It encompasses the northern coast of the State of São Paulo, which includes the Ocean Moutain Range, portions of the inland plateau and a small portion of the State of Rio de Janeiro (Cape Jacutinga - Municipality of Parati). This image was processed on a CCT tape with density 1600 bpi by the brazilian space research agency - INPE. It represents a quadrant of location S, base 218, point 76, deslocated 2"N, dated 11 September, 1990. This scene was partitioned with 627 lines and 576 columns over the village of Picinguaba. The choice of the channels: TM3; TM4; and TM5 that took part in this image, was based on previous studies involving vegetation and LANDSAT TM imagery.

These channels are considered the most apropriate for vegetation studies. They comprize the visible, near-IR and mid-IR spectrum, respectively. Lacaze and Joffer (1987) in a vegetation study in Andaluzia, Spain, concluded that TM3; TM4; and TM5 are the most indicated channels for these types investigations. They cite a strong correlation between channels TM1, TM2, TM3, TM5 and TM7. Channel TM4 was excluded because it did not show good correlation with the other channels. Leprieur et al. (1988) came to the same conclusion in a study of the Saint Quirin forest, eastern France. They also point out that TM3, TM4 and TM5 are most apropriate in the discrimination of species and forest ages in all situations. Similar results were found by Benson (1985), Horler (1986). Moram et al. (1993) selected TM2, besides TM3, TM4 and TM5 in the study of spectral signatures in the Amazon. This choise was based on an analysis of band separation to determine the most apropriate combination. In the analysis of visual photografic products of LANDSAT TM, Saraiva et al. (1987) tested all seven channels and found that TM3, TM4 and

TM5 are most usefull in the study of prairie grass and reforestation of Pinus and Eucaliptus. Ponzoni and Carvalho (1988) found that Santiago et al. (1986) chose these very same channels in the investigation of reforested areas in the State of Mato Grosso do Sul, Brazil, through digital processing.

In the digital processing of the images, the necessary phases for the understanding, manipulation and classification are included. The tecniques of pre-processing are usually perfomed by the supplier of the scene under study. These are radiometric, atmospheric and cartographic corrections. To increase the precision, a numerical terrain model was used. The cartographic correction was done through correction points on the terrain, recognizable on the digital topographic base as well as on the image. These techniques increase image quality (Novo, 1989).

After selection of the scene that contained Picinguaba, channels TM3, TM4 and TM5 were observed seperately along with a coloured composit (false colour) by alocation of the RGB system to the raw channels. The observation of the raw channels shows a greater variety of tones of gray associated to the radiometric responses of the vegetation formations, when comparing channels TM4 and TM5 to channel TM3. On the other hand, mineral targets are better identified by channel TM3 than channel TM4. Best definition of the coastline was obtained with channel TM5. Terrain features were best observed with channels TM4 and TM5. Through observations of various colour combinations, red was chosen for channel TM4, green for channel TM5, and blue for channel TM3.

The false colour composit 4, 5 and 3 gave the best visual representation of tone and texture of vegetation over Picinguaba. Through this analysis, it was possible to verify the discriminating ability of spectral imagery. Tonality variations of red-yellow indicate different vegetation formations and were observed due to a combined contribution of channels TM4 and TM5. Tone variations over densely vegetated areas were seen and are associated to various aspects, most importantly the direction of the sloped terrain. Texture of the composite did not vary significantly, indicating the overall reflectance of the unprocessed channels was very similar. The objective of the Analysis of Main Components is to identify redundant features, increasing effectiveness of classifications by reducing the number of (unnecessary) informations, thereby reducing time spent in the analysis (Serradj, 1992).

Vegetation indices were created as a combination of two spectral bands: red and the near-IR. The interest in using these bands is to identify different levels of chlorophyl activity of vegetation cover (Bariou el al. 1985). In the digital classification of the LANDSAT-TM image over the Picinguaba village, supervised classification was made using aerial photos, a map on vegetation and land use, and documentation from Picollo (1992). The complexity of this fragmented image was associated to the scale in which the analysis of the spectral and spacial LANDSAT TM image was made. At any rate, this complexity is associated to the diversity that can actualy be seen at the target area. Classifications were made in order to consider this diversity, expressed by the condition of surface pixels.

Results

The classified image over the study area was very fragmented, specially due to terrain features, with shaded and unshaded areas, and also due to local diversity in both mosaics alpha and beta. With the classified image it was possible to conclude that the direction of terrain slopes determines the state of the surface of the image. Slopes with northeastern orientation, with greater solar radiation, differ significantly from slopes oriented southwesterly. The degree of declivity also affects these differences. Such slope differences are associated to similar differences in the type of vegetation cover. Differences in vegetation cover are associated to different radiometric and spectral responses, when the compared locations are on the northeastern and southwestern slopes. Interpretation difficulties of the scene under study were due to diversity of the target (vegetation formations), and their radiometric proximity with similar spectral responses in the visible, near-IR and mid-IR.

This limitation was quickly noticeable with the unprocessed channels, restricting a better discriminatory analysis of the processed channels.

Temporal aspects were analysed through aerial phographs taken at various ocasions whereas only one satellite image was used. The analysis of non-simultaneous satellite images could have increased the spectral understanding of the observed area. Analysis of precipitaton data showed that the least aproporiate times for satellite observations are between December and March. During these months, cloud cover is more frequent and intense associated to the high precipitation levels. Thus, non-simultaneous satellite data, appropriate for the analysis of ecosystems and vegetation seazonal dinamics, has it's limitations because a good comparizon between various observations shoud be free of other intervening effects, such as cloud cover.

Conclusion

In the resulting digital classification, image pixel characteristics was below initial expectations. Shading and slope orientation interfered too much in the classification. The definition of the spectral classes represented the various existing systems relationships but did not yield to a classification in which pixels where associate to their best locations. This occured mainly with the marine wetland and inner valley vegetations. Therefore, the results obtained in this test, after following the step-by-step digital processing phases did not adequately represent the classes of vegetation formations. In conclusion, the satellite observed surface states of Picinguaba village solely constitute another possible information tool among others that are needed in the understanding of digital cartography with the purpose of representing the scene of a test area.

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SPATIAL AND TEMPORAL ANALYSIS OF FLOODS IN SOUTHEAST OF BRAZIL: MAPPING AND MODELING WITH GIS

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Abstract

In this study the spatial analysis tools of GIS and DTM models are applied to flood frequency regionalization, using annual maximum streamflow series of southeast of Brazil gages. The flood data are transformed in surface images obtained by kriging interpolation, and after exported to Idrisi GIS, where the images are analyzed using time series analysis and boolean algebra tools. The results shows that this approach may be used as complementary technique to improve spatial and temporal analysis of floods, and mapping hydrologic regions where the data are scarce.

1. Introduction

The phenomena of flooding has caused too many dies, demolishing hundreds of houses and uncovered thousand of peoples in southeast of Brazil. Due serious social outcomes resulted of these hydrologic events, is very important developing studies in sense to mapping the most probable areas of flood occurrence, mainly in areas where streamflow data are scarce.

The literature about this theme has shown that there are too many studies using statistical methods to estimate regional curves of flood frequency, which are based on analysis of temporal series of maximum streamflow data. It is possible to observe that these studies has as main objectives the numerical analysis, and they almost doesn't use spatial analysis tools available on GIS and DEM packages.

In sense to offer another option of regional flood analysis applied to areas where hydrologic data are scarce, we present here a methodology to spatial and temporal analysis and mapping of floods, based on association of geographical information systems and digital elevation models tools.

2.Test Area

The test area is site in north of state of Sao Paulo, southeast of Brazil. This area is drained by Pardo, Mogi Guaçu, Sapucai and Turvo river basins and has a high density of streamflow gages, if we compare with others areas of country. It is an region with several geomorphologic units and a geological diversification. In the west, there are sandstone plateaus with low relief, in center there are basaltic and diabase plateaus, and, in the east, high plateaus with quartzitic rocks and basaltic-sandstone escarpments. This region is characterized by a well developed economy based on mechanized agriculture of sugarcane, coffee, orange and pastures.

3. Some Usual Methods of Regional Flood Frequency Analysis

The regional flood frequency analysis of hydrologic variables has as objective the concentration of hydrologic spatially distributed, on maps, curves or functions, allowing to estimate hydrologic parameters where it doesn't exist (Lanna et al., 1993). Cunnane (1987) point out that there are two more important methods of flood frequency analysis at regional level: the flood index method and the bayesian method. We will treat here only the flood index method, because it has technical characteristics that can be adapted with more facility in spatial analysis tools of GIS and DEM.

Mosley (1981) presented a method to identificate hydrologic homogeneous regions, based on cluster analysis of catchments, having as reference the mean annual flow by area units (l/s/km²) and his coefficient of variation (CV). This method enable the formation of catchments groups which one having low variance of spatial and temporal flood intensity. Acreman & Sinclair (1986) adapted and applied this method to identify 5 hydrologic regions based in fluvial data from 168 catchments of Scotland. Also Wiltshire (1986a) has classified 376 catchments in 5 hydrologic regions in UK. These authors showed that each region has different frequency curves to a same flood index.

Crespo & Tucci (1983) used regression analysis between annual mean runoff and physical characteristics of catchments site in south of Brazil, to identify hydrologic regions. This study was based in annual series of maximum flow as a flood index proposed by Dalrymple (1960).

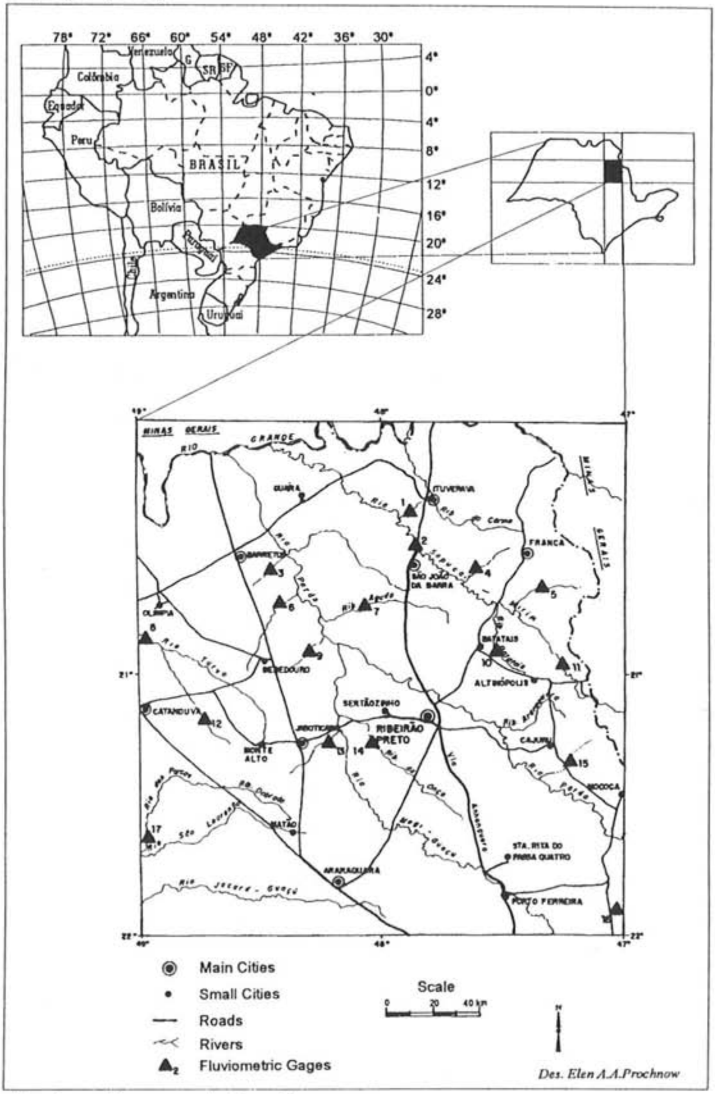

Figure 1 - Localization of test area in Brazil.

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4. The Method, Materials and the Results

To develop this research we used data from 17 fluviometric gages of DAEE (1991), where were collected values of annual maximum flows (AMF) and the catchment area (A). The AMF data were normalized upon catchment area, and used as an flood an index (FI) through the following equation: FI = AMF/A.

The multitemporal analysis was defined upon a 10 years time period (1981-1990). Each gage was registered in geographic coordinates, using as reference topographic sheets at 1:250.000 scale and after digitized through *AutoCad r12* (Autodesk, 1989). The digital files about the 10 maps of point values of FI (one by year), were exported to *Surfer for Windows* package (Golden Soft., 1994), where were saved as *.dat* file.

The 10 files of database were interpolated in sense to generate annual flood surfaces maps. Each surface map was generated using the kriging method and linear variogram model. Finished the interpolation of database maps, these were exported to *Idrisi for Windows* GIS (Eastman, 1995). In this GIS, the interpolated surfaces were structured in raster image format, (real/binary values), in 450 columns by 250 rows and with resolution of 0.2573 mm.

The multitemporal spatial data were analyzed using Decision Support and Time Series Analysis modules of Idrisi. Firstly, the pixels values of each surface map were hierarquized using Rank command. This procedure was used to mapping the pixels with most high values of FI in each year of temporal series. After, through Overlay command, the ordenated pixels values maps were added one to one, resulting in a hierarchic map of relative intensity of flood occurrence. Secondly, was applied the principal components analysis in the set of multitemporal spatial data of FI to generate the 3 principal components. These 3 components maps were used to generate a color composite map (RGB) through Composite command. This pixels values of color composite map were standardized in gray level scale (0-255) and sorted in homogeneous clusters by Cluster command. This groups were interpreted as hydrological regions of flood frequency.

Thirdly and finally, the ranked and color composite hidrological maps were compared with mean annual FI map, and then extracted the histogram and statistical summary of distribution of FI values to each region. The mean annual FI was taked as the image that containing the data to be extracted and the hydrological regions polygons were used as mask images. This procedure was realized using commands available in Database Query module of Idrisi. In sense to show the probability curves of regions, the data were ploted in a cumulative frequency diagram.

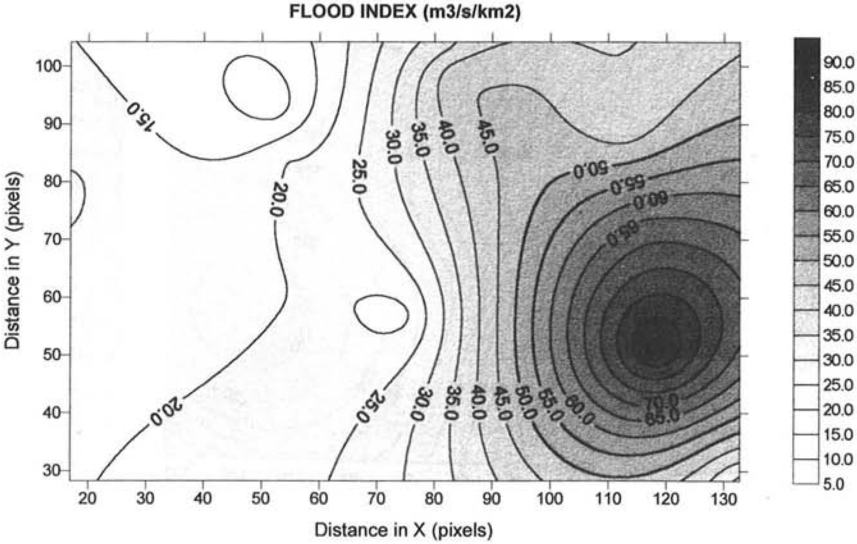

Figure 2 - Isoplethic map of flood index interpolated from 1981 data.

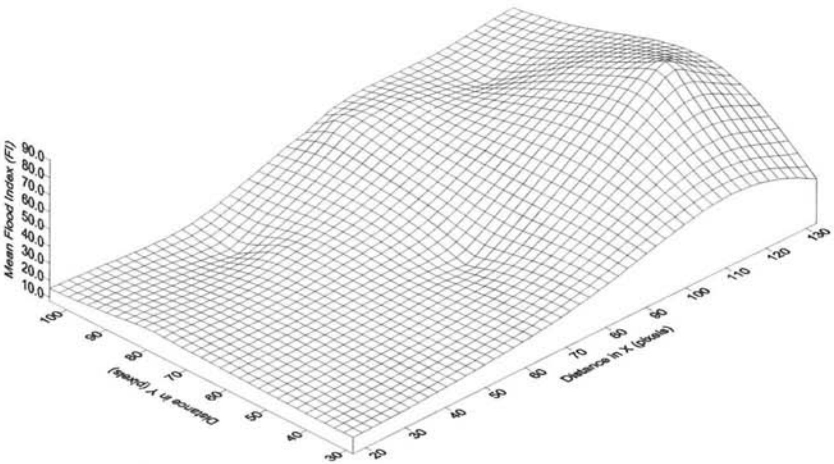

Figure 3 - Flood index surface of test-area based in 1981 data.

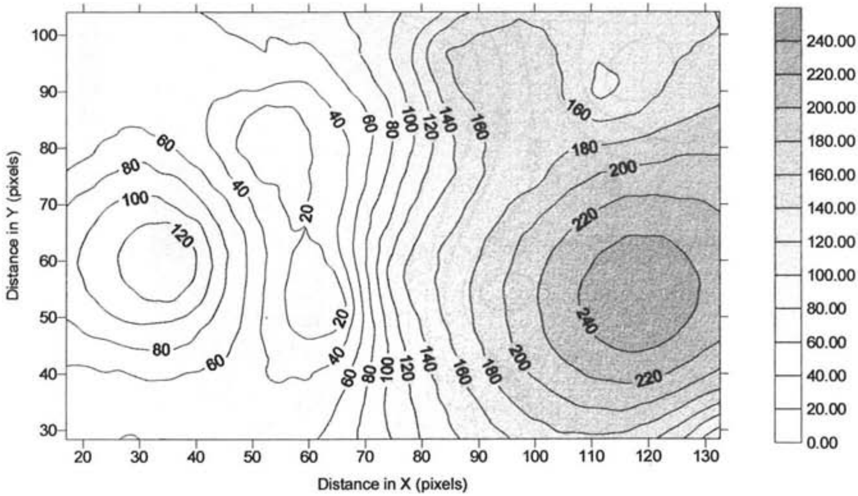

Figure 4 - Surface image (in gray levels) of FI intensity, produced by temporal and spatial analysis based on 1981-1990 period data.

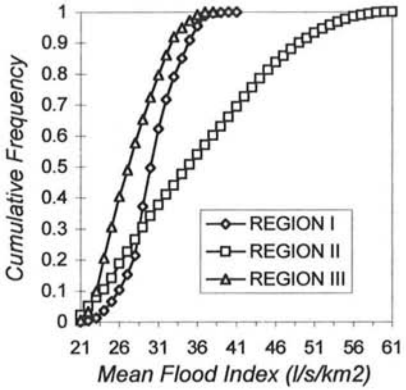

Figure 5 - Cumulative frequency curves of mean flood index of homogeneous regions of study area.

Conclusions

The use of digital image analysis combined with DTM techniques for regional flood frequency estimation, was founded to provide a very good and compatible with traditional methods of flood analysis. The digital data of flood surface, structured by raster model in GIS, are appear to be robust and consistent to estimate statistical parameters of annual maximum streamflow. The great capacity of data handling and the set of spatial analysis tools of GIS, may be used as basis for flood mapping in regions where hydrologic data are scarce. But the success of this approach will depend on spatial resolution and interpolation model of flood data.

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DUTCH ATLAS INFORMATION SYSTEM
Using the Internet for electronic atlas data retrieval

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Abstract

One of the main drawbacks for atlases is their constant need for updating. Atlas producers always face the dilemma when to invest in publishing a new edition . Therefore there has been a search for systems that could simplify the process of updating. On their introduction, electronic atlases seemed to offer this possibility, yet updating them usually still involves producing a complete new edition.

This paper describes tests on a system of distributing electronic atlas data by means of the Internet, thus allowing publishers to be able to provide up–to–date information against limited costs. The system proposed here does only use the Internet for providing the user with data that needs updating. The electronic atlas itself is an application that runs locally. The advantage of this is that the transfer of large amounts of information over the Internet is avoided, making the system fast and cheap, even when using a modem connection. Thus, sophisticated multimedia techniques can be used for the presentation part of the atlas while the data presented can be kept up–to–date by frequent referral to external databases on the Internet.

To evaluate the suitability of such a system, a demo application was prepared. This Dutch Atlas Information System (DAIS) was constructed using a multimedia authoring product called SuperCard and Marionet, a script-level interface to controlling Internet communication.

DAIS lets one produce thematic maps of a multitude of socio-economic data, using various methods, such as choropleths, proportional symbols and chorochromatic maps.

Updating atlas information

One of the main drawbacks of any atlas is the fact that a significant part of the information it offers will be already out–of–date the moment it appears in the shops. This is especially true for thematic maps of fast changing information, such as socio– economic data. But recent events have shown that topographic information can also change at an alarming rate. At the time the Dutch firm of Wolters–Noordhoff were preparing the 51st edition of their Bosatlas (a well known school atlas), war was still raging through former Yugoslavia and their depiction of this part of the world was therefore sure to be outdated.

When trying to keep their atlases as accurate and up–to–date as possible, producers always face this dilemma: Do we invest heavily to publish a new edition now, taking the risk that users do not see the need or do not want to spend money for a up–to–date edition? Or do we wait and then risk losing part of our market because users perceive the product as outdated?

To solve this dilemma, there has been a search for systems that could simplify the process of updating and thus reduce its costs. In the past, this has resulted in solutions such as loose–leaf atlases and softcover additions, but none of these turned out to be a success.

When electronic atlases started to appear on the scene, it was often stated that these would offer easier and cheaper updating.

Updating electronic atlases

For some years now, electronic atlases have been evolving from a experimental and research phase to maturity, taking their place on the market as alternatives or additions to paper atlases.

Electronic atlases appear in many different forms and formats. Kraak and Ormeling (1996) discern three types of electronic atlases: View–only, interactive and analytical atlases. The first is a simple collection of static maps, through which the user can browse, thus giving user possibilities similar to traditional paper atlases. An example of this is the Electronic Atlas of Arkansas (Smith, 1989), one of the first on the market. The second type, such as the InfoNation atlas (Electromap, 1991), offers a mapping environment were the user can control the way the data is mapped to a certain extent. Even more sophisticated interactivity is offered by the analytical atlases, which offer a range of data manipulation tools and even GIS–like functionality. This gives almost unlimited possibilities, but at the same time makes these systems unsuitable for beginners.

Electronic atlases are subject to the same "instant out–of–dateness" as their paper counterparts. They have the advantage, however, of being much easier and thus cheaper to update. Let's take for instance the changing of a border between two states.

In a printed product, this would usually involve totally redrawing one or more maps, making new colour separations for the affected pages and printing these. Thereafter these pages can be issued separately or incorporated in a new edition of the atlas.

In an electronic atlas, only the border would be changed in the files holding the two countries involved, and the updated files can be issued directly to the users. A new edition therefore involves relatively little effort and costs.

The problem remains how to get the updated information to the users. Although CD–ROMs, the most common media for electronic atlases, are relatively cheap to produce, making them available to all users is not so easy and here the same dilemma as described for traditional atlases arises: When to publish a new edition and for what price?

Recently we have seen the emergence of a new factor in all this: the Internet. This can be defined as a network of computer networks based on the TCP/IP protocol, as a community of people who create and use the network, and as the collection of resources stored on those networks (Peterson, 1996). Today the Internet has become a household word and is used to connect millions of computers.

The Internet offers an alternative to publishing electronic atlases in the same way as their paper counterparts. Instead of stand–alone products, sold on CD–ROMs and running on the customers PC, one can offer atlas information directly on the Internet. In light of this, the authors propose to classify electronic atlases according to the nature of their data–storage: Stand–alone atlases (where all data is stored on the user's PC), on–line atlases (where all data and the application itself reside on the Internet) and hybrid atlases, combining the features of the other two.

Stand–alone electronic atlases

This type of electronic atlas is the oldest and still by far the most common. It comprises electronic atlas software running on a local computer system using data that is either incorporated in the application itself or resides on the same computer in some form, as seen in figure 1.

As with paper atlases, the data delivered with the system will partly be outdated and will become more so over time. Some systems allow the user to incorporate updated or third–party datasets, but these need to be purchased separately on CD–ROM or floppy disk.

