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REPORTS ON ACHIEVEMENTS IN SURVEYING, MAPPING AND CHARTING IN ADDRESSING NATIONAL, SUBREGIONAL, REGIONAL AND GLOBAL ISSUES, INCLUDING: OTHER APPLICATIONS OF SURVEYING AND MAPPING IN SUPPORT OF THE IMPLEMENTATION OF AGENDA 21;

Leading edge Cartographic Developments and Challenges**

(Submitted by International Cartographic Association (ICA))

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Leading edge cartographic developments and challenges

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Introduction

Cartography is one of our oldest scientific disciplines. The oldest known map is almost 5 000 years old. It shows an area in Mesopotamia. The Roman itineraries providing information for troop movements are other early examples. The Carta Marina, 1539, is the first map of Sweden. The archives of the National Land Survey of Sweden, containing maps and records from the land reforms of Sweden during the 17^{th}, 18^{th} and 19^{th} centuries, bear ample proof of the rich cartographic heritage of Sweden.

Today, cartography is facing a new era. Almost all geospatial information is collected, stored and processed in digital form. A large variety of techniques are used to register positioned information, public information is converted to digital form and the Internet is used to disseminate information. That has given cartography another focus. The latest definition of cartography describes it as a process to compile, organise, visualise and use geographically related information. Some trends are:

- Cartographic information and services will be available in systems for planning, decision support and surveillance of environmental changes and management of natural resources.
- Cartographic products will be common in Internet and multimedia products. Especially mobile Internet in combination with the *blue tooth technique* will create an increasingly demand on cartographic products.
- Cartographic functions will be integrated in office information systems for wide use by non-professional cartographers.
- It will be common to use a map as interface in many kinds of systems.

- Cartography will be a tool to create virtual realities in order to simulate different aspects such as traffic behaviour and future environments in planned settlements.

- Cartographic technique will be used in operational systems for navigation and guidance of all kinds of vehicles.

- Cartographic technique will be used in automatic control of robots, mainly in construction.

- New sensors will collect high resolution data, that have to be processed by using cartographic technique. An example is land mobile laser scanning for mobile mapping.

- Maps in the archives will be scanned for public access, which will create a demand for rectification and other kind of processing.

In spite of this development cartography is still the scientific discipline to represent and communicate information about geographic phenomena. Since cartography now also includes 3D and through animation also 4D, cartographic techniques are used whenever spatially distributed phenomena are to be portrayed.

Cartography vis-à-vis GIS

In the analogue days of cartography, cartographic work at all levels was quite straightforward. Technicians were taught how to draw and scribe. The academics how to design maps and have these designs implemented by the technicians. Although the tools changed over time the general approach in map production did not until the advent of the digital computer.

Although the computer was first used to mimic the manual production process, new insights began to arise soon after and led to the development of the geographic information technology. The computer did not only produce maps, but the data entered were also used to create new information. Nowadays no one knows what a GIS actually stands for, because so many different applications have emerged. GIS has become a paradigm, a concept along which geographers, geodesists, photogrammetrists and cartographers alike think and try to extend their knowledge base.

The developments described here led to a serious identity crisis among cartographers. No longer it was the cartographer who had the monopoly over map creation, but seemingly ignorant software users started to make maps with relative success. Users of GIS placed the cartographer in the corner of the picture maker, the window dresser, who would take care of the last piece of the action.

In the last few years cartographers solved this dilemma by focusing on the quality of the information communication process. Paraphrasing the expression, we can say that the final quality is as good as the quality of its weakest component. Identifying these components and dealing with the emerged quality problem is a necessity in the processing of geographical information. With quality we mean primarily "fitness for use". This is an important concept, because maps and GIS-geometry have been exposed to all kinds of cartographic processing techniques, changing the model severely and changing in the course the "fitness for use" for particular applications, for better or for worse.

Cartography as we know it as traditional mapmaking has disappeared, but we have got something back, which is powerful and has more impact on spatial sciences. Those who would have called themselves academic *cartographers* in the past will step into the professional world as *spatial information brokers*.

Brokering spatial information involves the following activities:

- Setting up and monitoring the process of spatial information creation aimed at communication of the information.
- Identifying and monitoring the user requirements for specific applications.
- Specifying data quality requirement for specific applications and end products.
- Setting the specifications of visualising spatial data/information along the paths of cartographic and semiotics theory.
- Developing new products and services that facilitate access to spatial information both for experts and the general public.
- Mediating between suppliers/producers of spatial data and the user community.
- Bringing technical knowledge of data base, geometry and visualisation tools to the application field.
- Supporting standardisation initiatives at all levels of government and industry.

As with the traditional cartographer, the spatial information broker is a person who is not specialised in a certain discipline, but has the methodology as his or her professional objective. In practice, a background in geography or geomatics will steer the specialist probably in a certain direction of his or her field, but that does not seem to be a problem as it wasn't in the old days of traditional mapmaking. Within the professional career of the spatial information broker a bias towards a certain field will emerge eventually and lead to specific jobs. Some will become involved in map production, since maps will always remain in demand in society. Others will become involved in analytical GIS or land information systems where the data applications prevail.

Cartographic research in general (Ormeling in Artimo et. al., 1998)

Education in academic institutions is linked to research. If that would not be the case, it would be mere reproduction of knowledge. That is why both staff and students should be engaged in research projects. This research ought to provide a theoretical basis for both cartographic methodology and for practical work. Cartographic research can be defined as the research that explains or improves taking cognisance of spatial data from maps, and ensures that these visualised spatial data give an adequate idea of the patterns/trends of the abstracted attributes of nature as needed for decision making.

