THE CHANGES IN CARTOGRAPHIC MODELS

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Abstract

The main changes in cartographic models which occurred at using computers are considered in the article. The new functional possibilities, the changes in the contents of the models, the dynamics of the models, the new dimensions of the concept "scale" are described in the present research. A new stage in the creation and using the electronic models is grounded. This is the transformation of the data which is not proper of the manual process. The changes in the cartographic models are considered in historical viewpoint.

The development and using the computer devices led to considerable changes in the many fields of science and practice. Cartography is among them. We can say with out exaggeration that the recent applications of cartographic modelling cover more fields than classical cartography. Because of this it is necessary to give a new completely meaning to the philosophy, the theory and practice of cartography. It is impossible to describe all parts and aspects of a new cartographic science. In the present paper the author attempts to show some of the main changes, occurred in cartography by using digital cartographic models.

1. The changes in the kind of cartographic models

The idea that cartographic products are mathematical, image-signal models of a part of the reality which surrounded us, come from the famous definition of Salishtev (1990) about the identity of the map. This idea is approved in cartographic practice.

Now we accept both definitions of cartographic models (mathematical and image-signal) as completely natural. The existence of these two qualities simultaneously is not in regular low according to the theory of modelling and philosophy. For example, the following definition of the process of modelling was written in "Philosophy Dictionary", 22th edition (Smith, Shishkov 1991):

"Reproduction of elements considered as essential for a certain object of the research or process; it is consists of synonymous relation between appropriate symbols and these elements. A model is **illustrative** when the conformity with the arrangement of the elements and with the spatial-time proportions is such one that some similarity gives opportunity for recognising the objects from the model (engineering charts, geographical maps etc.). **Mathematical models** as a reproduction of the elements through coordinates, algebraic models etc., as a rule fully ignore any similarity. These models are valid for all different cases not for a particular object, related to determined range."

According to Smith and Shishkov clearness (readability) is obviously in conflict with the mathematical similarity. Even some of the cartographers understand this problem. For example Shirjaev (1977) proposes maps to be included into the group of particular models - "graph-mathematical" because of the mentioned two conflicting qualities. From our point of view, the model would not be simultaneously readable enough and entirely mathematically similar as in the sense used by philosophers and_mathematicians. This problem is solved by using the computer technology in creating and using of cartographic products. We will go into this problem through considering the development of maps.

The first maps are perspective drawings of a definite area. They are readable enough as they don't require any previous preparation for reading. These maps represent different objects in the way as they look visually. The perspective drawings don't have any mathematical similarity, except the cartographer's sense of space.