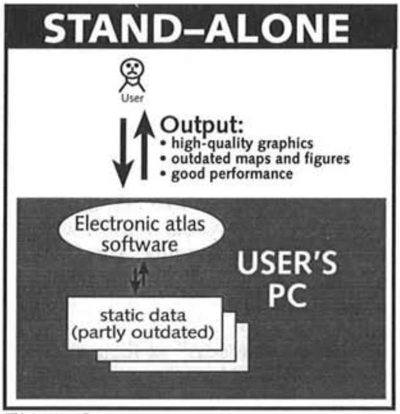

Figure 1.

The state of the art in multimedia technology allows these systems to be highly interactive and user–friendly and offer high–quality maps and other graphics. Because it runs locally, modern computer hardware, powerful yet cheap, can ensure a good performance of the system, resulting in fast response times and smooth running.

On–line electronic atlases

With the emergence of Internet, on–line electronic atlases have become a possibility as well as a reality. Here the electronic atlas software resides on the computers of the atlas producer itself. The data on the system can be kept as up–to–date as possible or there could be links to other sites were the latest figures can be found, such as National Statistical Services.

As can be seen in figure 2, the atlas system co-operates with a server program that supports the HyperText Transfer Protocol (HTTP), which is the standardised communication protocol for the Internet. The software usually runs on powerful mainframes or workstations, because many users can be connected to the server at the same time,

resulting in high data transfer volumes. On the user's side, only some type of HTTP–client software
is needed, for example a browser program such as Netscape or MS Explorer. A major advantage is the fact that this client software is available for virtually any type of computer, thus giving true cross–platform capability.
The functionality offered by the system can vary from offering simple static maps to an interactive mapping environment. Good examples of this are the National Atlas Information System of Canada[2], which is using proprietary software and the IRIS site[3], which utilises Java applets.

The problem with this set-up is the large data flow between the user's PC and the atlas server. Transferring finished maps over the Internet involves sending large graphics files and high interactivity and other multimedia features such as animation and sound add up to sending many kilobytes over the Internet.
Here the weak point of the Internet interferes: It is presently a victim of its own success. The present hardware infrastructure does not accommodate the large crowds that are currently travelling this "information highway".
This is resulting in frequent "traffic jams", especially when using a modem connection, as the majority of users do. As long as technology does not offer any solutions for this problem, the only way to make such a system feasible is reducing the dataflow as much as possible. This can be accomplished by offering only low–resolution graphics and limited multimedia functionality. Even then, the performance of such systems is considerably worse than that of stand–alone systems.

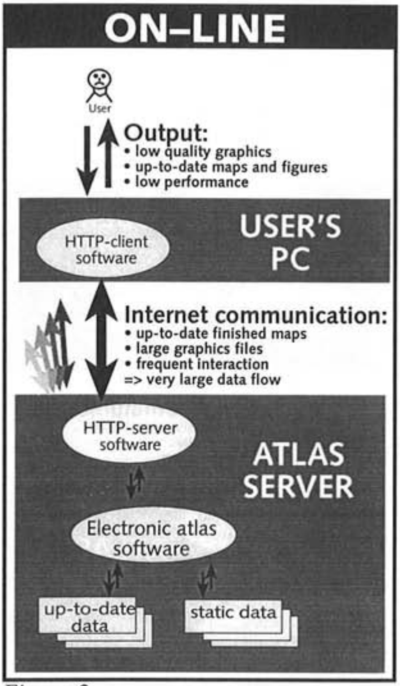

Figure 2.

A logical development of the two approaches mentioned above would be to combine some strong points into a system that offers both up–to–date information and a good performance with full interactivity and multimedia functionality. This can be achieved in a hybrid system, using both local electronic atlas software and Internet communication.

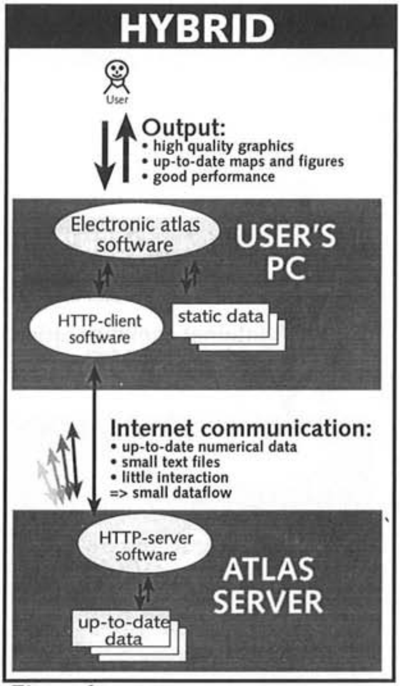

Figure 3.

Hybrid electronic atlases: using the Internet for electronic atlas updating

This approach, visualised in figure 3, offers "the best of both worlds": The data that is subject to frequent change, such as socio–economic figures, is only stored on the atlas server. Every time the electronic atlas software needs any of this, it communicates with the atlas server and receives it over the Internet. This data consist of small numerical data sets only, thus keeping the data flow to a minimum.

Data that is more static in nature is kept on the user's computer, but the system keeps track of the validity of this by occasionally checking if an update is available. If for example there has been a border change, it can download the updated boundary files from the server. The advantage of all this is that the transfer of large amounts of information over the Internet is avoided, because the only data transferred frequently are relatively small sets. Updates of larger files only occurs occasionally. This makes the system fast and cheap when using a modem connection. Thus, sophisticated multimedia techniques can be used for the presentation part of the atlas, while the data presented can be kept up-to-date by frequent referral to external databases on the Internet. The information available is not limited to the one database kept on the atlas server, in theory all the data on the Internet could be used. To enable this however, standardisation of the data–formats would be required.

The Dutch Atlas Information System

In order to evaluate the feasibility of a hybrid electronic atlas system as described above, the Cartography department of Utrecht University has constructed such an application. This, the Dutch Atlas Information System (DAIS)[4], demonstrates the concept by offering a multimedia front–end to the user with which he or she can construct thematic maps of the Netherlands from a set of up–to–date figures.

In order to facilitate fast prototyping as well as a flexible multimedia environment, the DAIS application was constructed using a multimedia authoring product called SuperCard (by Allegiant Technologies, Inc.). Started as a extension of HyperCard, the authoring application that Apple shipped with their Macintosh computers, it has developed into a powerful tool for assembling and delivering interactive multimedia content and custom applications. With the forthcoming SuperCard Runtime for Windows, projects can also be distributed to DOS–based users.

SuperCard projects (and other authoring packages such as Apple's HyperCard and Macromedia's Director) can be made to act as HTTP–clients by using an add–on program called Marionet (also by Allegiant), which offers a script-level interface to controlling Internet communication from within the multimedia environment. Thus, the DAIS application running at the user's computer can issue requests for information and files to the atlas server at Utrecht University. This atlas server uses straightforward HTTP– server software called WebStar, running on an Apple Macintosh. This handles the information requests coming in from the DAIS software and sends out files with socio–economic data sets and when necessary updated boundary files.

DAIS lets one produce thematic maps of a multitude of socio-economic data, using various methods, such as choropleths, proportional symbols and chorochromatic maps. All data are stored together with some meta-data, such as the nature of the data, the collection date, if it absolute or relative, etc. Thus, a user with no cartographic background can let the system decide on which mapping method to use, which graphic variables, the number of classes, the classification scheme, etc., In this way, the construction of "wrong" maps, such as choropleths from absolute data, can be avoided. Users with more skills can override all default settings with their own preferences, providing a highly flexible mapping environment.

Because it is meant to be a demo– and test–site, not a finished product, the system is constantly under (re)construction and the functionality will be subject to frequent change. Therefore, the best way to get an idea of its content is to visit the DAIS home–page (at http://kartoserver.frw.ruu.nl/html/dais/dais.html), download the software and test its usefulness for yourself.

Conclusion

DAIS has in the authors opinion proved the feasibility of hybrid electronic atlases. It is meant for demonstration purposes only, with no intention of becoming a finished or even a fully functional system. But even in its current form it shows that by utilising this set-up, the user can be offered an attractive, responsive atlas environment with high interactivity and good performance, resulting in low–cost, high–quality maps which, most important of all, depict up–to–date information.
The work presented here has only touched upon the technical implications and the merits to the users. Certainly some work is needed to evaluate the *economic* possibilities of these kind of electronic atlases as well.

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Notes

1. All trademarks are acknowledged
2. http://ellesmere.ccm.emr.ca/wwwnais/wwwnais.html
3. http://allanon.gmd.de/and/java/iris/Iris.html
4. The DAIS software can be downloaded from its home–page at http://kartoserver.frw.ruu.nl/html/dais/dais.html
   This site also offers more information on the system as well as an electronic version of this paper.

MAPS FOR DISABLED PEOPLE

COLIN E ANTWIS
FIELDSMAN TRAILS
FRON DEG, CLAYTON ROAD, MOLD
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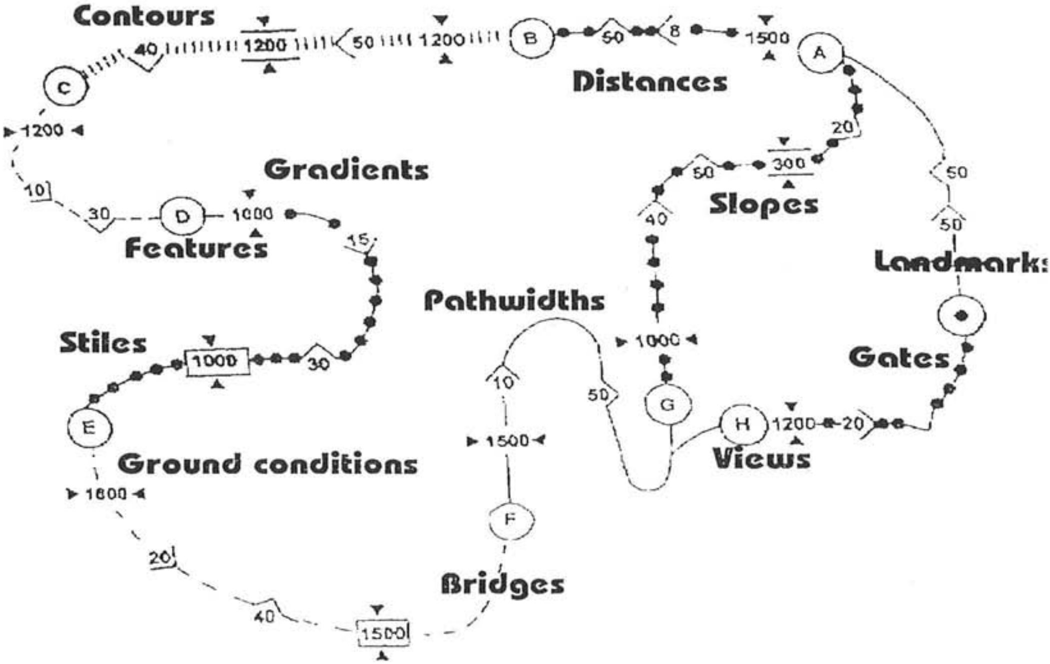

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- Gate
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- River
- Phone Box
- 6 Steps
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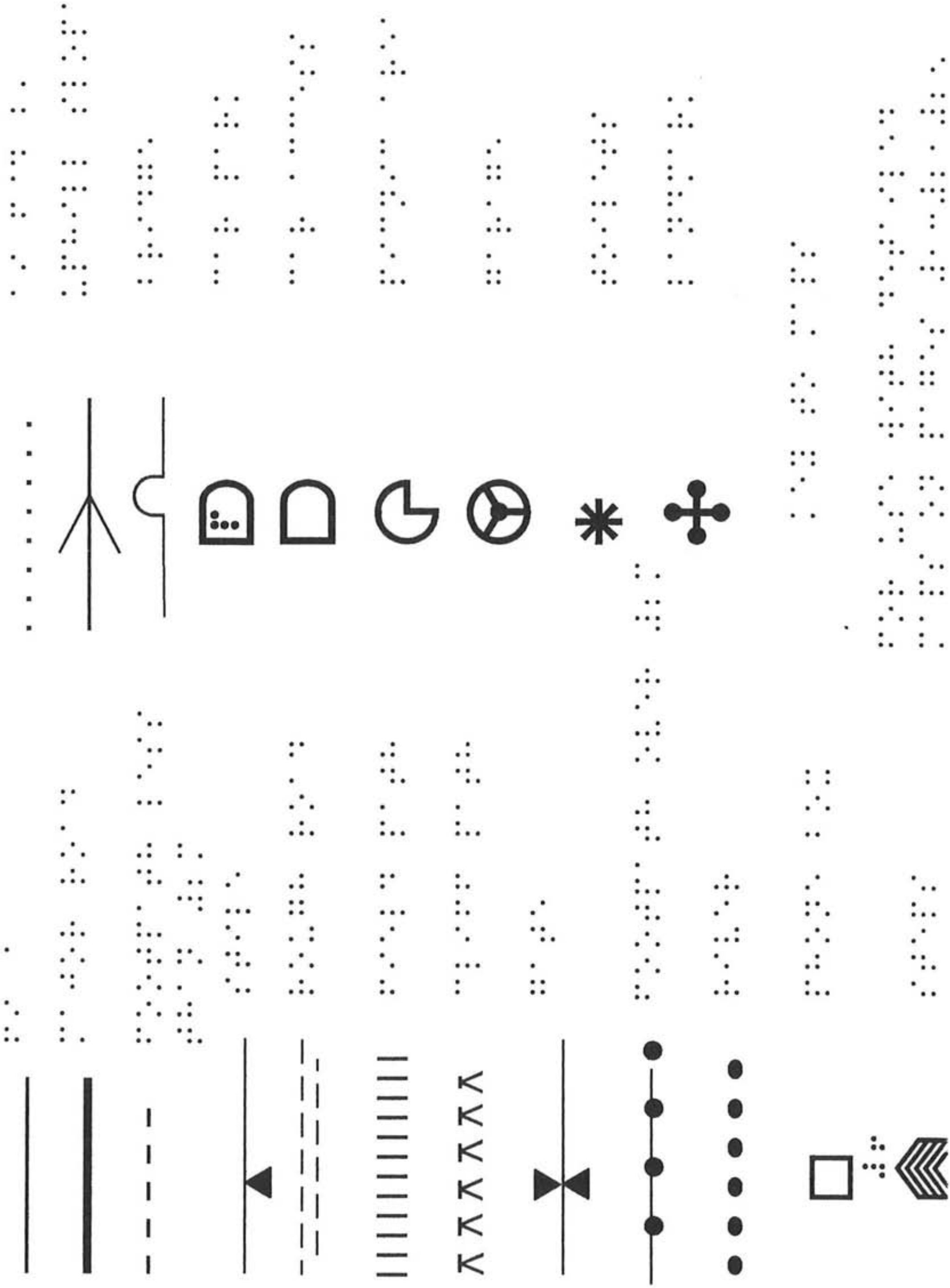
- Uphill slope
- Bridge
- P Car park
- Car Access
- Picnic area
- Garage
- Toilets
- Landmark

1941



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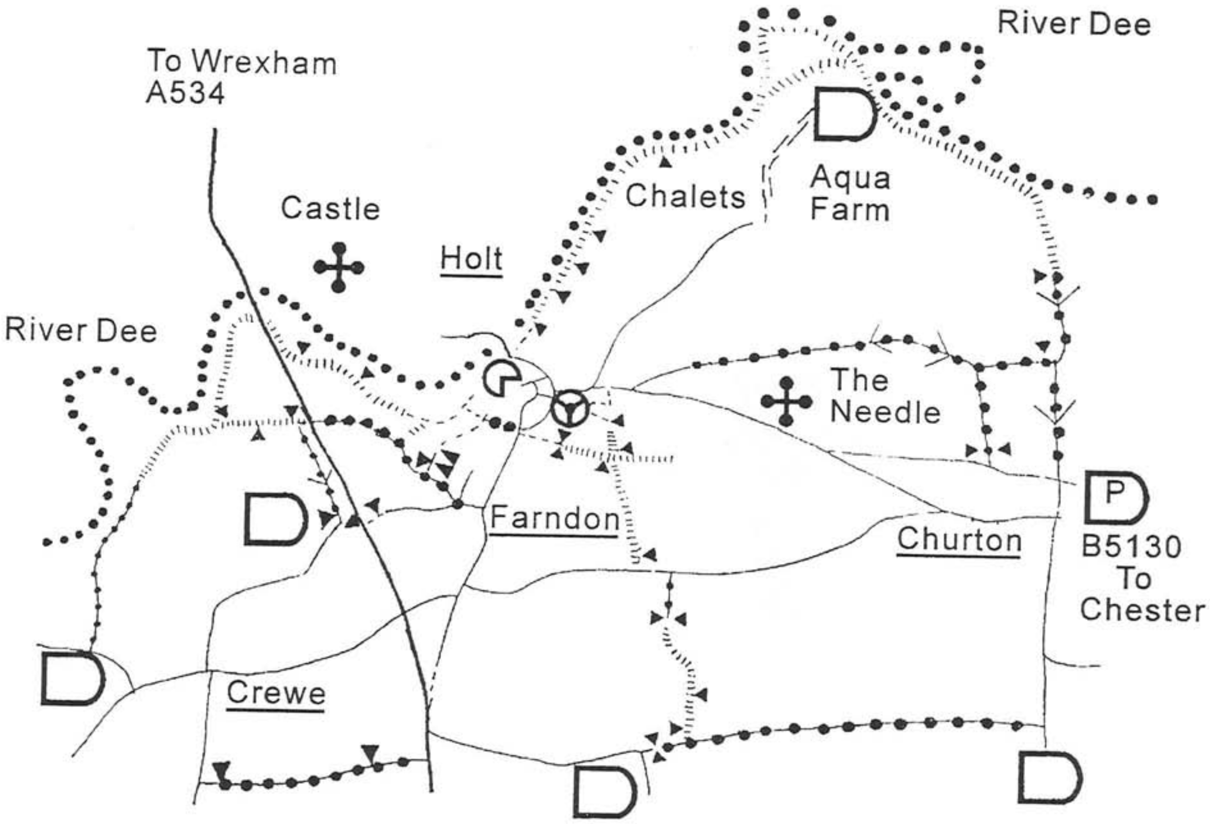

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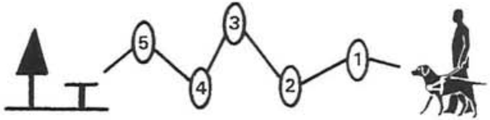

" FOLLOW THAT VOICE "

CROATIAN MILITARY CARTOGRAPHY

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Abstract

The article highlights the beginning and conditions of the foundation of Croatian military cartography, its activities during the Homeland war, plans and problems of further development.

During the homeland war the Service of the Croatian Military Cartography provided the necessary geotopographic and hydrographic material in analogue and digital form for the purpose of preparing and realization of combat activities. Simultaneously with providing the spatial data for war purposes, there were also activities carried out to connect the Republic of Croatia with the western countries and to establish prerequisites for the connection to cartographic systems of the western defence system.

In the forthcoming period, the Service of the Croatian Military Cartography will be fully engaged, first of all, in modernization of the existing cartographic material, in the production of new material and in establishing the geoinformation system of the Croatian Army.

1. Introduction

Since the entire military planning and performance of military operations is carried out in the space and on real land, the geodetic and cartographic profession are the factor that cannot be avoided within the frame of military forces.

Croatian military cartography was formed at the beginning of the War in 1991 in very inconvenient conditions, with insufficient number of military cartographic experts, without necessary cartographic material and without contemporary cartographic equipment.

After the enemy army had gone from the Republic of Croatia in 1992, there was a smaller quantity of topographic map proofs left behind in the barracks. Since the fair draughts for this maps were unapproachable to us (for all military topographic maps at the scales of 1:25000 to 1:300000, the publishing and fair draughts are kept in the military Geographic Institute in Belgrade), it was necessary to make the fair draughts in the most convenient way. At the beginning, one of the most important tasks was to provide for the area of the Republic of Croatia and its border territory a few copies of each map sheet of the latest edition.

Very soon it became clear that ordinary photocopies can not meet the military demands in the War, which initiated rapid and efficient way of reproduction. By scanning the print of each sheet, and with the help of raster plotter, the fair draughts were produced, and the facsimile was obtained by the reproduction in four-colour off-set printing. At the same time, the various general topographic and thematic maps started to be published. For special military purposes, the data obtained by processing the satellite photographs were used for updating the map contents.

The systematic work on geotopographic and hydrographic securing of Croatian army, i.e. the securing with appropriate spatial data and material (on land, at sea, in the air) in classical and digital form, started in the second half of 1991 by foundation and activities of the Geodetic Institute in the Department of Defense of the Republic of Croatia (DDRC). Today, this activity is organized within the scope of the Administration for Civil Engineering in DDRC.

A short presentation of the Service of Croatian Military Cartography has been given in the presentation of the entire cartographic activity in the Republic of Croatia in the period from 1991 to 1995 at the International Cartographic Conference in Barcelona (Frančula et al., 1994). This paper offers the retrospection of the problems as well, that we meet in our work.

2. Major problems in establishing and functioning of geotopographic support

The system of geotopographic and hydrographic support presents an important segment of military system of making decisions and giving orders.

In the system C^3I/C^4I (Command Control Communication and Intelligence/ Command Control Communication Computers and Intelligence) the optimum quantity of spatial information, i.e. the established military geographic information system has an essential significance in the control and analysis of the development of combat activities by using recent information technology (Domazet 1995). Such system must be recognisable by its efficiency, flexibility and resistance.

Because of the war conditions, too short time and many other circumstances, the military digital cartographic system, as the subsystem of GIS, has not been established. However, the experiences have been gathered and the necessity comprehended to have GIS created and developed as the basis of C^3I/C^4I systems.

The main difficulties in the functioning of the geotopographic system could be reflected in the following items:

- geodetic and cartographic incompatibility;
- problems referring to scale and updated contents on the existing cartographic material;
- non-existence of national topographic and cartographic database and standards for the transfer of spatial data.

Geodetic and cartographic incompatibility

The majority of the existing graphic cartographic documents and geodetic data refer to the coordinate system leaning against the old Austro-Hungarian system with the origin in Hermmannskogel by Vienna. The research has shown that the trigonometric network at the territory of the Republic of Croatia has been moved eastwards by 15" to 20" (about 400 meters), and in the direction of latitude, the deviations vary from +2" to -5". The network orientation has an error of about 7". The inner accuracy of the network is also not homogeneous, and the network scale is varying by magnitudes that do not meet current world standards.

The above mentioned prevents our cartographic material and data from being connected with the western countries, disturbs easy application of GPS technology etc. In the last five years, a series of GPS measurements have been made at the first order trigonometric points under the authority of the State Geodetic Administration, and in collaboration with the Faculty of Geodesy, University of Zagreb, the Institute for Applied Geodesy from Frankfurt, and the geodetic institutions in Croatia. The GPS measurements have been made through the connection on to the laser stations in Graz and Matera, and the coordinates have been determined in the World Geodetic System WGS84.

On the basis of these measurements, the parameters for the transformation of coordinates used for military purposes have been determined. Since the existing trigonometric network is not homogeneous, the transformation parameters have been calculated separately for the northern part of Croatia and separately for the southern part.

The establishment of homogeneous fields of permanent geodetic points for the area of the Republic of Croatia, will enable also the renewal of topographic maps, apart from other benefits for geodetic and cartographic profession (Gojčeta 1997).

Problems of scale in military topographic system and updated contents on the existing cartographic material

For the territory of the Republic of Croatia there was a military topographic system at the beginning of the war having the following cartographic series of scales: 1:25 000, 1:50 000, 1:100 000 and 1:200 000. This system of scales keeps the relation 1:2 in linear, i.e. 1:4 in aerial image reduction, moving thereby from larger to smaller scales.

The map at the scale of 1:25 000 represents a detailed tactical map, the map 1:50 000 is the basic tactical map, the map 1:100 000 is the tactical and operational map, and the map 1:200 000 is the operational map.

Apart from the series of scales from 1:25 000 to 1:200 000, there is also a map at the scale 1:300 000 having roads for quick manoeuvre pointed out.

There is a question raised with regard to the appropriateness of using all scales for military purposes, first of all, of the detailed tactical map at the scale of 1:25 000.

During the war the usage of the operational map at the scale of 1:200 000 was symbolic.

The problem is also to be seen in the contents that have not been updated (for example, on the map at the scale of 1:25 000 - contents from 1974-1979).

Non-existence of national topographic and cartographic database and standards for the transfer of spatial data

There is no national topographic and cartographic database on the state level of the Republic of Croatia, there are no defined standards for the transfer of spatial data, no regulations and laws referring to gathering, processing and updating of the spatial data, either in classical or automated way (Horvat et al., 1996).