There is no typical research approach in cartography but, instead, a typical research theme, which mainly has to do with the spatial information transfer process. In order to present the various research options the following model of spatial information transfer has been selected:

reality >spatial data > map > perception > user

In this model, 'user' stands for human perception systems, brain and consciousness. Each of the constituent parts of this research model and any combination of items or links can be subject of research. The most frequently occurring approaches are:

a) Psycho-Physical Research:

reality >**spatial data > map > perception > user**

When the whole above route is studied, this will allow one to compare the results of various different mapping methods against each other (instead of different symbols for specific information categories or instead of studying the effects of variations within symbols). An example would be the rendering of height information by using either contour lines, height layers, hill shading or altitudes or a combination thereof. Within one method, such as layer zone representation, it could compare the effects of different colour systems; within one colour system it could study the effects of different colour specifications.

b) Modelling Research

reality > spatial data > map > perception > user

Modelling reality is a cognitive action. Here the issue is which model is the most appropriate for a specific application, which model delivers the answer to a question in the shortest time, and also shows relationships with other relevant items in the area mapped.

The most important type of modelling research is on generalisation. But next to generalisation (research into which should provide us with the required scale-less databases necessary for GIS) options studied in modelling research are visualisation in 2-4 dimensions, and relief portrayal, and general map design. According to Meng (1997), current problems in the generalisation research that have to be solved first are: the lack of meta-methods, intellectual data structures, objective evaluation procedures for generalisation results, lack of cognitive considerations and lack of cost/benefit studies.

c) Data Extraction Research

reality > **spatial data** > map > perception > user

Feature extraction and pattern recognition techniques need to be developed in order to speed up' the revision or production of topographic data files.

d) Researching Model Linkages

reality >> spatial data >> map >> perception >> user

Apart from insufficient modelling, spatial information transfer may suffer from an excess of noise contained in the links in the spatial information transfer model. Perception aspects like colour blindness can be a cause for not succeeding in the spatial information transfer process. When cartographers have insufficient means of comparing the data model to reality this also can cause noise.

Research into the effect of **map use strategies** can lead to optimising the route/tract **map> perception > map user**. In order to start here we need to know what map users actually do when they read information from maps. What hardware and software sits in our perception systems and how can we best use that for information transfer?

e) Research into the Elements of the Information Transfer Model

reality > **spatial data** > **map** > **perception** > **user**

Each of the elements (reality excepted) can be inadequate from a quality point of view. Research has been focused on data quality here (consequently on the tract reality > data) and on informing the map user about this quality (the parallel tract metadata > metadata-map > perception > map user). In this field the question need to be solved which are the best indicators for spatial data quality, and which are the most efficient ways of visualising these indicators.

These research approaches can be effectuated according to different research modalities: inductive or logical applied research and deductive research. By logical reasoning it can be determined what is necessary in order to get at a specific result (or perception response). The result of such a reasoning process can consist of a knowledge system. In deductive research, on the basis of map analysis, one may draw conclusions about the way in which cartographers in the past handled their options.

Final remarks

As president of ICA I am very concerned about the identity of cartography. The interest in maps, especially old maps, is extremely high all over the world. Cartographic conferences are well attended and maps are used more and more in a large variety of applications, not at least on the Internet. So why worry?

My worries origin from how cartography has been handled during the advent of the information society. The general concept of GIS is considered to handle the presentation part, but GIS users stress the analysis part overlook the importance of the design of the output. Cartography has to be called computer cartography to be regarded as contemporary. In order to keep up the interest in cartography and attract students some schools start to give courses in visualisation instead of cartography.

In my opinion we need to develop specialists in all spatial sciences such as geodesy, photogrammetry, remote sensing and cartography as well generalists, who learn to integrate these sciences to be used by geographers, land surveyors and other practitioners. New ideas are mostly new combinations of existing knowledge. By specialisation and improving the co-operation between our societies we will cross-fertilise the spatial sciences and create integrated solutions.

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Some definitions

Geographic data or *geospatial data* include *spatial data* and *descriptive data. Spatial data* deal with location and shape (geometry) and relationships (topology) among geographical features. *Descriptive data* or *attribute data* deal with other characteristics of the features than geometry and topology. *Geographic information* concerns phenomena associated with a location relative to the Earth or knowledge obtained as a result of processing geographic data.

The term *Geographic Information Systems (GIS)* was first used in Canada in the 1960s to describe the system developed to manage the Canada Land Inventory, a national database containing land use and land cover. GIS is an information system with functions for collecting, storing, processing, analysing and presenting geographic data. A GIS software package facilitates these functions. An operational GIS applies these functions on specific geographical data organised in one or several databases. GIS may also be interpreted as *Geographic Information Science* in order to stress the involved scientific subjects. *Geographic Information Technology (GIT)* or *Geoinformatics* are rather new IT-oriented terms stressing the technology aspect of collecting and dealing with geographic information.

Geomatics is the collective term for the disciplines concerned with collecting, storing, processing, analysing, distributing and presenting geographic data or geographic information. That means that Geomatics infer the disciplines of geodesy, photogrammetry, remote sensing and cartography. Geomatics includes the integration aspect of these disciplines and is also information technology oriented