Non-existence of national topographic and cartographic database and standard for the transfer of digital data causes a problem in accepting digital data for the purpose of producing military maps which have been gathered by other segments of society.

The experiences of other countries in establishing national topographic and cartographic database are just being studied and the national format for data transfer produced (Frančula, Kovačević 1993; Lapaine 1997; Galić, Biljecki 1997).

3. Facsimile publishing of military topographic maps, production of new maps

Facsimile publishing of military topographic maps

At the beginning of 1992 the Department of Defense initiated the procedure for facsimile publishing of military topographic maps at all scales on the basis of the proposal given by the Faculty of Geodesy, University of Zagreb. By means of facsimile procedure, the existing printed images have been scanned and separated into basic printing colours (CMYK).

Since there is no adequate technology and experience in these procedures and because of urgency, the separation into basic colours has been made analogously, directly onto the films, without any editing by computer.

Some smaller supplementations have been made on obtained separated copies in the face contents, while the margin contents have been changed completely. In the face contents the supplementations or changes have been made when there were new data available, e.g. for the state border, titles, object characteristics etc. The margin contents (names and denotations of map sheets, scale data, equidistance, information about projection, magnetic declination, convergency of meridians, year of publishing etc.) were created by means of computer.

In the procedure of facsimile map publishing, the demands of maps with respect to the map accuracy have also been taken into consideration. Certain tolerances on the film as related to the theoretical values of trapezium, i.e. 0.2 mm along the northern and southern side, 0.3 mm sideways, and 0.4 mm diagonally, have been allowed. The theoretical values of trapezium have been calculated before scanning for every sheet, the frame sides of the sheet have been measured, and the necessary percentage of enlargement or reduction calculated (taking into consideration the thickness of the paper as well). We have not succeeded to solve the problem of paper deformation of original map in this way completely when the deformations were nonlinear. The deviations of the north and south side, as well as east and west side of the map trapezium which was used for scanning, were often not of equal values. Since it was not possible to correct different deformations of the frame, the deformations by diagonal or of a part of a map, we have tried to bring the map frame into as accurate dimensions as possible, since the possibilities of the scanner itself were limited.

So far, about 50% of topographic maps sheets at various scales covering the territory of the Republic of Croatia and marginal parts of the neighbouring countries has been processed.

Digital military cartographic systems

In the last few years, digital methods in the production of maps have found a wide application in the practice (Frančula 1996). They make it possible for the individuals to have free access to the spatial information, to process them and visualise cartographically. Digital methods in the Republic of Croatia have been already very much applied in the creation of the unique geographic and land information system (Brukner 1994), in cadastre (Lapaine et al., 1997) and maritime cartography (Horvat 1992; Solarić 1997).

The construction, usage and development of C^3I/C^4I systems require also the construction of modern military digital cartographic system which would enable desk-top cartography, including into the geoinformation system production of electronic operational maps and atlases, etc. Croatian military cartographic activity has made some initiating steps in the last two years in this field.

As temporary solution, the technology of global processing of digital raster data has been adopted, as well as separation into basic colours. The dimensions and colours of scanned material, margin contents, topographic descriptions, and updating of new established state boundaries have been submitted to the processing and changes. However, since the raster data refer to the scanned sheets of the map on the paper, to the quality and sharpness of line, and especially area features (seas, lakes, forests, shadows) could not be improved.

In order to solve this demand, we started to process the maps with the technology of vector data processing. Using this procedure we plan to solve the problems of cartographic map processing that we have had so far (transfer to modern technology, high accuracy, easier supplementation and updating of the content, simple and quick obtaining of fair draught, better quality of the print etc.), and also the requirements of military GIS. The initial results have been achieved through vectorisation of scanned maps, using library of digital symbols, letters and abbreviations in composing the map contents.

Electronic operational map

Providing the data about the Earth and space in digital form enables omniscient comprising of spatial parameters in the most various analysis, calculations and optimization, especially in conducting electronic operational map (Štemberger 1994).

Electronic operational map is connected with the database (data about one's own forces, enemy, territory etc.) enables the control and graphic presentation of combat situation, and the renewal with the same data simultaneously on different locations.

The satellite images and digitized images of aerophotogrammetric survey can be used as the base for electronic operational map along with the digital maps in the raster or vector form.

For the purpose of conducting electronic operational maps on the operational level of commanding and making decisions, the HV system of raster maps at the scale of 1:200 000 has been established (Kovač et al., 1993). The raster base has been obtained by scanning and geocoding. The affine transformation has been used thereby. The amount of errors moves from 5 to 30 m. The graphic base and all objects to be presented on the map are arranged into hierarchical layers.

The next period in the development of the electronic operational map field will be characterized by the creation of various graphic bases in the vector form. The vector form is convenient for different calculations, computer analysis and optimization.

The hitherto achieved results in creating the digital base of cartographic data

The development of the information technology has had an essential influence onto the quantity of gathered data in the cartographic and geodetic activity either through the survey with the data recorded in the digital form (automated geodetic, hydrographic and photogrammetric survey) or through digitizing of basic or auxiliary original sources.

The most important results in the formation of digital cartographic database are the following:

- digital base of trigonometric points of all orders at the territory of the Republic of Croatia and marginal parts of neighbouring countries (about 50 000 trigonometric points given in the state coordinate systems and WGS84);
- library of symbols, letters and abbreviations in digital form for the existing series of military maps scales;
- digital raster maps at the scale of 1:25 000 and 1:200 000 for the territory of the Republic of Croatia and Bosnia and Hercegovina. The maps have been scanned with the resolution of 600 dpi, 256 tones of grey scale;
- digitized images of aerophotogrammetric survey made in the parts of the Republic of Croatia.

4. Hydrographic support

Hydrographic survey and production of hydrographic material was made in the Hydrographic Institute of the former Navy in Split. It was renamed into the State Hydrographic Institute in 1991 which is competent for the hydrographic survey and production of charts, publications and manuals for the territorial waters of the eastern coast of the Adriatic Sea.

All equipment, graphic and numerical data, and the staff have been kept. The interactive computer graphic system DEI with modern hardware configuration and software support provide the possibility for all tasks to be solved for the purpose of maritime economy and for the purpose of Croatian Navy (Horvat 1992).

The cartographic and geodetic incompatibility has imposed itself as a problem, also on charts published by DEI in the conditions of standardizing the presentation of contents on maritime maps, and also of geodetic basis, in accordance with the recommendations of IHO. The charts produced for military purposes offer, apart from graticule Mercator's projection in state coordinate system, the graticule according to the data of WGS84 as well.

Besides the maps for the military purposes, there is also a military navigation manual being produced in analogue and digital form, which will give the graphic presentation of all harbours, marines and bays and other interesting objects along with the navigation data.

In the period to come, the production of electronic navigational map will stipulate the vectorization of maritime maps and other hydrographic material with the final aim to enable the creation of the hydrography information system (HIS) and to be included into the military GIS.

5. Production of military aeronautical charts

Department of Defense of the Republic of Croatia has published two sheets of the aeronautical chart in Lambert's conformal conical projection with two standard parallels at the scale of 1:500.000. Special thematic contents have been given according to the key, dimensions, symbols, colours and instructions for the presentation in accordance with the recommendations of ICAO.

Apart from the graticule in Lambert's conformal conical projection in the state coordinate system, there is also the graticule according to the WGS84 given on the map.

6. Remote sensing and collecting the cartographic data

We use the satellite images SPOT and LANDSAT satellites, as one of digital forms of the topographic materials.

The usage and application of digital satellite and aerial photographs as well as the technologies of remote sensing have increased during the last few years. The development and applications of remote sensing are mostly concentrated on obtaining information about territory changes, i.e. topographic maps renewal. Our purpose is to find the best method for detecting the territory changes by analysing the methodology of merging multitemporal and multisensor images. This is the analysis of the methods of detecting and separating the roads, railways, bridges, canals and other objects from SPOT satellite scenes to provide the supplements of the topographic maps.

By comparing several methods for artificial objects detection (principal component analysis and method of finding and reviewing the differences of gray scale between two images) in SPOT and aerophoto images the notable results were obtained (Javorović 1996). These methods could be applied to all other multispectral and multisensor images.

The scales of output products depend on the projects and original satellite images. They are processed mostly at small and medium scales. In the case that higher accuracy of output presentation is required, the methods of merging images, i.e. the integration of multispectral images and images of better spatial resolution are applied for the purpose to combine data with different characteristics.

Research activities in the field of remote sensing are concentrated to develop more automatic methods for interpretation and classification of satellite images. The research of the use LANDSAT TM satellite images at the Faculty of Forestry University of Zagreb (Kušan 1996), has provided the way of the space surveying and mapping the forests as well as the inventarisation and supervision of the changes by which the supplement of present DEM with the height of the trees for the radiocomunications and radar system needs has been enabled to answer our requirements.

The projects are submitted to accuracy analysis. In the most remote sensing applications, especially when the satellite images with rather rough resolution are treated, the precise location, length and area determination is not possible. Based on the experience in the image geocoding, the errors as well as their influence on precise position, length and area determination are evaluated in the work (Viher, Javorović 1994). All the material is georeferenced according to Gauß-Krüger rectangular coordinate system. The user can, using the absolute and relative error formulas, decide upon the acceptability for his particular application.

7. Conclusion

The most important question that we are trying to give an answer to is how to use the existing cartographic sources for updating or production of new cartographic material, i.e. of the entire military cartographic systems in the best possible way.

So far we have solved successfully the problem of deficiency in cartographic material in classical form.

The obsoleteness of the existing map contents, their cartographic and geodetic incompatibility with the maps of the western defense system, and first of all, the need to create the digital basis for C^3I/C^4I demands the initiation of the systematic production of new maps.

In order to agitate the production of new maps, it will be necessary to introduce and accept new technologies and to raise larger financial means for their maintenance. We believe that we will solve the majority of the problems with the support of scientific cartographic, geodetic and other institutions in the Republic of Croatia.

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MAPPING AND MAP-MAKING:
New approaches to the teaching of cartography

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Introduction

This paper is intended as an addition to the debate about what should be included in the current cartographic education of students in a wide range of undergraduate disciplines. It introduces a holistic syllabus for the teaching of basic cartography to students in many different subject areas and is based on a book published by Longman in 1997 entitled *Mapping: Ways of Representing the World* (Dorling and Fairbairn, 1997). The book integrates ideas from the fields of cultural geography, cartography and GIS into a concise and easy-to-read introduction to modern mapping and the issues which surround it. The paper discusses some of the problems encountered when trying to design such a syllabus and explains the reasoning behind the choice of topics covered in the book and its emphases.

Cartography has become a diverse field of study in the 1990s. It is clear that the narrow technical confines of map-making practice no longer furnish an adequate paradigm for the study of cartography. In parallel with developments in geography, a number of potential perspectives on mapping need to be addressed. These should be set in their historical context, but should also embrace the current explosion of interest in handling and presenting spatial data. The book distinguishes mapping from map-making and, although one of the major thrusts of the book is to promote views on good practice in the latter (for example, the importance of projections and generalisation, the role of accuracy and the possibilities of new map-making in GIS), the impact of developments in the former (for example, the greater use of remote sensing data, the "democratisation" of mapping and the role of government, commercial and learned institutions) forms a major emphasis to the syllabus.

Historical Background

Traditionally the graphical presentation of two-dimensional, static, spatial data has been the role of the cartographer within the broader field of surveying and mapping. However, the former linear model of spatial data handling which involved geodetic survey, followed by field observation, photogrammetric mapping and final presentation in cartographic form is now subject to considerable modification, and the fundamental view of spatial data handling has been modified to include a number of other related technologies, such as satellite remote sensing, global positioning systems and GIS (Fairbairn, 1996). Cartography no longer occupies a place as the final activity in a uni-directional flow of data. Instead we must recognise that the relationships amongst these topics are complicated and fluid. Paradoxically the technological framework within which map-making is being undertaken is becoming more complex and difficult to understand in its entirety, yet at the same time the task of creating a map graphic appears to become ever simpler as access to powerful and integrated spatial data handling tools spreads. The development of mapping into electronic media has greatly increased the numbers of people who are able to produce maps and the different types of maps that they produce.

Cartographic education has always tended to focus on these technological aspects which together constitute *map-making*, the process of creating a physical artefact, the map. Clearly, however, the mental interpretation of the world and the creation of a 'world-view' which can be converted into a spatial representation is a pre-requisite. This is the activity of *mapping* which must, of course, precede map-making, but may not necessarily result in it. Because the study of mental representations is fraught with difficulty, the study of cartography has, in the past concentrated on the products themselves, describing their variation and their methods of production.

However, in recent years, in parallel to the rapid growth in complex technology applied to cartography there has been growing interest from the social sciences in the meaning of maps, what they convey about the society we live in and how choices about what to map are made. From the study of historic maps, to the maps that school children draw, or the maps produced by national mapping agencies, there are messages between the lines showing roads, rivers and boundaries.

All of these changes have implications for cartography in the future and at least an overview of them needs to be understood, even by students whose main interest is technological. Maps are not simply a collection of vectors and fills.

Cartography is now being taught, in practice, in disciplinary areas ranging from computer science to historical studies. Many of those teaching cartography and even more of those being taught it do not realize that what they are being taught is cartography - the conception, production, dissemination and study of maps and map-making. What they do know, however, is that they are using and making more maps and they are doing this because the technology that makes map manipulation simpler has become so widespread. Cartography has become an information technology. From its twin roots of theoretical study in geography departments and practical exposition in geodetic engineering departments, it is now a pervasive and integral technology in a host of educational programmes. This trend will not be reversed and will not decelerate. And given the increasingly eclectic nature of university teaching most of the students on these programmes will not have enough time to study cartography in detail.

What is needed, therefore, is an overview of cartography that at the very least lets students know that there is more to mapping and the choices they are making than merely pulling down images from the Internet or choosing to colour the sea blue. Today's university student needs to know, for example, where the Mercator projection came from, why it is still widely used, who thinks its is poor projection, for what purposes it is poor and why, and how they can find out more about these and many other issues. They also lack the time and encouragement to develop the specialization traditionally assumed to be necessary to address these issues.

Contemporary Directions in Teaching

Subject rationalisation

In the educational sector many technological disciplines are currently being integrated under a series of broader headings. The move towards 'geomatics' is an example of such rationalisation. The studies of geodesy, field surveying, GPS, photogrammetry, remote sensing, cartography, GIS and information technology are adopting a common curriculum based on accepted principles in spatial data handling. A new cohort of students, from engineering and scientific backgrounds, are therefore being exposed to cartographic issues as part of their 'geomatician' training. In the social sciences cartography is increasingly being taught in modular courses in West Europe and North America, where students from a broad range of disciplines often choose to study "mapping" (perhaps seeing it as both an easy and useful "option").

Students and studying

In all cases, the trends for the student are towards studying in large class sizes, concentration on highly specific topics, but with the requirement to address a wide range of background information, increasing choice in modular degree courses, and relative reduction in student wealth, but with considerable access to IT facilities outside the laboratory. In addition to pressure on tangible resources, lack of time is a difficulty for many students: time to undertake practical exercises and time to understand the concepts. Cartographic education needs to adapt to these changes. A major problem is the current expectation that students will work by themselves considerably more than before: staff-student contacts are more limited; large class sizes mean less one-to-one tuition; more work is done using domestic resources (e.g. computers). In addition, as staff specialise, courses are becoming 'individualistic' and the concept of a large, required core of information in many subjects is fading.

Textbook design

Despite smaller student disposable incomes and, in many cases, shrinking library budgets, the market for academic textbooks seems buoyant. To a great extent, in geography and geomatics, this reflects the need for topical writing covering modern technology and ideas. The 'half-life' of information in these subjects is short, and new material is always welcome. The increasing specialisation mentioned above also contributes to a compartmentalised, and therefore varied, range of products available at the local bookshop. Finally, the pressure on academic staff to initiate and prepare textbooks is strong - many assessment exercises welcome evidence of mastery in presenting research and knowledge in this way.

Many contemporary textbooks for the tertiary sector are likely, therefore, to be overviews (usually directing students to more topical journal material for concentrated investigation), are likely to be cheap to buy and may well be collaborative works by authors from different disciplines.

Contemporary cartographic issues

New tools

In the field of cartography, it is clear that, aided by the new tools - especially PC and Macintosh based drawing software - presentation of spatial data is being successfully accomplished by many with no formal training in this area at all. Earth and atmospheric scientists, tourist information centre staff, public utilities maintenance engineers, emergency services monitors, soldiers on the battlefield and schoolchildren surfing the Internet are all producing usable map products of a high standard every day. A fundamental problem is whether it is possible for cartographers to ensure that such maps and presentations meet the cartographic norms established over centuries of map-making activity and, indeed whether cartographers maintain the existence of their discrete discipline.

New views

These thoughts are not designed to promote the exclusivity of cartographers. Mapping and map-making are human activities and are therefore, of necessity, subject to the prejudices of their initiators. The recent recognition of this has led, in itself, to the development of a contemporary cartographic issue which needs to be conveyed to a learning audience: the fact that although a scientific view would suggest that maps are and should be presented in a neutral, objective, impersonal, unadorned manner, disengaged from personal, subjective view of the world, in fact, maps are context dependent, often available only to the initiated, unlikely to be value-free and should be viewed with caution (although not necessarily scepticism).

New geographies

As geography becomes a highly disparate field and the prevalence of one particular paradigm is being replaced by a multiplicity of views regarding the essence of what geography is, the map may again become central to geographical enquiry. All schools of geographic thought call attention to mapping as a geographic method, particularly in human geography, and as regional, spatial science, humanist, feminist, social theoretic and structurationist viewpoints compete with each other to gain the geographical 'high ground' their different assumptions and interpretations of the world are reflected in their cartographies. Mapping, and in particular GIS, came to the fore in the recent battle over the core funding of geography in British universities. GIS was used to defend the 'scientific' status of geography and no doubt those promoting this technology will expect to be rewarded for 'saving' the discipline.

New applications

Whilst geography develops in these ways, so the contemporary study of cartography is also widening to encompass all aspects of mapping. This is due to the increasing applications of cartography in a wide range of earth and social sciences, the recognition of the core place of cartography in current areas of development in information technology (such as geographical information systems, visualisation, multi-media and virtual reality), and the recognition that the craft skills required to undertake map-making are diminishing in importance. A renewed interest in cartography is evident in some of the schools of geographical enquiry considered above.

New readings
Within social science students are often encouraged to study maps as they would study normal texts, with little appreciation of how different maps are. Maps are not simply another document to be 'deconstructed'. They are constructed by numerous sources. Often, many more hands make a map than write a book, or even film a movie. Students need to appreciate how the study of maps and map-makers requires an understanding of what is special about cartography. There is, after all, a much longer history to cartography than to the written text.

New linkages
Cartography is as inextricably linked with the new study of geomatics as it is with geography, and surveying and mapping activity is an important core subject in any cartographic syllabus. It must be recognised that it still sits somewhat uneasily within the geomatics field, particularly in engineering schools. Measurement scientists have, in the past, tended to downgrade the contribution of those who present the spatial data in map form, considering cartography a technology, rather than a rigorous discipline. Their narrow view of cartography as a set of drafting techniques has tended to neglect the role of cartography in forming the fundamental spatial reference framework within which all spatial measurements are carried out, and the importance of linking map presentations with applications areas, with map use and with the whole area of knowledge transfer in the surveying and mapping process. The study of spatial reference frameworks has gradually been taken over by specialist geodetic scientists and the issues of map use, design and applications have generally, in many countries, been of concern to geographers (and psychologists and some others) only. Cartography, has therefore, stood emasculated as a subject within the field of surveying and mapping, relegated to a technician-level activity, although possessing the mystique and craft that required long apprenticeships to acquire. This view needs to be challenged.

New assertiveness
A reversal in current trends can only be achieved by assertion on the part of cartographers that their discipline forms a vital part of geomatic activity. It is within the broader confines of this subject that the cartographic identity can be maintained. This is why it is vital that cartographers be in the vanguard of the moves towards adopting geomatics as a sensible overall term for what was previously a poorly-defined set of processes. It is also just as essential that cartography continues to be presented as a core spatial science within the educational programmes in geomatics.

Syllabus Development
Throughout history, cartographers have always been extraordinarily ready to accept change in working practices and data manipulation possibilities (Fairbairn, 1994). This

flexibility is reflected in academic cartography, where considerable weight is placed on curriculum content and relevance. The emphasis is, of course, still on the presentation of data, which requires that demonstrable skills in this area be learned and retained. It is necessary, therefore, for today's cartographers to be exposed to topics such as:

Visualisation: it is expensive but necessary to direct students to advanced visualisation packages such as AVS and Khoros which potentially offer much to the geomatics practitioner (Slocum et al., 1994).
Multi-media: cartographers can take advantage of the possibilities afforded by novel means of interacting with spatial data presented in many different ways (Cartwright, 1994).
Virtual reality: the possibilities and limitations of these novel and exciting techniques can be examined by the cartographer (Fairbairn and Parsley, 1997).
GIS data handling and its implications: data manipulation within GIS requires an appreciation of the nature of the data involved and a full understanding of the meaning of the results.
Presentation issues: the creation of a map involves knowledge of scale, projection, generalisation, design and a host of other activities which may take place today in the digital environment but build on long-established norms and practices.
Access to data: as compilation of spatial databases takes in larger, more complex and more numerous datasets, institutional issues such as copyright and costs must be fully understood.
Metadata: there are further relevant issues which the data compiler, long used to considering them in the analogue model of cartographic production, must address - these include data source, reliability, lineage and date.
Networked data and communications: the World Wide Web has a range of applications for cartography and geomatics from displaying sample products to accessing up-to-date spatial data for compilation purposes.
Customisation of the data handling environment: as map-makers and map users alike become more sophisticated in their spatial data handling they will require more individual means of accessing and manipulating the data.
Map use and applications: often, cartographic education in the past has ignored the final ends to which cartography is a means - the practical use of map displays. In the integrated geomatic model, cartographers must be aware of the use of and requirements for maps in areas as diverse as navigation, education and leisure activity.
Data handling requirements from a computing perspective: the geomatics practitioner must be aware of database management systems and contemporary issues relating to data structuring, data querying and data retrieval.
Relevance of cartography to GIS: clearly, many of the topics listed above relate, in a broader context, to the fact that cartography's major interaction is no longer with the land surveyor and the lithographic printer, but with the GIS developer and user. For most users, GIS, for all its analytical and synthetical potential, is a means of producing a custom-made map quickly and to a high standard using one's own data. That task is eased with in-depth cartographic knowledge.

Introduction
- Geography and mapping
- Maps as the subject of this book

Chapter 1: The history of cartography
- The human mind and the shape of the earth: reconciling interpretation and reality
- The relationship of mapping to other human activities
- The Islamic tradition in map-making
- *Case studies* Methods of studying the history of cartography; Ptolemy and the scientific nature of Greek cartography

Chapter 2: The shape and content of maps
- Maps and their scale
- The graticule
- Map projections
- Larger scale mapping
- Generalisation
- *Case studies* The map icon in entertainment, communication and advertising; The 'Peters Projection' and its instigator

Chapter 3: Navigation, maps and accuracy
- Positioning
- Navigation
- Accuracy
- *Case studies* GPS and positioning; Mercator and his world-view; ECDIS; In-car navigation; Digital data in the cockpit

Chapter 4: Representing Others
- Who are maps made for?
- Map compilation
- Interpreting the interpreters
- An infinity of images
- *Case studies* American Indians and Geographical Information Systems; Brian Harley - taking mapping apart; Cartography and the Internet

Chapter 5: Mapping territory
- Land ownership and mapping
- Colonisation and the sub-division of the earth
- The impact of the military on mapping activity
- Contemporary government mapping
- *Case studies* Settling the USA: the Public Land Survey System; Mapping the Gulf War; The NIMA inventory of digital spatial data; William Roy and the Ordnance Survey

Chapter 6 New Scales, New Viewpoints
- The new 'world-view': an alternative icon
- Remote sensing and data
- Scale and accuracy beyond belief
- Old and new views
- Fractals: scale free mapping.
- *Case studies* Pictures from space, the military and mapping; Mapping time travel; Eduard Imhof and terrain mapping; The three and four dimensional mapping of disease patterns

Chapter 7: Geographical information systems
- A short history of geographical information systems
- The democratisation of mapmaking: removing the mystique
- The applications of GIS and their effect on our image of the world
- A critique of the GIS view of the world
- *Case studies* Jack Dangermond and the radical view of the world of GIS; Earliest Geographical Information Systems; Ways of owning the world; GIS and jobs

Chapter 8: Alternative Views
- Map propaganda
- Ecomapping
- Humanist Cartography
- The 'new' world atlases
- The cartography of war
- *Case studies* Doug Aberley: map-maker and bioregionalist; Janos Szegő and Human Cartography; Cartograms: changing the shape of the world; Michael Kidron and the Pluto Press Project

Chapter 9: Representing the future and the future of representation
- New tools and new data
- New roles and new maps
- Changing perspectives on cartographic practice
- Mapmakers of the future
- The parameters of map production
- *Case studies* Barbara Bartz Petchenik

Table 1 **Abridged Contents Page, Mapping: Ways of Representing the World**

Although this paper does not intend to be prescriptive about the content of cartographic syllabuses, it is clear that there are fundamental aspects which must be included in addition to those outlined above. Analysis of the basic cartographic tasks of generalisation, layout, design, colour and typography has been and continues to be essential for cartographic students, and more esoteric aspects which can be addressed include expert systems and temporal mapping which have potential to move, in the future, to become commonplace in geomatics data handling.

A Textbook

The textbook whose abridged contents are illustrated in Table 1 has been written to address some of the concerns discussed above. Its primary remit was to introduce aspects of cartography to those studying human geography, and it therefore does not directly fulfil the 'wish-list' proposed. However, it has been prepared to give as broad a picture as possible of contemporary cartographic issues, placing them in a wider societal context, yet retaining much of the technical material which is necessary as the core of cartographic education. Some of these technical issues are new (multi-media workstations, scientific visualisation and virtual reality), some reflect contemporary academic concerns (the role of institutional cartography, humanist cartography), some assess the immediate future of the discipline (the role of children, the impact of satellite remote sensing, the decline of 'corporate' mapping). All are seasoned by a grounding in the history of the subject and the impact of accepted practices developed over years of cartographic endeavour.

If cartography is to retain its identity as a valid discipline worthy of study, and practiced by trained personnel and specialists, we must ensure that its profile remains high within the communities of scientists, historians and the general public who are increasingly willing and able to convert their "mappings" into maps without the benefit of traditional "map-makers" and "map-making". A wide-ranging syllabus directed towards both the technical specialist and the interested professional should stress the continuing importance of cartographic principles, whilst introducing new concepts relating to visualisation, multi-media and virtual reality which are increasingly becoming the preferred method of interacting with spatial data.

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TELEMAP/CAD. SOFTWARE FOR CARTOGRAPHIC EDITION

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INTRODUCTION

The introduction of hight performance software in production of different fields of the science has given the investigators power tools for major data procesing. The cartography is included in this changes where processing automation has played a very important role.

TeleMap/CAD module forming a part of Telemap system has a cartographic profile and it offers a wide whole of tools allowing a data compilant in a short period of time constributing, in this way, to use efficiency the media and human resorces.

Automatizing process it will be able to count on a power data base to acomplish further works such as a Geographical Information System, and others.

TeleMap/Cad has been aplied in different works, among them:

- In researching of evolution the coastal line of diferent zones.
- In cartographic covering of keys.
- In charts type of depth.
- In digitalizing of executive plans.
- In printing of researchs carried out in the geographic information system's module.

A module allows to import the DXF format, which coordenates can be given in centimeters, meters or decimal degress.

A module exports files in DXF and BMP formats, which coordenates can be given in centimeters, meters or decimal degrees.

MAP is the default format of the module's working files.

The system was developed in Borland C++ based on Windows 95.

It is recomended for Pentium microcomputers.

DEVELOPMENT

TeleMap/CAD is a cartographic and graphic issue which in a window environment put on expert's hands a power tool to produce a map with all the cartographic requeriments.

When the all document, data and features to be used in the map production have been selected and prepared a mathematic basis including the cartographic projection, scale, geographical datum, reference ellipsoid and limits of the zone to be cartographed, is defined.

TeleMap/CAD is capable to choice different types of cartographic frames, to establish or not some features of the same such as a size and type of the coordenates, texts and grid color, and to define whether is painted a grid or cross between parallels and meridians intersections.

The maximun lenght of the cartographic frame is 1.3 per 1.3 meters.

The cad objects organization is based on CAD objects location in purely thematic layers with determined properties for map issue application such as a color, to be an active, to be visible and editable. By default, there is always a layer named "0". The layers can be re-named and erased.

Compilant sources.

Several sources for map compilant can be used:

- From existing data bases from other sources in DXF formats, or from the own TeleMap/CAD. The sacle projection or reference ellipsoid conversions in a module can be made.
- From image (plans, maps, photographies) previously scaned in BMP, RLC and BIF formats. These images can be georeferenced having associeted control points allowing to charge the images in an accurate geographic position. A several images tile of the zone to be maped can be built. About these images an interpretation is begun. Non-georeferenced images can be also used and scaled.
- By means of digitalizing table using the own module tools.

Another facility offering by TeMap/CAD is to create symbol libraries designed within the module. The created symbols can be puntually inserted, allocated on a polyline or formed a part of fill pattern.

TeleMap/CAD offers a wide whole of tools for designing any type of graphic document (plans, maps, skeths, etc.), among them:

Selection Tools

The above mentioned module comprises the tree types of CAD objects selection:

- By point, where the CAD objects are selected putting a mouse button on the trace.
- By cross, where any CAD object intercepting a draw elastic box will be selected.
- By window, where the CAD objects only which are entirely within the unpliable box, will be selected.

Display tools.

The above mentioned module comprises the four following types of tools:

- Entire display of a drawing where the established limits are shown.
- Display by window, where the elements comprising a zone delimited box, are shown.
- Previous display, where to five previous movements can be allowed.
- Real display, where a drawing real scale is approximatively defined at the time of printting.

Drawing tools

Diffeerent tools for maps and drawing compliant are given by the above mentioned module, among them:

- Squares.
- Circles
- Ellipses.
- Polylines.
- Double-lines.
- Arcs.

- Bezier curves.
- Polygons.

Each CAD object can be located on any coordenate and it is given in centimeters, meters and decimal degress. A thickness and type of determined line can be also given. A color of the objects depends upon color of a layer where these objects are.

Text handling tools

The lettered is reached by the following tools:

- The texts are located on a defined coordinate by the right top margin; a type of letter and its height to be used is pre-determined.
- The text are allocated on polylines.

Objects handling tools.

The following facilities are given by the above mentioned module:

- CAD objects movements from one layer toward another (active).
- The type of CAD objects line is changed.

Lineal objects handling tools.

TeleMap/CAD count on a group of tools for issuing polylines, among them:

By means of truncating of two polylines intercepting, where a segment is disappeared againts an axis.

By means of cutting out of a polyline by one point or two.

By means of joining of two polylines by their ends.

By means closing of a polyline making to coincide it with the last of the polyline vertexes

By means of opening of polyline making differnts the first and the last polyline vertexes

By means of issuing and adding of vertexes to the plolylines.

By means of closed shape padding with the solid ,hatch or symbols patterns, and their combinations.

By mans of objects reflexion from a vertical or horizontal axis.

By means of moving, copying and rotating the selected CAD objects from one point basic.

Meassurements tools.

An area, perimeter and distance about any element of the map can be determinad using the above mentioned module. the measure units are given in centimeters, meters or hectares.

CONCLUSIONS

⇒ The plans, maps and other graphical documents can be provided by TeleMap /CAD.

⇒ The acurate cartographic works can be provided by TeleMap/CAD.

⇒ The maps digital format can be obtained so that a best and more rapid information storage and updating is provided.

ADIFLOT: SOFTWARE FOR ELECTRONIC NAVIGATION AND ITS CONTROL

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Abstract

AdiFlot solves by means of computer the problem concernig the monitoring of a fleet of vehicles supplied with Global Positioning System (GPS) receivers. It is composed of three modules: *Project Maker*, *Fleet Manager* and *Electronic Navigator*.

Project Maker is an auxilliary module for geographically linking of maps at different scales to conform a working project. Such project will be used by the basic modules *Fleet Manager* and *Electronic Navigator* where position, speed, traveled kilometers and other information about vehicles are tracked for further analysis.

The vehicles's position, their tracks and other information related are displayed in real time on a digital map providing, besides, the path of those vehicles in a day the user select.

The system is a *Windows* application developed in C++ for IBM compatible microcomputers. This give it a conmfortable and easy-to-use graphics interface supporting virtual memory and multitasking.

1. Introduction

The present age paradigm characterized by the computer sciences and microelectronic associated to technological development of positioning methods which climax is in the Global Positioning Systems (GPS) by satellites, has revolutionized the vehicles and electronic navigation control methods.

As the result of need of creating a traffic control and electronic navigation system combining imagine processing and GPS techniques, in GEOCUBA - Investigación y Consultoría, ***AdiFlot*** has been developed.

AdiFlot solves by means of computer the problem concernig the monitoring of a fleet of vehicles supplied with Global Positioning System (GPS) receivers allowing to display on a digital map in real time vehicles position and their tracks, and rendering possible to re-built a track followed by these vehicles.

This system was developed in C++ on Windows for IBM compatible microcomputers using a programming oriented to objects.

2. Description

AdiFlot is a software developed in *Windows* providing a very easy and comprehensive friendly user interface. For ***Adiflot*** implementation, C++ programming language was used because of its quality to create a compact code, its rapid execution and its easy to implement complex algorithms. In addition, a object oriented programming as an advenced programming method was used.

This software solves by means of computer the problem concernig the monitoring of a fleet of vehicles supplied with Global Positioning System (GPS) receivers.

Working with ***AdiFlot*** is based on projects consisting of a group of fragments of maps at different scales which structure is in levels from smallest scale to largest providing, if required, a close-up or reduction of a zone displayed.

These projects are created in *Project Maker* module which is an auxilliary module for geographically linking of maps at different scales to conform a working project for a zone to be used by the ***AdiFlot*** basics modules.

A communication with a device sending the message from the GPS receivers, is established by the *Fleet Maneger* and *Electronic Navigator* modules allowing to display on the screen the monitored vehicles which are in the map's zone displayed and the vehicle under control, respectively in each module. Thus a user will be able to make a control and vehicles monitoring or electronic navigation by using the tools and option offered by the system,.

A set of graphical tools for handling images is offered to the user. Tools are associated with menu commands and can be selected by pressing the mouse left button providing a rapid alternative to choose a menu command. Different cursor replaces the *Windows* cursor when some tools are selected.

These modules allow to receive and store the messages from a GPS receiver providing information about the actual time and vehicle position. With this information, useful calculations to the mariner can be made by ***AdiFlot***, such as speed and traveled distance, for further analysis.

The vehicles's position and their tracks are displayed in real time on a digital map providing, besides, the path of those vehicles in a day the user select.

This software is oriented to the Electronic Navigation and its control, and offers to the user the following possibilities:

- Real time displaying of the controled vehicles on a map.
- Movement between different map's zone and close-up/reduction of a region displayed.
- Displaying vehicles tracks.
- Displaying general information about selected vehicles.
- Previous dinamics simulation.
- Storage of data in a database.

3. The Minimun Requirements of Hardware and Software

- 386 Precessor or higher.
- 8 MegaBytes memory RAM.
- VGA video card or higher.
- Serial port.
- Microsoft compatible mouse.
- MS DOS 6.0 or higher.
- Windows 3.1 or higher.

4. Conclusions

AdiFlot is a starting point of a new line of develpment for traffical control and transportation involving, on the one hand, an improvement in mobility and vial safety and reduction of highway and road bunchings; on the other hand, a movement control of vehicles of a specifical fleet.

This software is important for its wide range of applications for monitoring and control of fleets in different fields such as pipeman cars, ambulances, road goods transit among others.

For the futute is intended to link ***AdiFlot*** to a Geographical Information System allowing to accomplish complex spatial analysis.

COLUMBUS: A NAVIGATION SYSTEM WITH ELECTRONIC CHARTS

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Abstract

Colombus is a navigation system with electronic charts in raster format which combines cartographic information, consisting in nautical charts similar to the original paper charts, with an exactitud of positioning from a Global Positioning System (GPS) and Differential GPS (DGPS) receiver. Thus, a vessel's position on a chart can be plotted by the Mariner; several views of a navigated zone as well as angle measurement, distances and markings can be displayed; the routes can be planned; the indication/alarm can be established; and information on vessel's position, its speed and route, among other significant informations for sailing can be obtained. Real time data files are created allowing to re-built, if required, a vessel's planned route. ***Colombus*** can be of significant aid to the Mariner taking into consideration that the major accidents at sea are occured by the human errors.

This system was developed in Borland C++ based on *Windows*, for IBM compatible microcomputers.

Introduction

In the last years, the most advanced countries in digital cartography have worked actively in the development and producing of Electronic Charts Systems (ECS) and Electronic Chart Display and Information Systems (ECDIS). Day after day, other countries are added to this activity that should result in significant benefits to the international maritime community.
As a result of accesible and easy use of radionavigation techniques, in particular, a Loran-C and GPS (Global Positioning System by Satellites), this media are used widwly. GPS and Differential GPS allow the users who use electronic charts systems to count on a hight preciseness and fidelity level in the positions never reached before.
The ECS can be divided into electronic charts in raster format or in vector format. In a vector- based ECS, electronic charts data is comprised of a series of lines (vectors) in a which different layers of information may be stored or displayed. For raster-based ECS, the data is stored as pictures elements (pixels).
From the commercial point of view, the electronic charts in raster format have had much more acceptance within the mariners than the ECDIS, because, before all, the former already has an information. From the manufacturer's point of view (Hidrographic Offices), the information in raster format is much more easy to process.
There are now many electronic chart formats all over the world, being the most recognized those created by NOAA (USA), United Kingdoom Hidrographic Service and Canadian Hidrographic Service.
In our country, a Nautical Electronic Chart System named ***Colombus*** has been developed by GEOCUBA-Investigación y Consultoría for which the further has counted on a cartographic information required.
Colombus is a very familiar media to the mariners because it displays a chart with the same colours and symbols as original paper charts. This system has been designed to be used onboard of any type of vessel eigther small, or middle or large port supplied with a GPS receiver.
An information about the position is received in real time and displayed on a chart as well as another data that should result in significant aid to navigation. In addition, ***Colombus*** is supplied with an alarm system and it is capable to plan a route and store it.
In this version of the system, five cuban charts at different scales are used in HSRP canadian raster format, one of the most diffused all over the world.

Description of the System

Colombus is an automated system oriented to object and developed in Borland C++ based on a Windows environment. The former is designed to be used onboard of small, middle or large port vessels supplied with microcomputers and a GPS receiver switching on to the computer through its serial port.

Important Functions

Before sailing with ***Colombus*** is necessary:

1. To establish a route planning.
2. To establish the option alarms which will be armed in a different moments of the cross-way.
3. To configurate a communication port and switch on a GPS; from that moment, the positions are received.

Route Planning

A route consist in a serie of lines wich are drawn on a chart, as on a paper chart. The former is comprised of points named Waypoints (WP) in which, generally, a course is changed or any significant action is accomplished. The WP are numbered by an ascendent form system, and the facilities to be added these WP, changed their locations and erased, are given.
The route plannings can be stored to be used in other occasions in the same navigated zone or not to be established once again coming back to the starting point. In each moment, there is an active route only, and may be there are other more visibles.

Alarm System

Desviation from the planned route: A major magnitude of desviation from the planned route or XTR in m, Km and nautical miles, is established. If this value is exceed during the cross-way, an alarm is provided by the computer indicating in red that value through information window.
Arrival on WP: A time or distance from WP required to be overwarn to carry out route changes is provided. After an alarm is covered, the fallowing WP is covered by the system.
In addition, in both cases, the value is indicated in red through information window.
GPS position lost: When a position is not being given or the differential corrections have been lost by GPS, a message is displayed.

The position are received and plotted in real time

An information from a GPS receiver such as the actual time, position, amount of satellites, reception status (differential or autonomous mode), vessel's real route, its speed and other, can be received. Based on this information, specifical calculations useful to the mariner can be made by ***Colombus***.
A preciseness positioning is considerably arised when GPS receiver is workingin differential mode which is necessary for coastal navigation and berthing, even during periods of low visibilities. The former is reached when the corrections, received from a referency station located on a geodetical point near the coast, and supplied with a GPS receiver and radio-transmitter, are received.

This software is capable to receive information from different types of GPS in NMEA 0183 format.

A received position is plotted on a chart, and in case of non-corresponding with the chart which is displayed, first, a chart is finded within the available charts at the same scale, but if there isn't any, it is finded within the charts at the small scale until a corresponding with that position chat is finded.

With ***Colombus*** can sail without using electronic charts because may be it has no a digitizing charts in a specifical area. In this case, a marcator network plotting is charged until it has a chart with the position given by GPS.

There are different forms to display a vessel's movement on a chart: relative, real and planning.

Relative Movement: A vessel's symbol is always in the middle of the screen, and a vessel's movement is provided by the chart.

Real Movement: A vessel's symbol is moved, and the chart keeps itself stationary until the ship comes to the ends of the chart's visible part on the screen.

Planning Movement: A chart can be moved toward any direction leaving the vessel out of area displayed. This mode usually used to inspect non-navigated chart's areas, routes planning, among other. Generally, it is not used when the positions are being received.

A planning route is stored

While the positions are being received, they are being stored. Thus, several vessel's routes can be re-built which should be of major useful, in particular, when any accident has occured.

Display of charts at different scales

The system provides an interactive view of more detailled or panoramic charts of the same region changing scales (zoom). The charts are internally ordered from the small scale to the larger providing, if required, a close up or reduction of a zone displayed.

Useful information to the mariners

Through ***Colombus***'s information windows can be shown:

Vessel's data: A data of the actual position based on the geographical coordenates (latitude, length) given by GPS, the vessel's effective route and its actual speed on the depth, and the distance done by the vessel from the begining of the cross-way, is displayed.

Mouse cursor position data: This information displayed by default, comprises of geographical coordinates and markings to cursor. According to the former, if the user of the system desires to be aware of a point and its marking on the land, it is enaugh to put a cursor upon this pointon the chart and the desired informations are rapidly displayed through information window. In addition, a marking, time and distance to cursor can be obtained.

WP data: Through this information window can be displayed in the begining a data about the cross-way error to WP or XTR, the distance from the vessel to point, the arrival time to point, the estimeted time for arriving and the steering real route. The steering real route is the route to which the vessel's rudder is put to come back to WP
Positioning quality: A preciseness and amount of satellites received by GPS wich are used for determinating a position, is displayed.

Chart calculations

The type of navigation should be indicated before the calculations are made. For a coastal navigation, the rhumb-line navigation is choiced, and for a sea navigation, the great circle navigation is selected.
Angle: An angle magnitude on the chart for which tree points of an angle are indicated using a mouse, a second of which will be forcelly its vortex, can be calculated.
Distance based on the coordinates: A distance between two any points on Earth can be calculated if the coordinates of these points are specified.
Distance based on two points: A distance between two any points on the chart displayed on the ***Colombus***'s screen can be awared. Those points must be indicated using a mouse.
Distance between WP: A distance between any points of the route planned, can be calculated.
Route length: A total distance between planned route WP can be calculated.

The Minimun Requirements of Hardware and Software

- 486 Precessor or higher.
- 8 MegaBytes memory RAM.
- VGA video card or higher.
- Serial port.
- Microsoft compatible mouse.
- MS DOS 6.0 or higher.
- Windows 3.1 or higher.

Conclusions

This system efficiently handles a cartographic database, consist in pictures identical to the paper charts on which a vessel's position is displayed every once as a position message from GPS is received. It is a very important aid tool to the navigation. Thus, the first steps are being taken by our country to begin the electronic chart productionin raster format and. cover the cuban sea with nautical charts in digital format.
The nautical charts in digital format onboard of vessels every once more are in demand as a result of technology advance. For this reason, it is necessary to count on a easier and entertaining navigation system providing a preciseness and safer navigation. A positioning using electronic charts has became a tool that the mariner, any way can disregard of it.

GROUNDWATER RESOURCES AND VULNERABILITY MAPPING OF THE CITY OF STOCKHOLM

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Abstract

The Geological Survey of Sweden (SGU) has recently completed two groundwater maps of the city of Stockholm for the Environment and Health Protection Administration. In urban areas like Stockholm the groundwater conditions are very complex and rather difficult to describe. This is due to extensive land fillings, pumping and drainage, groundwater leakage to tunnels and sewerage's etc. which creates a situation with multiple groundwater levels and varying flow directions. The objective of the survey was to present the administration with digital groundwater information as a foundation for the design of a groundwater quality monitoring network and the evaluation of the groundwater contamination situation in Stockholm.

The result of the survey was presented to the city as two different themes of hydrogeological maps, a groundwater resources map and a groundwater vulnerability map, both adapted for the scale of 1:20 000. The resources map shows the main aquifers and features of the groundwater system. The vulnerability map shows the sensitivity of the groundwater to the infiltration and spreading of contaminants to the subsurface environment. The maps are based entirely on existing geological and hydrogeological information from various sources.

The geographical and hydrographical information used consisted of selected data from the Swedish National Land Survey's (LMV) T5-database. The geological framework was based on engineering geology maps in the scale of 1:10 000. The information retrieved from these maps included soil, land fillings, wetlands and the depth of clay. Hydrogeological data, including close to 1000 well point records with groundwater levels and stratigraphical data were collected. Data describing the city drainage networks, sewerage's and tunnel systems was also collected as was records from earlier engineering studies and field measurements.

Geographic database handling, analysis and map production were done in a GIS (Geographical Information System) environment. The result was delivered to the city administration as digital data and plotted maps.

Groundwater resources and vulnerability mapping of the city of Stockholm

Introduction

On commission by the Environment and Health Protection Administration, the Geological Survey of Sweden (SGU) recently performed a groundwater survey of the city of Stockholm. The incentive of the survey was a comprehensive investigation in progress on the environmental situation in Stockholm. For the continued environmental investigations, including the design of a groundwater quality monitoring network to evaluate the groundwater contamination situation, it was decided to carry out a groundwater survey of the city.

Because of the very short time span and limited economic resources available, the survey was based entirely on a synthesis of existing hydrogeological data from various sources. The use of GIS and the wealth and quality of the obtained data made it possible to produce reliable groundwater resources and vulnerability map data for the scale of 1:20 000.

Groundwater resources mapping

A groundwater resources map shows the main features of the groundwater system, i.e. the distribution of groundwater and aquifers. SGU has been producing groundwater maps since the late 1960's, mainly in the scales of 1:50 000 and 1:250 000. One of the most important features has traditionally been the definition and classification of the groundwater aquifers as potential resources for municipal water supplies. In the last few years the groundwater surveys have become more directed towards environmental and planning applications for local governments.

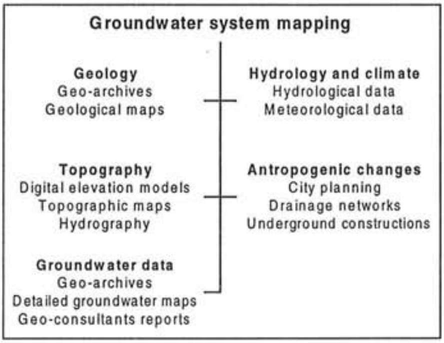

Figure 1
Content and background information in hydrogeological mapping

The geological framework is essential when describing and understanding the aquifer and groundwater flow systems. The mapping of the hydrogeological system in Stockholm was based on the classification of the soil and underlying bedrock after their hydrogeological character, i.e. their capacity to transmit and store water. The hydrogeological and geological information used included well yields, groundwater level measurements, bedrock and soil characteristics. Additional data used in the analysis were topography and natural as well as artificial drainage systems (tunnels, drainage networks, sewerage's, etc.). *Figure 1* illustrates the content and background information used in the mapping process.

The content of the groundwater resources map of Stockholm is evident from the map legend as shown in *figure 2*. The first section of the legend shows the groundwater resources in sand and gravel aquifers. These resources are shown in blue shades on the map depending on the size of the aquifers. The second section shows the occurrence of groundwater in other, less permeable deposits, mainly tills, clays and organic soils. This section also includes bedrock outcrops and land fillings.

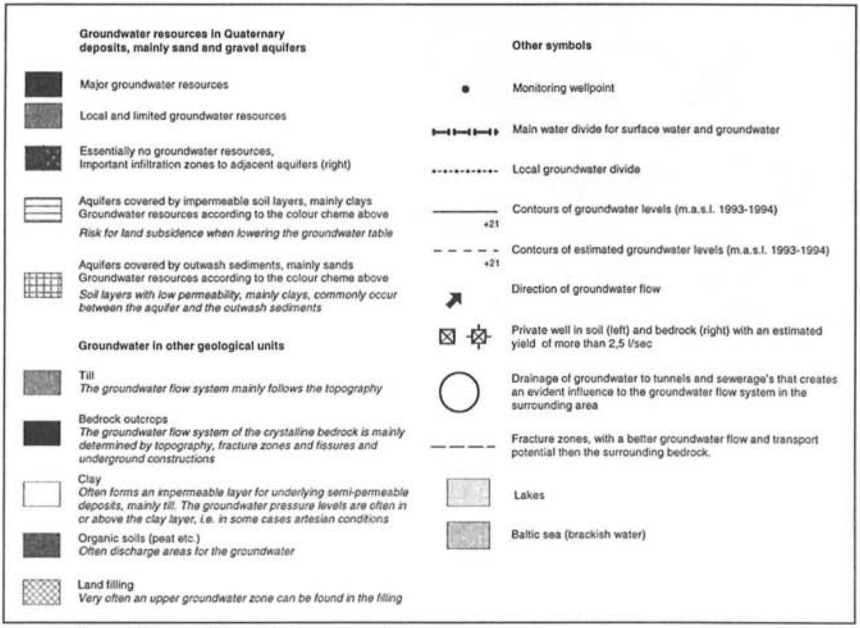

Figure 2 Extract from the legend of the groundwater resources map

Major groundwater resources corresponds to the parts of the main glaciofluvial aquifer, the Brunkebergsåsen esker, where the thickness of the saturated zone exceeds 10 meters and a hydraulic connection exists with surface water bodies. *Local and limited groundwater resources* are found where the extent of the saturated zone is smaller and the thickness less than 10 meters. *Essentially no groundwater resources* indicates that no saturated zone exist in these parts of the aquifers. These parts often function as important groundwater recharge areas to the saturated zones of the aquifers. Ornaments are used to distinguish the areas were the aquifers are covered by layers of impermeable clays, outwash sediments and /or land fillings. In the remaining areas outside the aquifers the content of the engineering geology map has been used, with explanatory notes on the hydrogeological characteristics for each soil type in the legend.

Other symbols representing hydrogeological information in the map includes monitoring wellpoints, private wells, water divides, groundwater contour levels, directions of groundwater flow, points of drainages and fracture zones. The directions of groundwater flow are represented by arrow point symbols with the direction as an attribute in the data base. The groundwater pressure levels are shown as contour lines.

Figure 3.
Human effects on a groundwater flow system. Drainage of water from a previous discharge area to a waste water tunnel changes the ground water flow directions.

The drainage of groundwater to a waste water tunnel in the Älvsjö area (the location of the 1997 ICC conference) is a typical example of how drainage networks and underground constructions change the natural groundwater flow system. This is illustrated in *figure 3*, an extract from the groundwater map.

Groundwater vulnerability mapping

The groundwater vulnerability map can be classified as an interpretative groundwater protection map, derived from information on the hydrogeological conditions and soil characteristics. The map shows the sensitivity of the groundwater to the infiltration and spreading of contaminants to the subsurface environment. The map is intended as a special-purpose environmental planning tool for non-geoscientists at all level of government. The classification of vulnerability is "educational" in the sense that the colours signal what areas are sensitive (red), intermediate (yellow) or safe (green) with respect to the consequences of an accidental contaminant spill.

The vulnerability of the groundwater to the infiltration and spreading of contaminants mainly depends on the soil properties (infiltration rates, hydraulic conductivity, porosity, etc.) and the direction of the groundwater flow. The groundwater vulnerability map of Stockholm is based on a combined classification of the soil types from the engineering geology map and the aquifers from the groundwater resources map. Other hydrogeological features, i.e. groundwater flow directions, water divides, drainage points and fracture zones, are included in the map. Included in the vulnerability map are also the type and location of potential contamination sources.

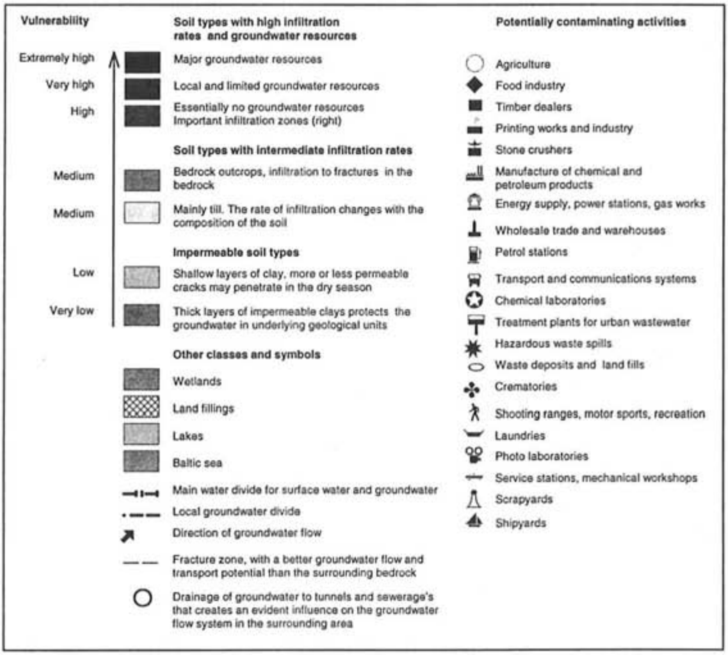

Figure 4 Extract from the legend of the groundwater vulnerability map

The extract from the map legend shown in *figure 4* is divided into three main sections describing vulnerability, *soil types with high infiltration rates and groundwater resources*, *soil types with intermediate infiltration rates* and *impermeable soil types*. A total of seven classes of vulnerability were used, from extremely high to very low depending on the soil properties and the nature of the underlying geological units. Red shades were used for the high vulnerability classes, yellow for the medium and green for the low classes. Other hydrogeological information was shown in blue and the potential contamination sources in purple.

The highest groundwater vulnerability is found in the parts of the sand and gravel aquifers not covered by impermeable soil layers. Areas with a clay thickness of more than

4 meters were regarded as having a very low vulnerability to the infiltration of contaminants to underlying aquifers.

Data acquisition and handling

Common problems when preparing a hydrogeological map are incomplete data sets, lack of data in particular areas, contradictory data in places, data measured by different incompatible methods, etc. Field work for producing new data was not possible in this study, therefore much effort was put into additional data collection and quality control of the data. Geological and hydrogeological data were collected from various sources, mainly geo-archives, data banks, geological maps, consultant firms and local government agencies. Mainly because of the available very detailed geological maps, the high density groundwater level monitoring net and the wealth of hydrogeological information in consultants reports, it was possible to prepare reliable hydrogeological information for the map scale of 1:20 000. A relational database application (Microsoft Access) was used to handle the point source data, especially the groundwater level measurements and soil stratigraphy. The digitalisation and elevation analysis were done using Arc/Info. Other database handling and thematic map production were done with a desktop GIS system, MapInfo.

The topographic information used consisted of selected data from the Swedish National Land Survey's (LMV) T5 database, i.e. the digital equivalent to regional topographic maps in the scale of 1:50 000. This database was also a source of hydrological information, e.g. river network and surface properties. Digital elevation data (50x50 meter grid) were used to generate 5 meter surface elevation contour lines.

The most important background information for analysing the groundwater system was acquired through the digitalisation of 17 analogue engineering geology maps of Stockholm from 1978, in the scale of 1:10 000. These very detailed, high quality maps contains the major geological features that controls the groundwater conditions, i.e. the distribution of bedrock outcrops, and soil classes. Other important features included are the extent of wetlands and land fillings and the thickness of clay and organic soil layers. The digitalisation method used was a scanning (0,5 meter resolution), coding and quality control procedure developed at SGU.

The information on fracture zones originates from airborne geophysical measurements, digital elevation models and field measurement data, interpreted in connection with other survey's made by SGU in the Stockholm region. For this study fracture zones with a better groundwater flow and transport potential than the surrounding bedrock were selected.

Within the city of Stockholm there are about 1200 registered wellpoints for the purpose of long-term groundwater level monitoring. About 800 of these are monitored on a somewhat regular basis. The measuring frequencies vary from twice a month to twice every second year, depending on the sensitivity to changes in groundwater pressure and the risk for land subsidence. The wellpoints are mainly located in land fillings and in coarse material (mainly till) covered by layers of clay.

Data describing the city drainage networks, sewerage's and underground construction systems were acquired from the Stockholm water authority. Supplementary information on tunnels, including groundwater leakage and pumping, was collected from the Stockholm transport authority. The obtained information on groundwater leakage and drainage to tunnels and other underground constructions was of importance for the analysis of anomalies in the groundwater flow system. So was also the study of 19th and early 20th century topographic maps from which lakes and wetlands that today are artificially drained or filled in were identified.

The definitions of watersheds and groundwater divides were done on the basis of topography, groundwater level data and natural as well as artificial drainage systems. Two types of water divides were differentiated, local groundwater divides and combined surface water and groundwater divides for areas that drains to the Baltic sea and lake Mälaren.

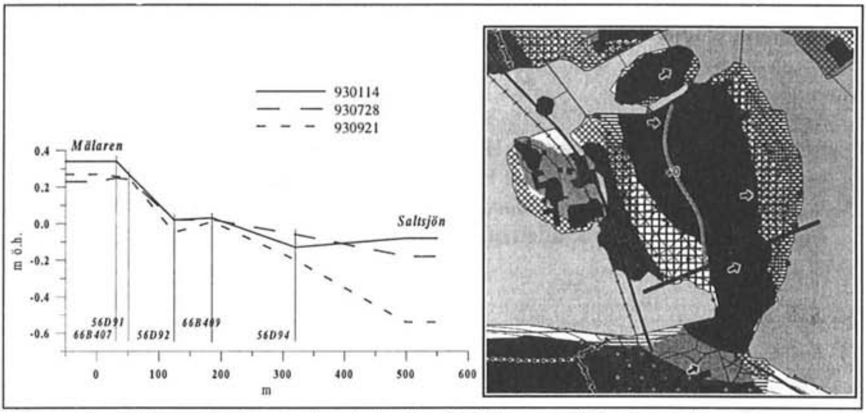

Figure 5. The groundwater levels in the Old Town aquifer depends on the pressure difference between the water level of lake Mälaren and the Saltsjön inlet.

Figure 5 exemplifies the time dependency problem in hydrogeological mapping. The groundwater system changes with recharge as controlled by climate and with changes in the natural groundwater regime as induced by man. The outflow from lake Mälaren to the Saltsjön inlet of the Baltic sea is regulated through lock gates. The pressure difference between the water levels of Mälaren and Saltsjön controls the groundwater flow system of a sand and gravel aquifer beneath the Old Town in central Stockholm. On some occasions the water level of the Saltsjön inlet exceeds that of lake Mälaren which creates reversed groundwater flow directions and introduces brackish water to the aquifer.

The differentiation of the thickness of clay in the groundwater vulnerability map was done with a geostatistical approach. Two classes, more or less than 4 meters thickness, were interpolated from point source stratigraphical data. The error of the analysis was estimated as 1 to 2 meters depending on the spatial distribution of the data.

Conclusions

The main objective of the survey was to produce a foundation for the design of a groundwater quality monitoring network and the evaluation of the groundwater contamination situation in Stockholm. This work is now in progress. The produced groundwater system information is basic for many engineering geology and other environmental applications and therefore ought to be of great value as a planning tool for regulatory and decision-making purposes at several levels of government. Other local government agencies, including the national road company, as well as consultant firms have recently taken a great interest in the results of the survey.

It is the authors hope that the delivered hydrogeological maps and digital information will help the city administration planners and regulators make informed environmentally sound decisions regarding land use, groundwater protection and groundwater remediation actions.

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INTERFACING CAD TECHNOLOGY FOR GENERATION OF DATA FOR TESTING THE PERFORMANCE OF PHOTOGRAMMETRIC INSTRUMENTS & SYSTEMS

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ABSTRACT

Generation of mathematical photograms (photos) as data is universally accepted as the basis for photogrammetric studies. New development in the field of computer technology has had a major influence on photogrammetry. CAD technology can be applied to generate the mathematical photos for calibrating stereo- and analytical plotters and testing digital systems. MATHP interfaces math photos and AutoCAD softwares for generating the math photos of the whole block, strips or selected photos. MATHP is capable of generating blocks with different specifications.

INTRODUCTION

Photogrammetry has experienced significant changes caused by advances in optics, electronics, imaging techniques and computer technology. It is applied in the form of mechanical systems e.g. stereoplotters, combination of mechanical and computerized systems e.g. analytical plotters and fully computerized systems e.g. softcopy systems.

Testing the results of the developed softwares or the performance (calibration) of the instrument's mechanism requires errorfree and well-defined input and output data in a compatible form. Generally, data is entered to the available photogrammetric system in the form of paper-base photographs, diapositives, numbers or pixels.

Actual photographic data is characteristically incomplete in that the object coordinates of all image points are not known. Furthermore, actual data is subjected to errors which disturb the course of the computations and analysis and make it difficult to evaluate as to which effects are due to the data, which due to the geometry of the problem or due to the computer software or the instrument's mechanism.

The main sources of actual data errors are the variation of the irregular photo errors from one photo to the next, the correlation of the irregular errors and the difficulty of determining its degree, incomplete elimination of the systematic errors, investigation of undetected errors, poor image quality and control data, image identification and inadequate redundancy of control data (Oswal, 1969).

On other hand, entering the actual photo in pixels form causes a series of problems to image matching. These problems include (Greenfeld, 1991) foreshortened effect such as changing the value of the sampled gray level due to the elements smaller then pixel size, lab processing noise e.g. scratches or spots on the photographic material due to uneven processing or aging chemicals, digital camera radiometric calibration differences such as integration time, gray level range definition and exposure setting, digital camera noise during image digitization and textural problems such as existence of distinguishable structures, repetitive texture, hanging surfaces, ambiguous levels and thin objects.

Fortunately, the problems of using actual photographs for testing the photogrammetric . systems and instruments can be alleviated by a combination of fictitious data generation through a software and merging in it the capabilities of the CAD technology for preparation of the data in a compatible form for the photogrammetric instruments and systems.

In recent years, software designed to support computer aided drafting (CAD) operations has become popular. One commercial software package in this regard is AutoCAD, from Autodesk, Inc. Of equal importance has been the development of software designed to make use of efficient user interfaces e.g. options and menus. These advances in technology have enabled the development of the MATHP system.

The applied methodologies in MATHP development provide automatic generation of the fictitious data in numerical and graphical forms. The graphical form enables the testing of photogrammetric instruments e.g. stereoplotters and analytical plotters. Furthermore, the graphical form is suitable for testing the digital systems using CCD cameras or scanners. One of the most important aspect of automatic generation of graphical fictitious data is the prevention of manual graphical presentation e.g. using hand or software drawing of the numerical fictitious data which is time consuming and may have additional mistakes.

LITERATURE REVIEW

Mathematical photogrammetric data have been applied in numerous academic studies. Doyle (1966) developed a computer program designed to produce fictitious data for the testing of extensive programs of analytical aerotriangulation. Oswal (1966) developed a method for computing square grids for calibrating projectors and cameras. Oswal (1969) developed a software for generating math photos. He used the generated data for developing and testing some methods of analytical exterior orientation determination. Veress and Hatzopoulos (1981) used fictitious photographs for their simulated experiment to determine the proper geometry and design standards for variable geometric combinations of aerial and terrestrial photographs and to study the effect of different computer generated errors. Tiwari and De (1984) used synthetic data for error propagation studies.

At the outset, five major problems are apparent: (1) non-availability of math data for all researchers; (2) softwares are portable for specific computer systems; (3) unsuitability of the data for all photogrammetric processing systems; (4) softwares were developed for specific photogrammetric task(s); and (5) the form of the generated data is not suitable for testing the photogrammetric instruments.

SPECIFICATIONS FOR GENERATING THE FICTITIOUS DATA

These specifications are classified as built-in and floating specifications.

I. Built-in Specifications

These specifications were taken into account during the development of the software. They outline the general layout of the math block and include:

a) Precision of image coordinates: The image coordinates of math photo points are computed to a precision of 0.1 mm.

b) Scale: The hypothetical ground system is chosen such that photos of near-vertical specification are produced at an approximate scale 1 : 1 . This decision conforms to the International Society of Photogrammetry's relevant resolution on the desirability of reporting all photogrammetric errors at the negative scale.

c) Unit block: The size of a block has been adopted as 105 photos in 5 strips of 21 photos each.

d) Numbering code for strip and photos: Alpha-numerical code system is used for identifying each photo.

e) Number of points transformed per photo: Figure 2 shows the location of the 36 points transformed per each photo.

f) Numbering codes for points: Points can be identified by two numbering systems Single-Photo and Block Numbering systems. In Single-Photo Numbering system, points are directly identified by serial numbers 1 to 36. This numbering system is suitable for all single photo studies, for example, studying the effects of dimensional distortions (Oswal, 1966). In Block Numbering system, alpha-numerical code system is used for identifying each point of the block points. This numbering system of points is suitable for block studies such as determination of strip deformations, magnitude and components, studying the effects of systematic and random errors on the results of the whole block, comparison of the results of the different procedures of block adjustment e. g. sequential and bundle, helping the researcher for developing new methodologies for block adjustment, and investigation of the effect of changing the block specifications on the results.

g) Ground coordinates of block points: The planned X and Y coordinates of the perspective centre of the first photo of the first strip in the block are taken as the coordinates of block origin.

h) Applied mathematical model: Perfect perspective projection from ground to photo and absence of all error sources has been assumed.

II. Floating Specifications

Floating specifications can be changed by the researchers, depending on their studies and the available data and are entered to the software operating system by editing data file. They include camera focal length and format, origin ground coordinates, height variation, longitudinal and lateral overlaps and flight specifications.

CONCEPT OF THE MATHP SYSTEM

The structure of generating math photos process is shown in Fig. 1. Four main modules (generating math photos "MATHP" software, generating AutoCAD files "DXFGEN" software, control interface and AutoCAD software) can be identified.

Central to the system is MATHP software that reads the floating block specifications from input data file (three data files are available to the system) and uses these specifications along with built-in block specifications for generating the mathematical photos. MATHP software stores the generated data in ASCII common files format for further processing. MATHP software is a menu based program consisting of two master menus. The main master menu consists of five options and depending upon the user's choice. These options are basically for generating the mathematical data for the whole block, selected strips and selected photos, helping the user and exiting to the system prompt. The second master menu consists of two options for choosing the numbering system, Single Photo or Block Numbering system. Also, user interface helps the user to move across the generated data and send the required data to the available hardcopy interfaces.

DXFGEN software reads the generated data and prepares the suitable AutoCAD drawing files in DXF format. A menu pad is provided, allowing the user to work without knowledge of AutoCAD command sequences. Each key on this pad invokes a different mapping function. Map scale, legends, title blocks,

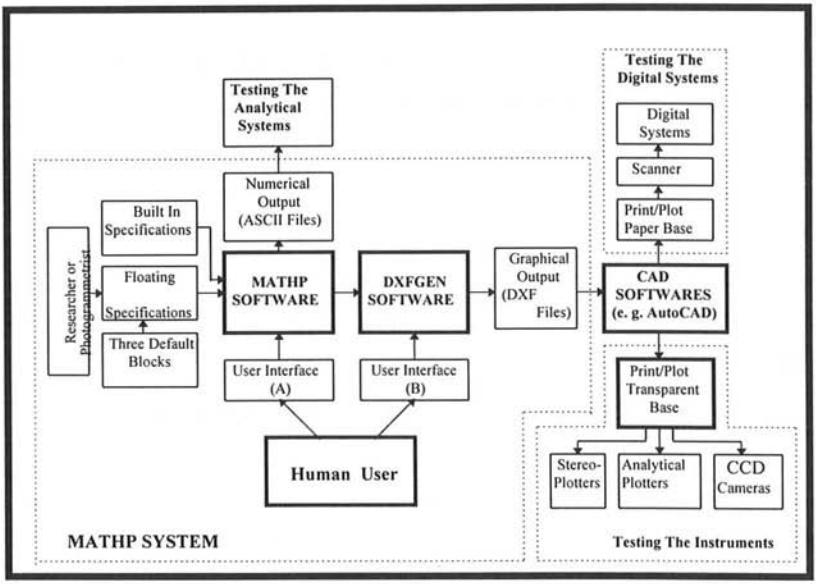

Figure 1 MATHP system architecture and its intermediate communication to the hardcopy devices.

border and coordinates griddings can be entered. DXFGEN is supported by default values for automatic map generation without user choices.

The main function of using AutoCAD software is to send the generated maps to the hardcopy interfaces by using AutoCAD's "Zoom" and "Print" or "Plot" options. AutoCAD also enables the user to add his modifications to the resulting map.

SYSTEM OUTPUT

The system generates the necessary data for both analytical and digital processing systems. Basically, these data are classified as numerical and graphical fictitious data.

a) Numerical Fictitious Data

photos per each strip, ground coordinates of the origin point, camera format, height variation and camera interior orientation parameters) and Photo-Oriented Elements (which include photo and strip numbers, camera exterior orientation parameters, points numbers with respect to the chosen numbering system and photo and ground coordinates of points).

b) Graphical Fictitious Data

It consists of the generated maps for location of the camera stations, location of points and for each photo, showing the image locations and their numbers as indicated in Figure 2.

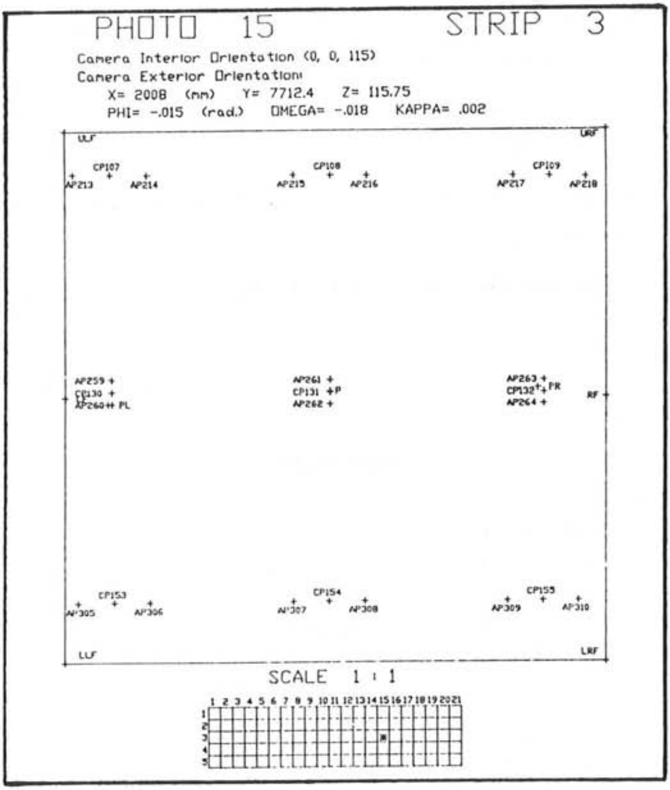

Figure 2 Graphical Fictitious Data for Each Photo

To test the output of the system, the data of a block of 3 strips of 11 photos per each strip had been generated and entered to bundle block adjustment software. The

RMS discrepancies between the generated and adjusted object coordinates of points were 0.017, 0.02 and 0.032 µm in X, Y and Z coordinates respectively. This indicates that the developed system is indeed able to accurately generate its output.

CONCLUSION

This paper discusses a new application of CAD technology for automatic preparation of the necessary data for calibrating the photogrammetric instruments. Using the colored facilities of the hardcopy devices, inkjet or laser printer or plotter, the gray level of graphical fictitious data can be changed to help some related studies to digital photogrammetry.

The developed system provides a real time solution for testing the photogrammetric systems and eliminates the need of manufactured plates which are costly and unavailable in all times.

The numerical and graphical fictitious data are useful for academic studies such as error behaviour investigations, determination of the suitable number of control points and their location, testing the results of the suggested methodologies of data processing, etc.

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MODERNIZATION OF MAP PRODUCTION ACTIVITIES WITHIN DEPARTMENT OF SURVEYS AND MAPPING

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The Department of Surveys and Mapping (DSM) is the Central Government Organisation responsible, among others, for the provision of conventional and digital mapping within the country. The department also provides large, medium and small scale mapping for development, Environmental Conservation and other purposes.

DSM has, in conjunction with SwedeSurvey, been engaged in a major modernization programme designed to upgrade its capacity to produce maps, especially village digital mapping increasingly demanded by users.

DSM is reasonably well equipped with modern computers and other mapping equipment and has enjoyed support from Government and donor agencies like Sida of Sweden and previously Britain's Overseas Development Agency.

In 1990 DSM signed an agreement for Institutional cooperation with Swedesurvey which has largely been responsible for the modernisation activities of the department, especially in the Mapping Division.

Since then DSM has made major capital investments in both equipment, software and human resources development in order to improve its mapping capacity and cope with demands from other ministries, departments, parastatals and private sector.

Local staff received continuous on the job training with a view to ensuring that they mastered the new technology and softwares, and as a result productivity has increased tremendously.

Recently through the National Atlas project, software and hardware suitable for Geographic Information Systems has been acquired. There are also plans to acquire equipment and associated software for the production of digital orthophotomaps.

INTRODUCTION:

Prior to 1990, the then Department of Surveys and Lands, had responsibilities for Surveying, Mapping, Management and Administration of all state landed property. The latter responsibility included the acquisition, leasing allocation and management of land, the leasing and ownership of Government office blocks, and the leasing, of houses for use by priority civil servants, especially expatriates. Surveying and Mapping received very little attention, the exception being cadastral surveying which involved the subdivision of stateland for allocation and leasing out purposes.

Although regular annual meetings were held with map users in order to obtain their views on their requirements for the future, these requirements were not used effectively during the budgetary estimates. Consequently a very small percentage of required mapping was delivered. Also over a number of years the Department did not have resources for the harnessing of technology to increase productivity. No attempt was made to respond to the ever increasing demands for mapping except through the use of British and South African contracts, which due to budget constraints achieved very little.

The photogrammetric section had only two B8 stereoplotters with no provision for digital capture; the reprographic section had a good rectifier E4 and everything else was manual, cartographic section had hardly any machines.

The cadastral division, however, had comparatively modernised as far back as the late seventies. It had for instance short and long range electronic distance measuring instruments, powerful hand-held calculators, and HP Computers and a flatbed Benson plotter. Computer generated maps or plans were at this stage only possible in the cadastral division.

During the early nineties three events, which favoured the modernisation of the map production activities occurred, albeit independently and at different times. The combination of these events, however, accelerated the transformation of the whole Department from probably one of the least developed at the time, to perhaps, a modern Department relative to developing small economies. The events referred to were:-

i) The restructuring of the Department of Surveys and Lands into the Departments of Lands, Housing and Surveys and Mapping (DSM).

ii) The Accelerated Land Servicing Project.

iii) District Physical Planning:

i) **DSM Restructuring:**

By its nature Land is the most politically sensitive responsibility of Government. For years successive Heads of the Department of Surveys and Lands had no alternative but to concentrate almost all their efforts to matters pertaining to estate management. This situation was exacerbated by the fact that the supporting staff with requisite qualifications had always been thin on the ground, initially because there were few trained officers but later due to the exodus of trained officers for greener pastures. Consequently the Director and even some of his Senior Surveyors had to attend to Lands and Housing matters.

The restructuring of the Department into the three Departments of Surveys and Mapping, Lands and Housing created a good environment for modernisation of the production systems for higher productivity. The immediate result was the reorganisation of the Department into three divisions of Surveys, Mapping and a third, Geo-informatics. The two divisions of Surveys and Mapping were to deal only with production matters, whilst Geo-informatics would constitute an interface between the production division and the users. In short, Geo-informatics is tasked with collecting, storing, collating, analysing and presenting, in appropriate format, survey and Mapping information. It is infact the Departmental GIS division and the clearing house for all end products.

ii) **The Accelerated Land Servicing Programme (ALSP):**

As a result of the fast growing economy but lack of provision of corresponding serviced land and housing, a stage was reached when the outcry for housing had reached such proportions that Government had to respond fast and effectively. Parliament released P500,000 000 for ALSP in all urban centres especially Gaborone for implementation by Ministry of Local Government, Lands and Housing to which DSM belongs. This increased the demand for production of maps and the provision of thousands of plots by both Government and private firms country-wide. The role of DSM was recognised as indispensable to the success of the project and consequently funding of its modernisation programme was greatly enhanced.

iii) **District Physical Planning:**

During the late 1980's as part of an ongoing Sida funded rural development project, there was a requirement for an input of physical planning. As there could be no physical planning without mapping it became necessary to study the situation, and such a study on Mapping requirements for District Physical Planning in Botswana was undertaken in 1988. The findings of the study were that the available mapping was grossly inadequate. The equipment available at that time was archaic and needed not only to be upgraded for digital mapping but increased substantially. The whole mapping division of the Department needed to be modernised by the provision of equipment and also through formal and on-the-job training. It was found that, for instance, having flown air-photography of thirty seven villages, only seven of these had actually been mapped over a four year period.

It needs to be categorically stated that this study and the recommendations thereof constituted the one major factor for the modernisation and encompasses both the other activities in both time and ascendancy as to decisiveness and effectiveness.

Over the last seven years the modernisation programme was carried through a strategy which ensured that, whilst the production systems were being improved, delivery of village mapping was met through other means. With little change, the procedures for achieving this feat were:-

i) **VILLAGE MAPPING**:

Phase I of the implementation strategy was to ensure that the Production of Physical plans and other developmental needs were not hampered by lack of maps. Swedesurvey was contracted by Sida to produce maps from aerial photography which was funded by the Government of Botswana. At the beginning of the project almost all village maps were produced by Swedesurvey, as the local production capacity was comparatively minute. With the decrease of the initial backlog and the increasing capacity created at DSM the amount of village mapping contracted to Swedesurvey was reduced over the years until recently when none was contracted to Swedesurvey.

As the mapping capacity increased even despite the initial backlog being reduced, due to increased development requirements, the demand for village mapping has more than doubled, and at the same time as capacity increases the backlog is building up. It is, however, a very different situation, as we expect that most of the mapping will be done in-house and a manageable percentage contracted out, both worldwide and regionally.

ii. **LONG-TERM MAPPING EXPERT**.

From the inception of the project until very recently, a long-term expert has been continuously attached to the project. His main responsibility was to manage the modernisation programme and undertake on-the-job training. This was a very crucial position especially at commencement of the project. This was especially pertinent as no officer within the Mapping Division was familiar with the modern map production techniques including digital mapping.

The other advantage of the long-term mapping expert was that he was infact an ambassador for the Swedesurvey and the National Land Survey of Sweden, and he could call for assistance from a pool of highly qualified and experienced personnel. It is unlikely that this project could have been successful without the attachment of the long-term expert. The attachment directly reflected the commitment and professionalism of those assigned to the task and their support base.

Currently the position of long-term expert has been terminated in favour of a short-term mapping expert. Whilst the need for consultations and problem solving continues, the project appears to be capable of being managed locally without a long-term expert. As the project is scheduled to end in June 1997 it was sensible to discontinue the position early, in order that possible problems can be dealt with during the life of the project.

The continued success of the project is also due to the fact that both officers who have occupied the post have become well informed on it and are familiar with conditions prevailing in Botswana, continue to be associated with it. Their contribution has been invaluable to Botswana.

DIGITAL MAPPING.

The introduction of digital mapping, and the complete transformation of the production system from being wholly manual to a completely digital and partially automated system, was carried out through:-

Attachments and training

Acquisition of requisite equipment and software.

Short term consultancies.

ATTACHMENTS AND TRAINING

The most senior of the photogrammetrists were attached to the Swedesurvey office in Gavle to learn digital map production system as practically as possible. In addition all operators underwent intensive in-service and on-the-job training given either by the long term experts or a specially contracted specialist. Most of the training was digital mapping using the software SOS-MAP which was found to be very user friendly.

In addition the photogrammetric training was given in the use of aerial triangulation software PATMB and PATM GPS. Later the training in digital production to the cartographic section was also delivered using SOS-Software mainly for data capture and storage whilst a software, OCAD, was used for production of the cartographic products.

The training programme for this project was continuous, intensive and practical. The beneficiaries are now operating with confidence and it is now irreversibly evident that the new production system will be able to progress after the end of the project.

EQUIPMENT AND SOFTWARE.

Prior to this project, the Department had only two Wild B8 stereoplotters. Early in the project a wild A10 and two reconditioned Wild A8 stereoplotters all fitted with linear encoders were acquired. Later one of the B8's was fitted with a linear encoder whilst the other was transformed into a fully analytical stereoplotter via the Qasco analytical conversion system. A drum plotter and flatbed plotter were also acquired as part of the software and hardware digital mapping system.

Later computers and digitizers were obtained for the Cartographic work, which are operational on the digitisation of medium to small scale mapping. Much new equipment was also acquired to improve production. Also for control purposes GPS technology was acquired and at present the Department boasts seven GPS receivers which are fully employed.

SHORT TERM CONSULTANCIES.

Highly experienced consultants were engaged for training and consultancy. The consultancies were targeted at problematic issues in the endeavour to improve the Department's productivity in general.

FUTURE PLANS

Currently the project on the National Atlas has just begun full-scale, PC version will follow later. Funds have been secured for the implementation of GIS initially by automating other production systems, conversion of data from manual to digital, designing and building an integrated cadastral and topographic GIS database. The type of technology transfer recommended is that through institutional cooperation as above. The National Atlas is thought to be a major project that will not only benefit the country through provision of a multi-user information, but will also be the route through which the advantages of GIS will be learnt and therefore its future funding.

There are also plans to venture into digital photogrammetry and digital orthophotomapping. This is very important as towns and villages are developing rapidly and line mapping is too expensive and slow for tasks such as census and other statistically related development.

CONCLUSION:

The Department of Surveys and Mapping is now playing its role as a National Survey and Mapping Organisation very well. Almost all large and medium large settlements in the country are mapped at 1:5 000 digital format. Users such as utilities have been saved millions of Pula and consequently the consumer whc is also the taxpayer. Nationally the role of the Department is becoming increasingly recognised and appreciated.

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VISUALIZATION OF A GIS-BASED WATER BALANCE MODEL

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Abstract

Modeling the water balance of a major flooding event can provide insight into the timing of the flood and the amount of water storage that occurred on the land surface. During the spring and summer months of 1993, a large flood occurred in the Upper Mississippi River Basin (UMRB), an area of over 700,000 km^2, causing one of North America's most costly natural disasters. The purpose of this study is to model and visualize the flood water balance (inflow to the basins minus outflow from the basins). A Geographic Information System (GIS) was used to create an extensive flood database of daily hydrologic measurements acquired during 1993, and to model the water storage in the UMRB. The resulting products were 365 daily raster grids of water storage for the major UMRB watersheds. To better portray the effects of the flood on the land surface, a methodology of visualizing surface hydrologic processes is being developed. The static series of GIS raster grids is being transformed into a temporal sequence of maps using geographic visualization (GVIS) procedures and software. One of the primary visualization products that is being developed is an animated choropleth map of the UMRB showing the daily increases and decreases in water storage for every major watershed in the study region during 1993. User interaction with the maps through the Internet is also being investigated.

Introduction

This study first began during meetings of the Scientific Assessment and Strategy Team (SAST), an interagency group established by the White House on November 24, 1993, to provide scientific advice and assistance to officials responsible for making decisions regarding flood recovery in the UMRB (SAST, 1994). At the time of the meetings, SAST project members identified the need for a daily water balance of the flood region to determine how much precipitation occurred and how quickly it moved over the landscape. The resulting study, which has been funded by the U.S. Geological Survey (USGS), consists of three phases: (1) the creation of a GIS flood database of streamflow, precipitation, and evapotranspiration daily values, (2) hydrologic modeling using the GIS database, and (3) extending the modeling to include the use of scientific/geographic visualization (GVIS) technologies in the depiction of the 1993 flood. Phase 3 is the primary focus of this paper.

The 1993 Midwestern U.S. Floods

The flood along the Upper Mississippi and Lower Missouri Rivers and their tributaries during the 1993 spring and summer months has been described as an event unprecedented in modern times. The precipitation amounts, record river stages, areal extent of the flooding, persons displaced, crop and property damage, and flood duration surpassed all previous U.S. floods during modern times (U.S. Department of Commerce, 1994). The flood affected approximately one-third of the United States, with damage estimates assessed at $18 billion. Although the worst of the flooding occurred between May and September of 1993, the actual beginnings of the flood can be traced back to the Fall of 1992 when very heavy November rains occurred along portions of the Mississippi River. Snowmelt coupled with a wetter-than-normal Spring created an oversaturated land surface that was extremely prone to the flooding which started when extremely heavy rainfall amounts fell in May (Changnon, 1996).

The main focus of this study is a region that encompasses the main stem of the Mississippi River above Cairo, Illinois, and the main stem of the Missouri River below Gavins Point Dam near Yankton, South Dakota. Also included are the many tributaries of these rivers such as the James, Des Moines, Illinois, and many other rivers and streams. This region of nearly 700,000 km^2 was previously defined by the Scientific Assessment and Strategy Team (SAST) as the area most affected by the spring and summer floods of 1993 (SAST, 1994). The states that are entirely or partly contained in the study area are Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin (Figure 1).

Creation of the GIS Database and Hydrologic Models

The GIS database compilation and modeling of the 1993 flood was a joint project undertaken by the authors and hydrologists from the University of Texas at Austin, Dr. David Maidment and Pawel Mizgalewicz. The University of Texas team was responsible for building the database and modeling the water balance using GIS, while the University of Utah team assisted with the collection and formatting of the data sets, particularly the streamflow data. Daily values (for 365 days of 1993) of streamflow and monthly values of evapotranspiration (derived to daily values) were obtained from USGS, while 1993 daily values for precipitation were obtained from the National Climatic Data Center (NCDC).

White and others (1996) discuss the procedures used in the construction of this database and the hydrologic modeling steps involved. The streamflow, precipitation,

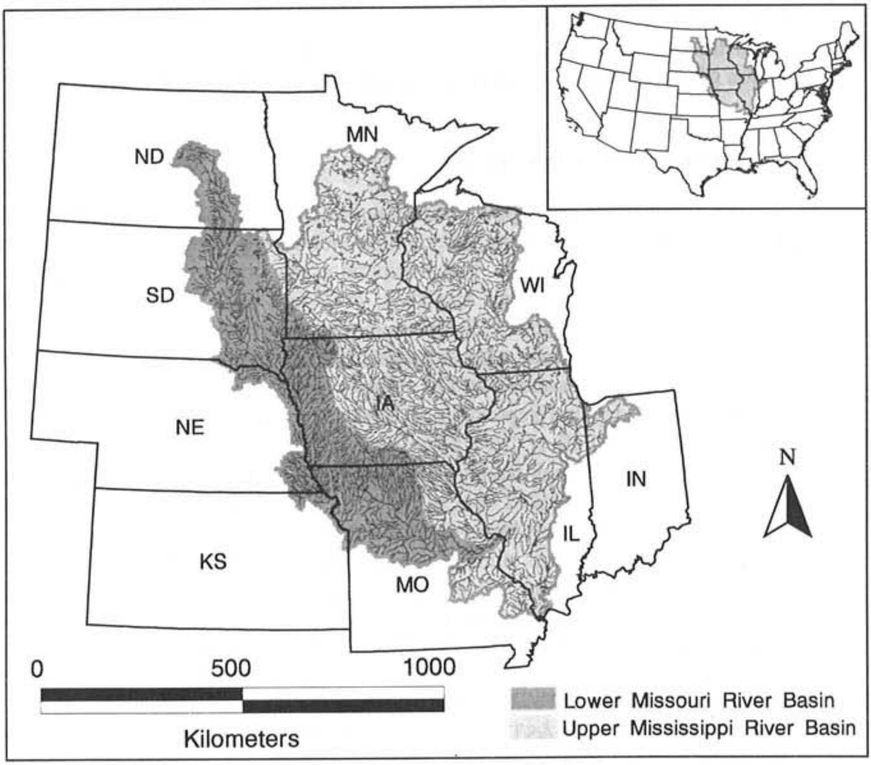

Figure 1. Location of the Upper Mississippi River Basin study area. The USGS defines both river basins as the "Upper Mississippi River Basin".

and evapotranspiration values described above were incorporated into tables within ESRI Arc/Info® GIS software. The raster GRID module of Arc/Info was used, in conjunction with a 15" digital elevation model (DEM) and a gridded RF1 river reach file for the Upper Mississippi and Missouri Rivers to create the digital terrain model. Both the DEM and the river reach file were obtained from USGS Internet sites. Included in this model were additional grid cell attributes such as the locations of USGS streamflow gauging stations. These locations defined the outflow points of the watersheds delineated on the terrain model. Three sets of 365 raster grids each were created, with each gauge station-defined watershed assigned a daily streamflow, precipitation, and evapotranspiration value. Each daily raster grid set was then used as input into a water balance equation. This equation calculates daily change in water storage depth per unit area of a watershed using precipitation, evapotranspiration, and stream-flow (inflow minus outflow) as variables.

The water storage values in each gauge station-defined watershed were averaged over the 180, 8-digit Hydrologic Unit Codes (HUCs) that make up the UMRB. The 8-digit HUCs represent the smallest hydrologic cataloging units as designated by the USGS. Each of these hydrologic units is defined by surface topography and is assigned a unique eight digit numeric code (Seaber and others, 1987). Since the HUC forms the basis of much of the USGS' water-resource and related land-resources planning work, it was felt that this hydrologic unit should define the spatial resolution of the visualization work described in the next sections. Another factor in our decision was the relatively homogeneous spatial configuration of the HUCs, which leads to effective visualization of the water storage changes in the basin.

Application of Geographic Visualization Techniques

Introduction

The results of the GIS modeling described above produced a series of static maps of a major flood – an event that is inherently dynamic and constantly changing. One of the primary reasons that the USGS funded this project was to develop a methodology whereby hydrologic processes, such as those active during a broad-scale flood, can be modeled and portrayed in a manner that is understandable to the scientific community, and the general public as well. The rest of this paper will deal with the development of some methodologies for visualizing large flooding events, and how these methodologies communicate cartographic concepts to the map user.

GVIS and Cartographic Communication

MacEachren (1994) discusses geographic visualization (GVIS) as a model of three-dimensional human-map interaction space that is a part of three continua: (1) private to public map use, (2) map use that explores unknown facts or presents known facts, and (3) map use that ranges from high to low user interaction. He states that GVIS is embodied by map use that is private, exploratory, and highly interactive, whereas cartographic communication is at the other end of the map interaction space: public, presentation-based, and less interactive.

This study will focus on both GVIS and cartographic communication. The construction of the database and subsequent computer modeling both fall under the private, exploratory, and interactive umbrella of GVIS. In this stage the researchers have gathered data sets for the 1993 flood, organized the information into a geospatial computer database (a GIS), and used the modeling capabilities of the GIS to derive a water balance for the flood. Each step in the process has taken us closer to a model of cartographic communication in which the results of the water balance study are made available to the public in a form that is readily understandable and visually dynamic. This involves the transformation of the static series of 365 water balance/water storage maps, using scientific/geographic visualization procedures and software, into models that help explain and depict the temporal nature of the flood.

Conversion of GIS Raster Output

The results of the water balance modeling are several tables of numbers corresponding to water storage depth (in millimeters) for the 365 days of 1993. Each of these numbers are actually attribute values assigned to a particular watershed within the UMRB. Although the main flood months in the basin were early May through early August, data for the entire year of 1993 was used to close the water balance on December 31. The spatial configuration of the gauge station-defined watersheds was fairly heterogeneous, so the water storage values were averaged over the 180 HUCs to enable us to visualize a more homogeneous spatial distribution. This averaging procedure was accomplished by intersecting the gauge station zone grid with a grid of HUC zones (this grid was actually a rasterized Arc/Info polygon coverage of HUC boundaries). Average water storage values were assigned to each HUC zone after the intersection, and then those values were attributed to the original HUC polygon coverage.

A total of 365 average water storage attributes was assigned to each HUC polygon in the Arc/Info coverage. These values were then used to group the HUC polygons into ranges of water storage depth measurements which became the class intervals in a series of choropleth maps.

Animated Choropleth Map of the UMRB

The authors are currently working on the development of an animated choropleth map which depicts the water storage changes that occurred in the UMRB during the 1993 flood months (roughly May through August). Each watershed/HUC polygon has been color-coded a shade of blue depending upon the depth of water stored on a particular day. Various methods of class interval determination are being examined ranging from natural breaks, equal interval, and quantile methods to the bin-scoring methods proposed by Monmonier (1994) which are specifically designed to evaluate potential class interval breaks for dynamic temporal choropleth maps. In Monmonier's method, merits and demerits are assigned to maximum change and minimum change thresholds, respectively, to distinguish between important versus insignificant transitions between data. This method should theoretically produce class interval breaks which best represents the temporal data. However, as Monmonier points out, the technique may produce a busy classification which may inhibit the map user's ability to understand the temporal data.

Figure 2 shows an example of the classification of water storage depth using the equal steps or equal interval method. ESRI ArcView® GIS software was used to create the classified maps. In Figure 2, four days are depicted: July 29, 30, 31, and August 1. These days correspond to some of the worst flooding (and greatest water storage amounts) during the entire event, particularly around the St. Louis, Missouri, area where the Mississippi River crested on August 1 at 15.11 meters (49.58 feet) above flood stage (Changnon, 1996). Several HUCs in the eastern and northeastern parts of the UMRB showed a negative cumulative water storage amount for the four days indicating that these watersheds were losing more water through outflow and evaporation than they were gaining through inflow and precipitation. The areas of negative water balance were assigned a color of white, while those watersheds with a

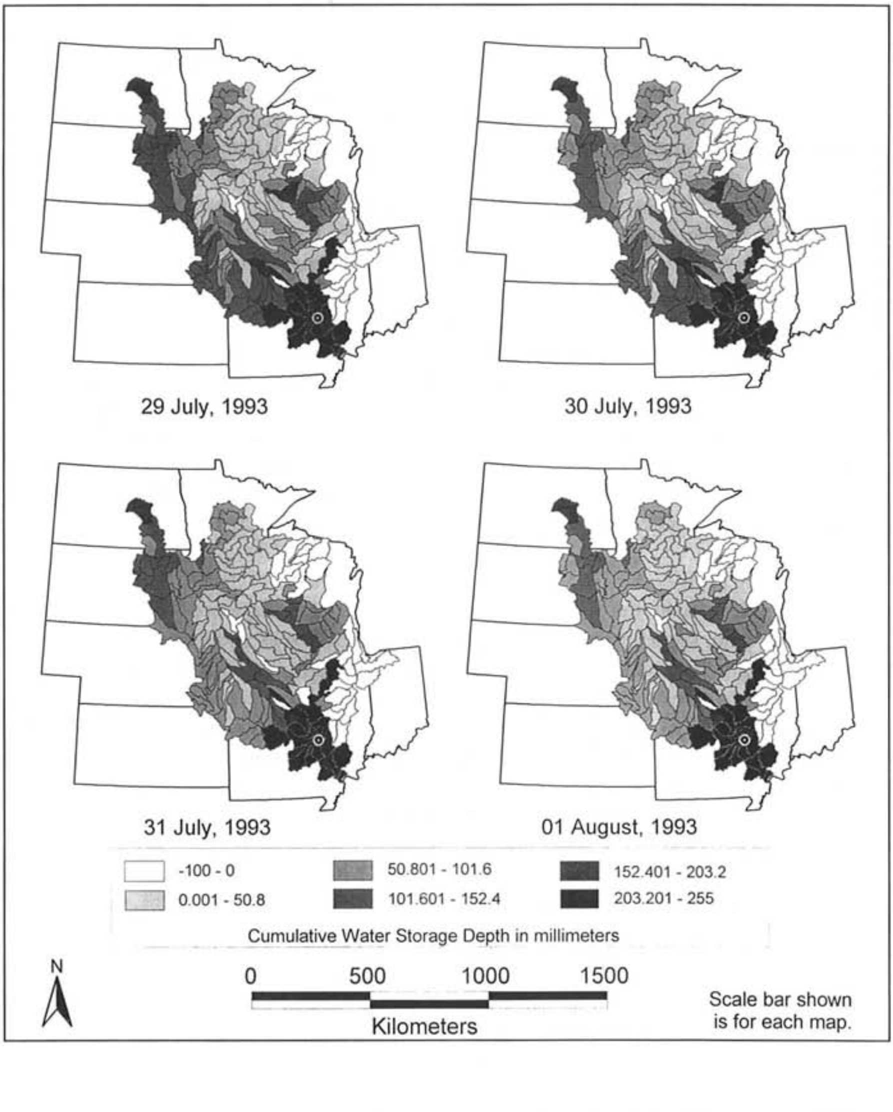

Figure 2. Water storage changes for four consecutive days, July 29-August 1, 1993 area classified using the equal interval method. Polygons are the 180 HUCs that cover the UMRB. The white dot in the southern end of the basin is St. Louis, Missouri.

positive water balance were assigned various shades of blue depending upon the water storage depth (light blue = small amount of water storage, bright blue = large amount of water storage). Note that for the purposes of this paper, the HUCs have been colored in shades of gray, corresponding to the shades of blue discussed above. The number of class intervals was set at six, including the interval colored white (negative cumulative water storage). The positive values of water storage were then divided into equal sized sub-ranges by subtracting the smallest value (0) from the largest value (254) in the data set, and the remainder was divided by 5. While the area around St. Louis remains constant in terms of water storage over the four day period, other watersheds to the north do show some fluctuation in their water storage amounts. Several river basin areas are well-delineated on the maps, particularly the confluence of the Mississippi and Missouri River basins around St. Louis, and the Illinois River (the dark extension northeast of the St. Louis region).

This portion of the study has sought to illustrate some of the potential of animated choropleth mapping in depicting the 1993 flood dynamics. Although it is not really evident from the static sequence of maps in Figure 2, the movement of water through the UMRB is depicted quite well when the maps are put into motion. The authors are currently evaluating different types of animation/visualization software including Macromedia Extreme 3D® and IBM Visualization Data Explorer® to determine which may do the best job in animating the choropleth maps.

Use of Levee Data

In addition to the data sets that have been time-sequenced in an animated choropleth map, the addition of a polygon coverage of levees and associated attributes is also being investigated as another means of visualizing the dynamics of the flood. One of the attributes of this coverage is a levee failure date. When the levee coverage is placed adjacent to a HUC water storage coverage for a given day, the timing of the changes in water storage per HUC on that day can be considered. It is expected that an animation will be sequenced so that some indication of a levee break or breach would coincide with a dramatic increase in water storage for an adjacent HUC.

Cartographic Communication and Presentation

The construction of an animated choropleth of the flood is just one aspect of the overall hydrologic modeling and visualization study of the 1993 floods. In addition to two-dimensional visualization procedures discussed above, other means of portraying the dynamics of the flood event are being investigated. Three-dimensional perspective views, based on the DEM will be used to enhance the map user's understanding of the terrain upon which the flood occurred. Satellite multispectral and radar images will also be used as a realistic surface draped on top of the DEM. Also, the entire choropleth animation may be viewed as a dynamic 3-D surface. These additional GVIS models will be constructed using IBM Visualization Data Explorer software.

Effective cartographic communication of the water balance model has been the primary objective of this study. This can only really occur if the graphic models are made understandable and available not only to the scientific community, but to the general public as well. One of the most effective means of presenting map data to the public is through the use of the Internet. Many maps depicting temporal data are available on the Internet in several different animation formats (i.e., MPEG, Apple QuickTime, Windows AVI, etc.). However, these formats offer little opportunity for the interested map user to interact with and explore the map. A relatively new format for viewing and interacting with graphics on the Internet is through the use of the Virtual Reality Modeling Language (VRML). With VRML, the map user can truly explore a "virtual world" by navigating or flying through the world. Real-world data can also be handled in the virtual environment of VRML. The terrain models constructed during this study can be exported to the VRML format and made available to the public through the use of common Internet browser software such as Netscape®.

Conclusions

This study has been concerned with the visualization and communication of cartographic data. Specifically, the results of a GIS-based water balance model have been transformed from a static series of raster grids into a temporal sequence of animated choropleth maps. These maps effectively show how water was stored during the 1993 Midwestern U.S. floods, how the storage changed during the peak flood months, and how different colors applied to the changing water storage values can create an impression of flood water flowing through the basin. The graphics that are being created during this study will be extremely valuable to land use planners, flood forecasters, and the public, and can be applied to future flood events in other places.

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METHODS IN PREPARATION OF THE MAPPING OF LANDSLIDES ZONES NW OF IRAN

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Abstract

Methods of mapping zones that are susceptible to landslides have been based in the past upon interpretation of aerial photographs in combination with field surveys, maps.

Among natural hazards, lanslides present a major danger for most Iran areas, especially in areas of the **Azerbaijan** where the risk is increased by human settlement.

Research is being conducted in order to improve the methods of mapping the areas that are vulnerable to landslides, and current approaches are based on geological and structural studies, geomorphology and modeling.

The geological application of aerial photographs in the Kharvana to Julfa

region in NW of Azerbaijan-Iran demonstrates the use of aerial photographs in mapping the zones that are susceptible to landslides. This experiment shows that, provides streoscopy can be obtained, remote sensing from space froms a complement to fields surveys and is a highly effective tool for this type of mapping at scales ranging from 1:25000 to 1:5000.0

INTRODUCTION

Thousands of people may be killed by landslides each and property damage may be in the fens of billions of Dollars, but the techniques for recognizing and coping with landslides are well developed landslides are generally more manage able and predictable than earthquakes, volcanic eruptions, and some storms, but only a few countries have taken advantage of this knowledge to reduce landslide hazards.

A landslide involves vertical and horizontal movement of soil, rock or some combination of the two under the influence of gravity. These slope movements are usually categorized as being either : falls, topples, slides spreads or flows.

Ladslides are the consequence of diverse complex processes that probably affect every country that has topgraphic relief.

Many move so slowly that the effects are barely disceribe, others move hundreds of kilometers an hour, obliterating everything in their path.

Landslides are most commonly trigged by precipitation, but earthquake, and volcano-triggereds have killed more people than all other types of landslides combined. The masking of landslide damage by earthquakes, volcanoes, and floods, and the lack of landslide damage statistics in most countries have led to widespread ignorance about the social, economic and political consequences of landslide processes, and a paucity of programs for reducing the hazard. This lack is unfortunate because landslides are generally more predictable and manageable than earthquakes, volcanic eruptions, and many types of storms.

Regional appraisals typically range from mapping the landslide features of an area to producing a zonation of hazard based on causative factors, Detailed site studies usually attemp to quantify the forces responsible for the landslides or to ascertain the existing forces acting on a unfailed solpe or slope mass.

Among natural hazards, landslides present a major danger for **Iran** especially in area of the **Harzand-Zunuz** and **Kharvana-Julfa** in **Azerbaijan-Iran**. Research is being conducted in order to improve the vulnerable to landslides, and current approches are based on geological and structural studies, geomorphology and modeling.

Aerial photographs, because of their excellent spatial resolution and sterescopic capacity, have been regarded as a extremely important tool that is complementary to field surveys in compiling landslide inventories.

CLASSIFICATION AND RESEARCH NEEDED THE LANDSLIDE

Evaluating landslide hazard for sites requires a close coordination between geology and engineering. The geologist is concerned with determining : What is the landslide problem ? Why is the landslide here? What are the geologic conditions may suggest that the landslide hazard is less severe than initially thought.

Often, evaluation of landslide Hazard at sites relies on some from of slope-stability analysis. Fig1 shows a stability analysis applied to designing stabilization of a landslide. **Most** methods of slope-stability analysis are based on theorical models

Developed to ensure the stability of engineered embankments where the moisture content, material characteristics and slopes vary within narrow defined limits.

Many classification schemes have been devised to explain landslide processes, but the one by **Varnes** (1978) shown in **Table1** is used by most researchers.

The basic divisions in the **Varnes** classification are the type of movement-fall, topple, slide, spread and flow and the kind of material involved.

Note that **Varnes** prefers the term " slope movements".

I will use the more familiar "**landslides**" in this paper even though many processes loosely termed "**landslides**" involve little or no true sliding .

Recognition and identification of the types of landslides goes back at least to 186B.C

In China (li, 1989), but systematic identification and mapping of all landslide types in specific areas have developed mainly during the past few decade. For example, gelogic maps published around the turn of the century did not show a single landslide in the **SAN-FRANCISCO** of **California** in **U.S.A.**

By 1970 approximately **1200** landslides had been mapped in the region. Research needs are greatest for landslide prediction and the establishment of recurrence intervals so that the risk of landslidse failure can be determined. A balanced program to recognize and mitigate landslides should involve investigation of landslide processes, development of methods to delineate the hazard, and schemes to reduce the losses•

Type of movement			Type of material		
			bedrock	Engineering soils	
				predominantly coarse	predominantly fine
Falls			Rock fall	Debris fall	Earth fall
Topples			Rock topple	Debris topple	Earth topple
			Rock slump	Debris topple	Earth slump
Slides	Rotational	Few Units	Rock blockslide	Debris block slide	Earth block silde
			Rock slide	Debris silde	Earth slide
	Translational	Many Units			
Lateral spreads			Rock spread	Debris spread	Earth spread
Flows			Rock flow	Debris spread	Earth spread
			(deep creep)	(Soil creep)	
Complex			Combination of two or more principal types of movement		

fig1- Abbreviated classification of slope movements (from varnes 1978).

LANDSLIDES AND ROCKFALLS IN NORTH AND NORTH-WEST OF IRAN

Unfortunately there isn't any nominated center in order to record and evaluate landslides in **Iran**

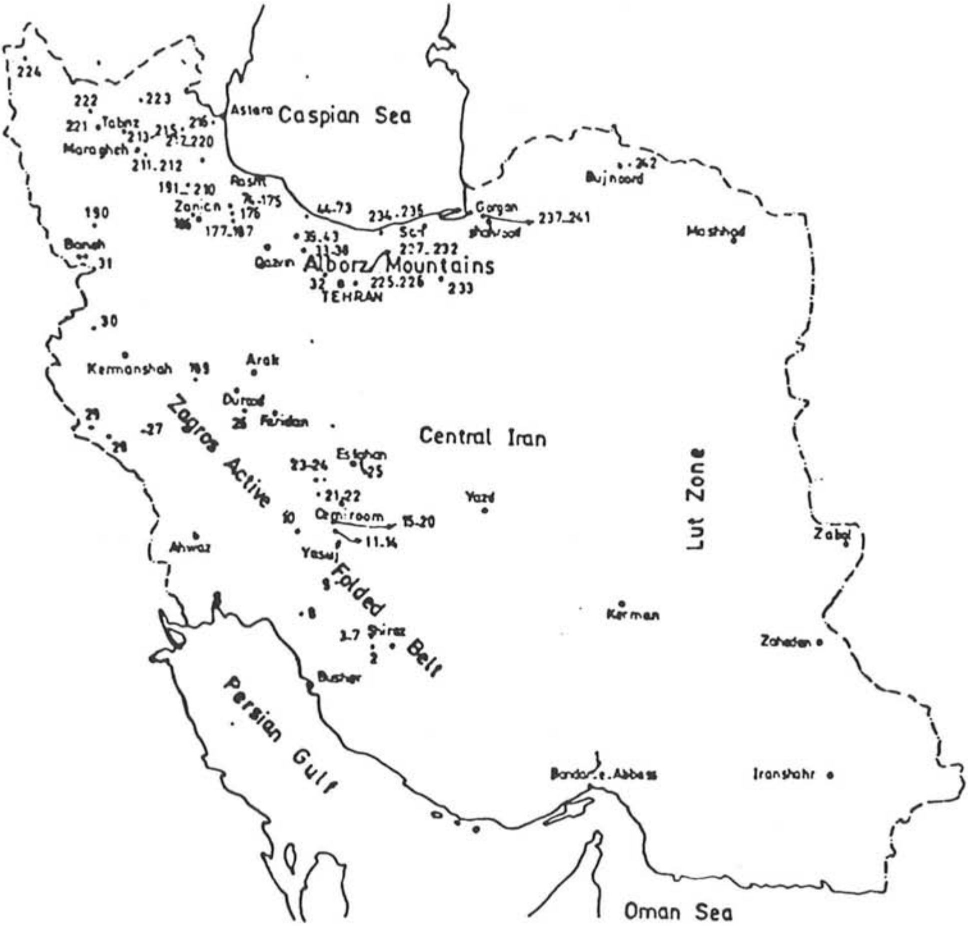
However in figure 2 location of some of theM is indicated. It can be considered as a preliminary map of landslides in Iran Recorded landslides in this map are about 250 **Cases,** which more than 100 cases are concerned to the Manjil-Roudbar earthquake(1990) **(Guilan state North of Iran)**

Kind of landslides and the prevail mechanism on them have not been indicated in the map.

Further more due to the lack of fundmental studies on landslides most of important landslides are not included in the map. Poor data included in the map, indicates that important information of landslides have not been recorded.

With respect to the data on the map it can be easily observed that most of landslides happened in the **Zagross** active folded belt and **Alborz** mountains. Unfortunately there isn't available any information regarding landslides in **Azerbaijan** where the most important valley in **Iran, Aras** river and its tall mountains in both sides is located.

Landslides and rockfalls are mainly happening in marns, weathered shales, hard



(Fig. 2) the preliminary map of landslide distribution in Iran.
(Almost 250 cases)

clays, loesses, tuffs (particularly in piedmont debris) and residual soils. Rainfalls and earthquakes are the most important factors in the mechanism of landslides.

Taher Kia has evaluated the nonsteadiness of slops around the Haraz road in the **North** of **Iran** (Alborz mountains) by means of satellite aerial photographs and remote-sensing Results of his research can be concluded as follows and it is **typical** for the landslides in Alborz mountains :

1) - Most of the evaluated areas particularly Haraz valley, due to presence of sharp slopes are not safe, construction of Haraz road has complicated the problem.

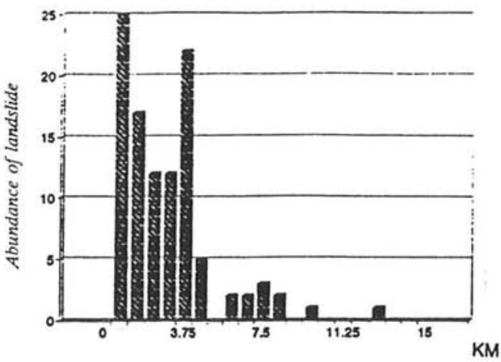
2) - Most of slides have been severed by earthquakes, several expansion and contraction, various icing and melting and permeation of water in to the root of greens.

3) - Due to tectonics activities in the area, rocks are weathered and are not safe.

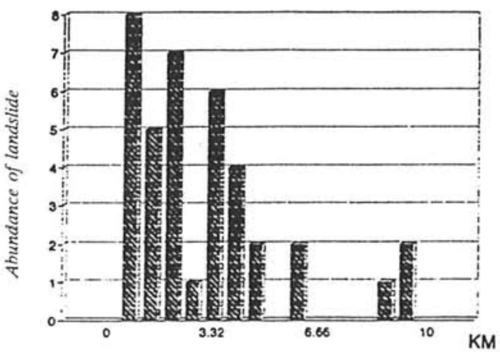
4) - There are three distingushable type of slides:

- Topplings along with rockfalls.
- Slides in line with a certain shearing surface.
- Landslides on disconnected mass.

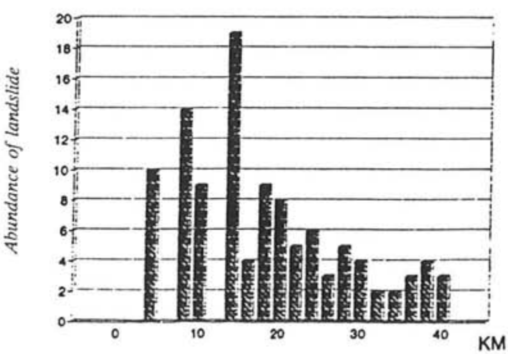
5) - Different landslides which were observed, are extendable to all areas in **North** and **North-West** of **Iran**, and can be classified in the following groups:



(a). Distance from fault of the earthquak of manjil in 1990



(b). Distance from old fault.



(c). Distance from of focus earthquak.

(Fig 3)

a) - Rockfalls : Three different kind of them were observed;

Free falls which are very rare, since there are few points with negative slopes.

- Deterioration by icing and melting.

- Jump and sliding.

b) - Rockslides : Followings are the recorded examples in 1982 at kilometer 85, rockslides happened in volcanic sediments Cretaceous system, in a zone with deep faulting.

At kilometer 59 it happened in the Jurassic shales and sandstones where the slop was 25 degree. Dimension of heavy faulting was 150m×100m.

In spring 1982 at kilometer 64, rock slides happened in a jurassic limestone area where the slop to the valley was 30 degree. It happened by earthquake and the result was 200 deadth and Thousands of dollar damage.

c) - Slumps in the clastic rocks.

As a sample in happened at a faulting area in km 13 of Fasham-Mashae, in a zone with Permian weathered rocks and dimension of **2km×2 km**.

d) - Debris slides, debris flows, sand flows, and mudflows are other types of landslides which are happing in big scale in **North** and **North-West** of **Iran**.

CONCLUSION

Although improvement is still possible in the methods of evaluating the weight of certain factors such as faults and drainage, the objectives of the project have been reached for the **Haraz** and other 8 valley in North and **North-West** of Iran test site.

We have demonstrated that the processing and interpetation of Remote-sensing data make it possible to map landslide hazards at scales that range from 1.25000 to 1.50000.

In order to do this, a stereopair of images is vital, but only limited field control is necessary.

The document resulting from this initial study has been assessed by comparison with published maps and field control in selected areas.

Remote-sensing offers the potential for significantly increasing our knowledge of landslides around the **North** and North-west of Iran, as well as for collecting data of uniform quality over sufficiently large areas will allow us to interpret landslides processes.

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SOUNDING SELECTION FOR NAUTICAL CHARTS: AN EXPERT SYSTEM APPROACH

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Abstract

Nautical chart is one of the most standardized cartographic products. Its important role and contribution in execution of safe navigation, led to the development of chart specifications approved and adopted by National and International Hydrographic Organizations. These specifications constitute "knowledge" and describe in detail all aspects of design and content of nautical charts. Therefore the basic chart design process is formalized. Due to the above mentioned reasons, the development of an efficient Cartographic Expert System for the design and production of nautical charts, seems to be feasible. When achieved, it will have a serious impact on the "automation" of chart production and on the reduction of the cost of the final product. This paper elaborates a process for the implementation of sounding selection, a rather critical task in nautical chart compilation, using expert systems technology. The result of this process is a component of an integrated Cartographic Expert System for the design and production of nautical charts which is being developed in the NTUA Cartography Laboratory.

1. Problem Statement

During the compilation procedure for the production of a nautical chart, hydrographic information and specifically soundings, are collected from various sources. These sources are mainly plotting sheets and nautical charts at scales larger than the scale of the chart under construction. "With decreasing scale, deeper soundings tend to be eliminated while the shoaler ones are retained for safety. The cartographer must ensure that he retains sufficient numbers of the deeper soundings to show the full range of depths; if he does not, he is likely to mislead the navigator who uses his echo sounder to help verify his position, or the mariner choosing an anchorage of suitable depth" [*Chart Specifications of the I.H.O, 1990*].

The problem from the cartographic point of view is a generalization problem which must be resolved in conjunction with a considerable number of criteria [rules]. Emphasis is given to the background soundings selection. Background soundings are those selected for depiction in open water areas where dangers to surface navigation are generally in the form of small isolated shoals. In background sounding selection, attention is drawn to hazardous regions. Sounding selection in the neighborhood of special cartographic features such as shorelines, piers, rivers, dredged channels are not considered here. These features are generally inshore features requiring a quite different approach.

The major criteria for selecting background soundings are summarized below :
Criterion 1. The shoalest soundings must be depicted. This criterion forces the cartographer to portray navigational hazards. This requirement is less severe in areas with depths greater than 90 feet (~ 27.4 meters) since this depth is greater than the draft of most large super tankers.
Criterion 2. The density of selected soundings must increase in shoal areas and decrease in less dangerous areas. This allows the chart user to determine at a glance the depth characteristics of the region, without the need to read every sounding value or contour label. He will be alerted of potentially hazardous shoals located in deeper water areas because the density of soundings will increase in the vicinity of the shoal.
Criterion 3. Local bottom irregularities and small "closed" depth contours should be emphasized with the depiction of a sounding. This criterion is applied to shoal depth contours and extensions of shoal depth contours into deeper water areas.
Criterion 4. This criterion deals with one of the aesthetic qualities of nautical chart making. In areas of homogeneous depth, selected soundings should form - as far as possible - an equilateral triangular pattern. As water depth gradually decreases, triangle size becomes smaller in a smooth continuous manner. The distance separation of soundings in relation to the water depth has been empirically determined and a Distance Separation Table (DST) *[Unitech Inc. 1990]* has been developed which lists the maximum and the minimum separation distances for different categories of depth range (*Table 1*).

Category	Depth range (m)	Min Separation (cm)	Max Separation (cm)
1	0-10	1.00	1.25
2	11-25	1.25	1.50
3	26-75	1.50	2.00
4	>75	2.00	2.50

Table 1. Distance Separation Table (DST)

2. Methodology

The development of an expert system, which will offer efficient and acceptable solutions to a particular problem, requires the study of the methodology followed by the human expert, and/or any related "knowledge" which may have been documented in the form of rules or specifications *[Stefanakis & Tsoulos, 1995]*. The problem we are dealing with, is very well documented and the above mentioned criteria will be the framework for its solution.

The distance separation of the soundings to be selected, depends on the category the area belongs to. This leads to the partition of the area covered by the chart, in sub-areas according to the depth ranges of *Table 1*. The expert system will apply the appropriate set of rules according to the depth characteristics of the sub-area examined. The result would be a set of soundings with densities complying with the specifications and forming a triangular pattern.

The system must "learn" to recognize some specific cases. According to the first criterion the shoalest soundings must be retained (this is not applied to categories 3 and 4 of Table 1, where water depth is deeper than 26 meters). Finally, according to the third criterion, soundings must be depicted in areas with contour irregularities and in small closed contours.

3. Algorithm description

The algorithm developed for the sounding selection is partitioned into four consecutive phases which are elaborated thereafter.

Phase 1

The objective of this phase is the partition of the charted area in sub-areas with soundings ranging according to Table 1.

- All soundings included in the data set, are utilized to produce the Digital Model of the seabed. This is implemented with the Triangular Irregular Network (TIN) whose structure allows for data interpolation, sampling and computation of parameters as slope, aspect etc. When TIN is generated a number of files - useful in the next phase - is created [file of triangles, file of triangle edges, file of triangle vertices, depth-contour file].
- Computation of depth value of each triangle at its centroid. The computation is done by linear interpolation on the depth values of the triangle vertices. The resulting interpolated depths are linked to each triangle. These values will be used later in the process for the identification of areas with homogeneous depths.
- Adjacent triangles with interpolated depth values belonging in the same category are merged to form polygons. During this process the depths which are located within the "merged" area are identified and "flagged" accordingly. At the end of this process, the outline of areas with homogeneous depths and the soundings located within these areas are saved into a temporary file.

Phase 2

Areas with depth contour irregularities or small closed depth contours must be emphasized with the depiction of depths *[figure 1]*. The system identifies those areas utilizing the generated depth contour file to create a TIN.

Following the same approach as in Phase 1, the system generates triangles whose vertices are taken from the depth contour file [with a user-defined weed-tolerance] and creates polygons of the same depth. Depth values are depicted within those polygons.

Phase 3

During this phase each sub-area created in Phase 1 is examined separately for the identification of those depths which conform with the cartographic criteria for background sounding selection.

- The shoalest soundings and those with depth values less than a limit, which is defined for each category, are retained. This phase is not executed when the areas examined, belong in categories 3 and 4.
- The selected soundings should form a equilateral triangular pattern. In order to achieve this, an equilateral triangular grid [with size in accordance with DST] covering each sub-area *(figure 2)* is generated. Concurrently, buffered areas around nodes are created. Soundings falling within these areas will be "flagged" for selection.
- Polygons formed in Phase 2 are introduced. If these polygons have area extent and perimeter value greater than a specific value, the system computes the locations around which will search for soundings.
- Soundings located in the buffered areas are selected.
- The system detects cases where selected soundings are located very close and the shoaler soundings are retained.
- The selected depths are stored into a file.

Phase 4

The output of the previous phase is a number of files containing the selected soundings for each sub-area. At phase 4 these files are merged and examined by the system, in order that problems of overlapping or closely located depths - which occur along the edges of adjacent areas - are detected and resolved.

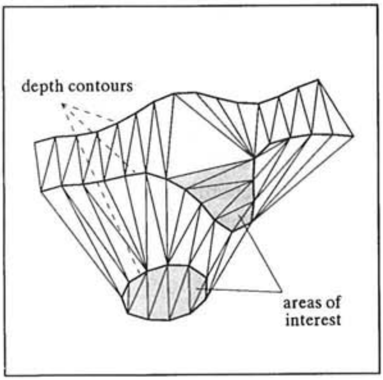

Figure 1

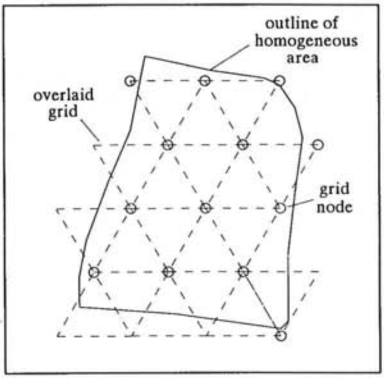

Figure 2

4. Implementation in an Expert System environment

The system described and analyzed above was implemented in a "mixed-programming" paradigm consisting of an expert system tool [CLIPS], a GIS package [Arc/Info] and procedural code [C++].

CLIPS is a productive development an delivery expert system tool, which provides a complete environment for the construction of rule and/or object based expert systems. The key features of CLIPS - most of them were used in present system development - are *[Giarratano J.C., 1993]*:

- Knowledge Representation: CLIPS provides a cohesive tool for handling a wide variety of knowledge with support for three different programming paradigms: rule based, object-oriented and procedural. Rule-based programming allows knowledge to be represented as heuristics, which specify a set of actions to be performed for a given situation. Object-oriented programming allows complex systems to be modeled as modular components. The procedural programming capabilities provided by CLIPS are similar to capabilities found in languages such as C, Pascal, Ada and Lisp.
- Portability: CLIPS is written in C and can be installed on different computers without code changes. CLIPS can be ported to any system which has an ANSI compliant C compiler and comes with all source code which can be modified or tailored to meet user's specific needs.
- Integration: CLIPS can be embedded within procedural code, called as a subroutine, and integrated with languages as C, FORTRAN and ADA.
- Interactive Development: CLIPS provides an interactive, text-oriented development environment, including debugging aids, on-line help and an integrated editor. Interfaces providing features such as pulldown menus and multiple windows have been developed for most environments.

For each of the above mentioned phases a programming module was developed *[figure 3]*. The four modules developed are: PRE1, PRE2, SELECT and OPT and are shortly described here.

PRE1 and PRE2 modules

Modules PRE1 and PRE2 implement the processes described in phases 1 and 2 respectively. PRE1 reads the TIN generated from the soundings located in the charted area and delineates sub-areas of homogeneous depth. PRE2 reads the TIN generated from the depth contours and identifies areas where contour irregularities and small closed depth contours occur. The problems which these two modules cope with, are of procedural nature and the code developed is in C++.

The TIN module of ARC/INFO was used for the generation of TINs in both cases. TINs can be exported in ASCII files which retain the structure of TIN elements (e.g. triangles, edges and nodes). These files are used as input to PRE1 and PRE2.

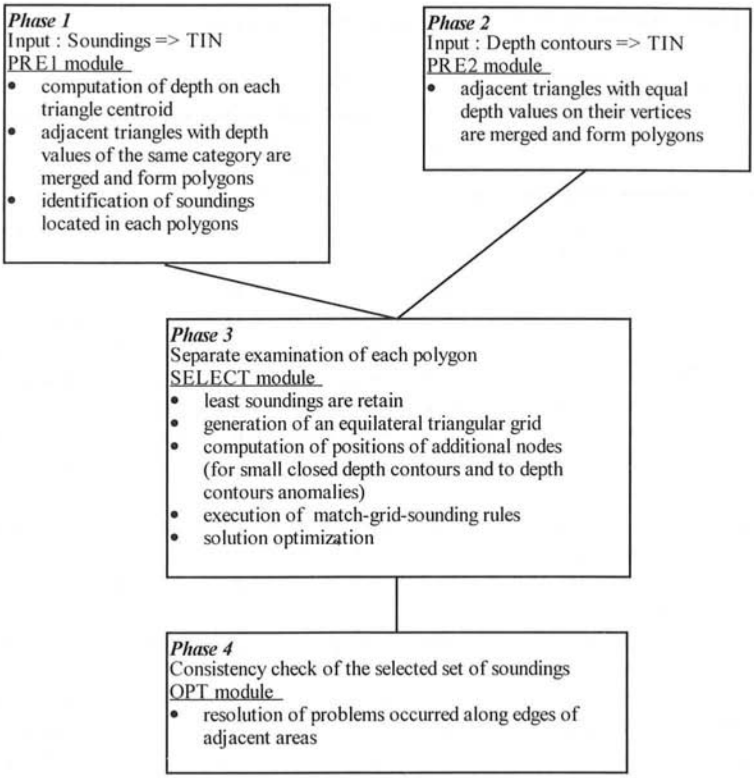

Figure 3.

SELECT and OPT modules

The reasoning process and system's search for a «good» solution is basically executed in SELECT module. This module examines separately each area of homogeneous depth as delimited by PRE1 module. Applying the cartographic criteria for background sounding selection as rules, the most appropriate set of soundings for the examined area is selected. This module takes into account areas with contour irregularities [delimited by the PRE2 module] as well as the existence of shoal soundings.

OPT module composes the particular sounding sets created by SELECT and attempts to resolve problems (e.g. overlapping soundings) which may occur along the edges of the adjacent sub-areas.

The problems that these two modules cope with, are not of procedural nature. The system must identify the best solution among a number of alternatives. To achieve this, the system applies a number of criteria in the form of rules which constitute procedural knowledge. The number of rules for the SELECT module is 45 and for the OPT module is 20.

The development and execution of these two modules is carried out within CLIPS. The inference engine of CLIPS decides which rules should be executed and when. A rule-based expert system written in CLIPS is a data driven program where the facts and objects, if so decided, are the data that trigger execution through the inference engine.

In order to elaborate on the characteristics of a data driven program, the development of the SELECT module is described. In this module the soundings located into the area under consideration, the nodes of the generated equilateral triangular grid and the nodes located into the areas produced by PRE2, are represented as "facts". Associated with each fact-sounding, is a slot which declares the sounding status. This sounding status slot takes values either "selected" or "not-selected". Sounding values asserted into the system have a "not-selected" status except the least soundings which asserted as "selected". Within the vicinity of each node, match-grid-sounding rules are established in order that the system select the most appropriate sounding in the area. The system then alters the status of the selected sounding from "not-selected" to "selected". The remaining soundings in the area must have a "not-selected" status. When the program terminates, the sounding facts with sounding status "selected", constitute the final solution. *Figure 4* shows the original data set and *figure 5* the selected soundings with the use of the system.

A number of complementary tools have been developed and incorporated within the system. These tools allow user intervention during program execution, estimation of sounding selection success and computation of parameters that lead to optimized solutions.

Display of the selected set of soundings, as well as of alternative solutions during program execution is achieved with other tools developed, giving output in DXF format. Description of these tools is beyond the scope of this paper. These tools can be utilized by a CAD system like Autodesk's AutoCAD or Intergraph's MicroStation or by Arc/Info for cartographic display.

5. Conclusions

The system described was tested with a number of data sets and the quality of the results reported is very satisfactory. It must be pointed out that the system gives better results when the ratio of the scale of the original data set and the output chart is greater than 1.5. Processing time required is short and the user interface developed allows the user to utilize the system without special instruction.

There are some new modules which must be developed, as the one interfacing the Expert System environment with the GIS package and some enhancements to the existing code. These will improve the functionality and the performance of the system.

Due to the above mentioned reasons, we believe that Expert Systems technology is particularly suited for the solution not only of specific problems in the chart design and production process, but they can be used as the core-module for the development of an integrated Cartographic Expert System for the design and production of maps and charts.

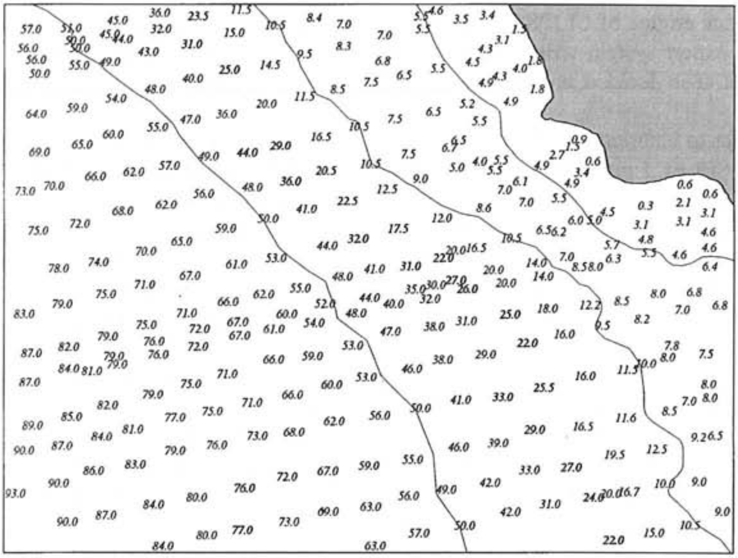

Figure 4. Sounding density on the plotting sheet

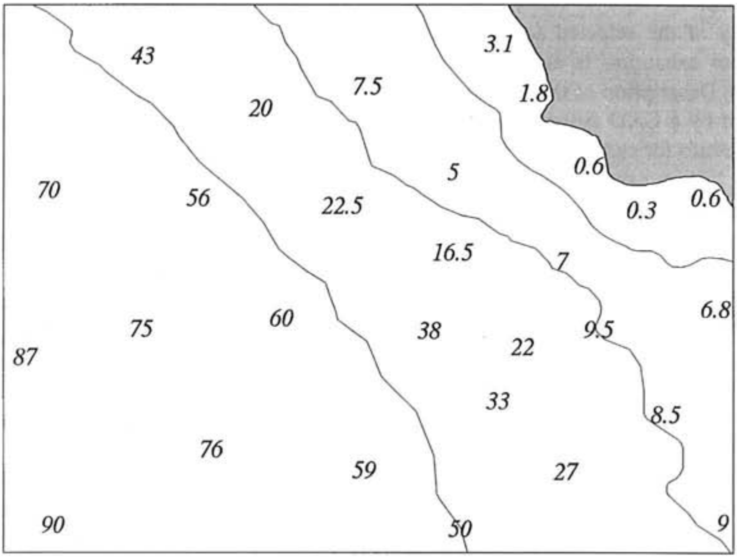

Figure 5. Selected soundings

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TOWARDS THE DESIGN OF A DBMS REPOSITORY FOR THE APPLICATION DOMAIN OF GIS

Requirements of Users and Applications

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Abstract. Much attention has been devoted in the past to support classes of applications which are not well served by conventional database systems. Focusing on the application domain of geographic information systems (GISs), several architectural approaches have been proposed to implement commercial or prototype systems and satisfy the urgent needs for operational geographic data handling. However, those systems suffer from several limitations, because either they perform lots of processing on an application layer, which lies on the top of the database management system (DBMS) repositories, or the underlying data models do not accommodate all dimensions of geographic data (i.e., thematic, spatial, temporal, quality and multimedia). This paper examines the generation of a DBMS repository for the application domain of GIS and focuses on the first phase of the standard database design process, i.e., the requirements of users and applications.

Keywords. GIS architectures, DBMS repositories, nature of geographic data, classes of GIS operations.

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1. Introduction

Geographic Information Systems (GISs) are computer-based systems designed to support the capture, management, manipulation, analysis, modeling and display of spatially referenced data at different points in time (Aronoff 1989). Today, GISs are widely used in many government, business and private activities; which fall into three major categories (Maguire et al. 1991): a) socio-economic applications (e.g., urban and regional planning, cadastrial registration, archaeology, natural resources, market analysis, etc.); b) environmental applications (e.g., forestry, fire and epidemic control, etc.); and c) management applications (e.g., organization of pipeline networks and other services, such as electricity and telephones, real-time navigation for vessels, planes and cars, etc.). The role of GISs in these applications is to provide the users and decision-makers with effective tools for solving the complex and usually ill- or semi-structured spatial problems, while providing an adequate level of performance.

GISs are enormously complex software systems. A GIS should be supported by an operating system, and depends on the presence of a graphic package for input and output, routines supplied by the programming language in which the GIS is written, and numerous other software products (Goodchild 1991). Many of the more powerful contemporary GISs are designed to rely on a Database Management System (DBMS), relieving developers of many of the common data housekeeping functions. However, traditional DBMSs have only dealt with alphanumeric domains and have proved not to be suitable for non-standard applications, such as GISs, which are characterized by more complex domains.

The design and implementation of a DBMS repository for the application domain of GIS is an active area of research. This study presents the problems of architectural approaches adopted in the past towards the development of commercial and prototype systems (Section 2) and examines the generation of an operational DBMS repository for geographic applications. Specifically, it focuses on the first phase of the standard database design process (Elmasri and Navathe 1989), i.e., the requirements of users and applications (Section 3). The discussion is concluded by a brief presentation of the remaining steps towards the design and implementation of a DBMS repository for the application domain of GISs (Section 4).

2. Architectural Approaches

Four architectural approaches have been adopted generally, to implement commercial or prototype systems and satisfy the urgent needs for operational spatial data handling. These approaches are (Aronoff 1989, van Oosterom and Vijlbrief 1992, Samet and Aref 1995):

- *Single conventional DBMS:* In this approach, both spatial and non-spatial data are represented in tabular form in the pure relational model. Operators needed to define and manipulate spatial entities are contained in an application layer which is built on the top of the conventional DBMS.
- *Partial conventional DBMS:* In this approach, a conventional DBMS is used to represent thematic information associated to spatial entities, while a separate subsystem is used to handle spatial data. Operators needed to define and manipulate

spatial entities are contained in an application layer which provides a uniform interface to both subsystems.

- *Extended conventional DBMS:* In this approach, a conventional DBMS is modified to also support GIS application domains. This is accomplished by adding new constructs to a conventional DBMS, so that to enhance its modeling power and provide better support for spatial applications. These new constructs include support for abstract data types (ADTs), procedural fields, complex objects, composite attributes, and so on. Additional operators needed to define and manipulate spatial entities are contained in an application layer which lies on top of the extended DBMS.
- *Object-Oriented DBMS:* In this approach, the object-oriented model is used as a basis for the application domain of GIS. The concepts of the underlying model (e.g., classes, inheritance, encapsulation, types, methods) are very convenient. Any additional operators needed to define and manipulate spatial entities are contained in an application layer which lies on top of the object-oriented DBMS.

The role of the *application layer* in all approaches above is to supplement the set of capabilities offered by the underlying system architectures, so that the operational needs for spatial data handling are satisfied. In other words, the application layer provides the set of GIS operations which are not available in the underlying DBMSs. Obviously, this set varies from one software package to another and heavily depends upon the system architecture. The execution of operations within the application layer is frequently accompanied by an up-/down-loading of voluminous data (spatial data are usually voluminous) from/to the database. This is an expensive task which should be avoided in a production environment. What is usually suggested as an alternative solution is pushing the operations of the application layer into the DBMS repository (Stefanakis and Sellis 1996b).

Although several commercial and prototype systems have been extensively used to support a wide variety of geographic applications (Maguire et al. 1991), they suffer from several limitations, which render them inefficient tools for geographic data handling (Stefanakis and Sellis 1996a,b). Systems based on a *single conventional DBMS* adopt the relational model, which is not rich or powerful enough to model the structural complexities of geographic data. In addition, relational algebra does not offer the expressive power to support spatio-temporal operations. Systems based on a *partial conventional DBMS* organize the spatial and non-spatial component of geographic data into separate databases and consequently processing is mostly performed on the application layer. Systems based on an *extended conventional DBMS* (Aref and Samet 1991, Haas and Cody 1991, van Oosterom and Vijlbrief 1991) or an *object-oriented DBMS* (Abel 1989, Scholl and Voisard 1992, David et al. 1993) are more promising. However, prototype systems developed in the past either perform lots of processing on an application layer, or the underlying data models do not accommodate all dimensions of geographic data (i.e., thematic, spatial, temporal, quality and multimedia dimensions).

3. Requirements of Users and Applications

The effective design of a DBMS repository for the application domain of GIS requires the notion of the users' expectations and the intended uses of the repository in as much detail as possible (Stefanakis 1996a). The purpose of this Section is to present the nature of geographic data and the basic classes of operations for handling these data.

3.1 The Nature of Geographic Data

Geographic data are usually divided into four categories (Maguire et al. 1991): a) physical objects (e.g., building, road, lake, forrest, etc.), b) administrative units (e.g., private property, province, national park, military area, etc.), c) geographic phenomena (e.g., temperature, precipitation, accidents, fish distribution, etc.), and d) derived information (e.g., level of poverty, suitability for cultivation, environmental strain, etc.).

These data have a set of characteristics that make them distinctly different from the more familiar lists and tables of conventional data used in the information systems developed for business applications. Geographic entities (i.e., geographic objects, units or phenomena) in a system have six dimensions along which attributes may be measured (Aronoff 1989, Laurini and Thompson 1992). These dimensions are:

1. *Identifier:* It provides a means to refer to different entities. Geographic entities may be assigned arbitrary names, geographic/place names, or numeric codes. It is important for the naming system to be precise, consistent and able to guarantee uniqueness.
2. *Spatial data:* They describe the spatial characteristics of geographic entities. Spatial characteristics consist of:
   - *Geographic position:* It is needed for locating or delimiting geographic entities on the earth's surface. The locational definitions can be quite complex, because geographic data tend to occur in irregular and complex patterns. The location of geographic data can be specified using: a) direct position (in reference to a coordinate system, e.g., UTM), b) indirect position (street address, zip code, etc.), or c) relative position (e.g., north of, inside, etc.).
   - *Geometric data:* They describe the basic spatial properties, like the shape, perimeter, areal extent, or volume, of individual geographic entities. These data are derived from the positional information of geographic entities and are usually treated in the same manner as non-spatial data.
   - *Graphic data:* They describe the presentational (cartographic) form of geographic entities (e.g., the cartographic form of a church at different scales, i.e., levels of generalization).
   - *Spatial relationships:* They describe the relationships between geographic entities which result from their relative position (e.g., north of, adjacent to, inside, etc.). Spatial relationships (topological, direction, distance) are generally numerous and may be complex (Papadias et al. 1997). They may be either explicitly defined or calculated as needed.

3. *Thematic data:* They describe the non-spatial (textual/numerical) properties of geographic entities (e.g., vegetation type, land parcel owner's name, highway class, etc.).
4. *Temporal data:* They describe the temporal characteristics of geographic entities. Temporal characteristics consist of:
   - *Temporal position:* It describes the occurrence of geographic entities at temporal instances (e.g., date of road construction, etc.), or the duration of geographic entities throughout temporal intervals (e.g., period of land ownership, etc.).
   - *Temporal behavior:* It represents the evolution (behavior) of geographic entities in time (e.g., the erosion of a barrier island, etc.).
   - *Temporal relationships:* They describe the relationships between geographic entities which results from their temporal position or behavior. Temporal relationships (temporal topologies), are generally numerous and may be complex. They are based on the fact that time may be linearly ordered. Hence, for any two different events, one will be simultaneous with or earlier than the other. Temporal relationships may be either explicitly defined or calculated as needed.
   - *Temporal presentation:* It describes the time as presented to the users of the system (e.g., in animations).
5. *Data quality:* It is a measure of the quality of data collected to describe geographic entities. It includes (Christman 1991) the positional and attribute accuracy of entities, the completeness and logical consistency among data elements, and the temporal information assigned to geographic data.
6. *Multimedia data:* They consist of sound, pictures and/or video data that accompany geographic entities (e.g., Greece should be accompanied by the national anthem, several pictures and videos of archaeological sites and islands).

3.2 The Basic Classes of Operations for Handling Geographic Data

The wide variety of geographic applications (Maguire et al. 1991) renders the generation of a compact set of operations for handling geographic data a very hard task. However, a DBMS repository for handling geographic data should provide the following basic classes of operations (notice that extensions to this basic set of operations should be possible in order to fulfill the requirements of particular applications) (Aronoff 1989, Tomlin 1990, Laurini and Thompson 1992):

- *Data maintenance:* This class encompasses a variety of methods for insertion, deletion, and modification of data in a geographic database system.
- *Data selection:* The operations of this class support the selection of geographic entities based on their attribute values. Depending on the dimension(s) involved, operations for data selection fall into the following four categories.
  - *Spatial selections:* The selection is based on the spatial data of geographic entities.
  - *Thematic selections:* The selection is based on the identifier or the thematic data of geographic entities.
  - *Temporal selections:* The selection is based on the temporal data associated to geographic entities.

- *Mixed selections:* The selection involves more than one dimension (spatial and/or thematic and/or temporal) of geographic entities. Notice that the dimension of data quality should be considered in order to have a measure on the accuracy of the selected set.

– *Data analysis:* There is an enormous range of basic operations for geographic data analysis. Several classifications have been proposed in the past (Aronoff 1989, Tomlin 1990, Burrough 1992). Data analysis operations process the attributes (spatial, thematic, temporal, quality) of geographic entities and result in either the generation of new entities or the modification of attribute values assigned to existing entities. In brief, data analysis operations include (Aronoff 1989):
  - *Classification and generalization operations:* Classification is the process of identifying a set of entities as belonging to a group, according to their attributes. This is usually accompanied by the assignment of new attribute values to those entities (sometimes termed as *recoding*). Generalization is the process of making a classification less detailed by combining classes of entities.
  - *Measurement operations:* Based on the attributes of geographic entities, these operations provide a measurement, such as the size, shape or distance (spatial, temporal, etc.) among entities.
  - *Overlay operations:* They combine two or more sets of geographic entities and result in the generation of new entities with spatial dimension derived from the way initial sets intersect, and the rest of dimensions (i.e., thematic, temporal, quality) derived from the arithmetic (i.e., addition, subtraction, average, minimum, maximum, etc.) or logical (AND, OR, XOR, etc.) operations applied.
  - *Neighborhood operations:* They evaluate the characteristics of the area surrounding a specified location. Every neighborhood operation requires the specification of at least three basic parameters: one or more target locations (neighborhood focus), the neighborhood around each target, and the function to be performed on the elements within the neighborhood. Examples of typical neighborhood operations are point-in-polygon, interpolation, topographic functions, contouring, etc.
  - *Connectivity operations:* They accumulate values over an area being traversed. Every connectivity operation include: a specification of the way spatial elements are interconnected, a set of rules that specify the movements along these interconnections, and a unit of measurements. Typical connectivity operations are contiguity measures, proximity (buffer zones generation), network analysis, intervisibility, etc.

– *Data presentation:* This class encompasses a variety of methods for the presentation of data selection and/or analysis results. The presentation may be either in map-like, graph, tabular/text, or multimedia form.

4. Conclusion

The design and implementation of a DBMS repository for the application domain of GIS is an active area of research. The contribution of the paper can be summarized as follows:

- The architectural approaches adopted in the past towards the development of commercial and prototype systems are presented and their problems are highlighted.
- The process of designing a DBMS repository for the application domain of GIS starts off by examining the requirements of users and applications (i.e., *phase 1* in standard database design process). For this scope the nature of geographic data (dimensions of geographic entities) and the basic classes of operations for handling these data are presented.

Future research is focused on the remaining phases of standard database design process (Elmasri and Navathe 1989). Specifically:

- *Phase 2: Conceptual design.* The conceptual design of the DBMS repository involves two parallel activities (Elmasri and Navathe 1989): the *schema* and *transaction* design. The conceptual schema design examines the geographic data requirements and produces a conceptual schema in a DBMS-independent high-level data model. The conceptual model of the DBMS repository for the application domain of GIS is made of a semantic data model, which adopts the enhanced entity-relationship model (EER-model) (Elmasri and Navathe 1989), along with a spatial, a temporal, a quality and a multimedia data model, which are all defined by appropriate abstract data types (ADTs). The transaction design, on the other hand, examines the classes of operations for handling geographic data and produces high-level specifications for these transactions. In this phase and those that follow, it should be taken into account that the DBMS environment may be distributed, in order to satisfy the emerging needs for geographic data handling.
- *Phase 3: Choice of DBMS.* Apparently an Object-Oriented DBMS (OODBMS) will be most likely adopted due to the concepts of the underlying model (e.g., classes, inheritance, encapsulation, types, methods), which are very convenient.
- *Phase 4: Logical design.* This phase involves the mapping of the conceptual schema to the object-oriented data model.
- *Phase 5: Physical design.* This phase examines the specific storage structures and access paths for the database files to achieve good performance for the various database applications.
- *Phase 6: Implementation.* The actual implementation of an OODBMS repository for the application domain of GIS.

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