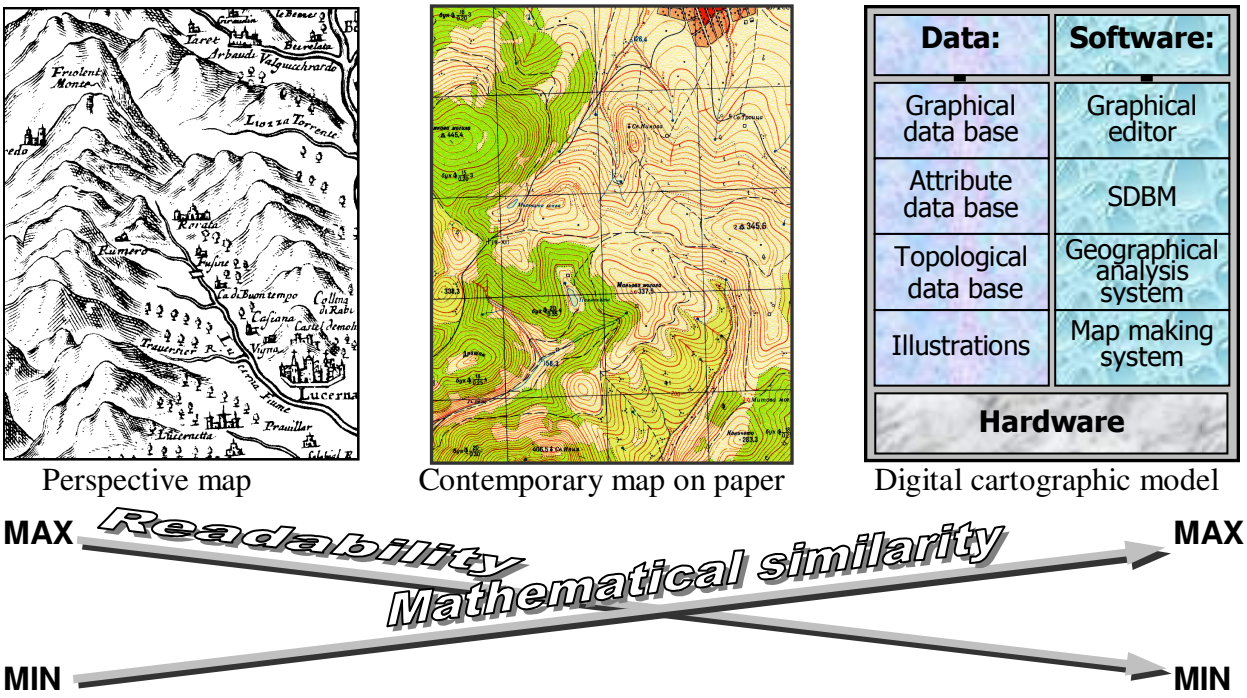

Fig. 1 An example for dependence between the clearness and mathematical similarity

The maps became more exact (mathematical similar) and less readable with developing of measuring methods. The symbols appeared at the beginning. At that time they were artistic and reminded of the appearance of the depicted object. Gradually they become more abstract and less near to the appearance of the object. The maps already require some preparation for reading.

After that, cartographer started to be applying different methods for cartographic representation: cartogram, cartodiagram, localized diagram, contours, point method etc. They are exceptionally abstract and more often depict processes, phenomena or statistical surfaces than real objects. On the other hand they are made up according to definite mathematical methods.

The maps which are created today on paper combine some clearness (considerably lower than this one of the perspective drawings) with mathematical constructions. Because of this we can relate them to mathematical models as well as to visual ones. This duality leads to many compromises whit exactness, details, circumstance (assortment, moving the objects because of overlaying and preservation of the geographical reality etc.) and regarding clearness – they can't function with out a legend.

The appearance of the computer techniques discontinued this duality because the digital models are entirely mathematical. They don't have any clearness because they are created and represented in digital environment. The geometry of the objects is described by coordinates and the relations between them – by tables. For visualising of the digital models it is necessary to depict a part of their contents by definite way on the monitor or on the printer.

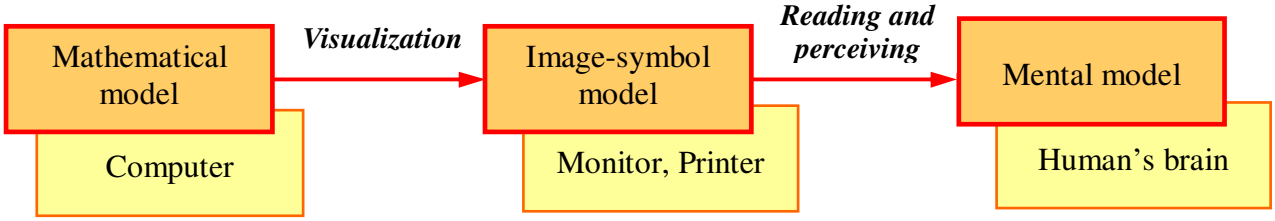

Fig.2 The digital models are accepted by image-symbol model

The cartographic models have evolved from visual image-symbol models to computer mathematical models. The image-symbol models in digital environment are used for communication between the man and the computer. Whole classes of tasks have appeared for which solving the creation of the intermediary (image-symbol model) is not necessary. For example, the geographical analyses (terrain, network and spatial): creating of terrain profile, solving of optimisation tasks, extraction of objects in a definite buffer etc. It is not necessary for the cartographer to see a visual model for solving these tasks. They can be solved directly on the digital model.

2. Transformations of the digital models

In classic geography the map is such one, as it has been created by the author. With the exception of a certain hand-written editing, the map could not be changed after it has once been formed. With digital models are possible various transformations after the model are created.

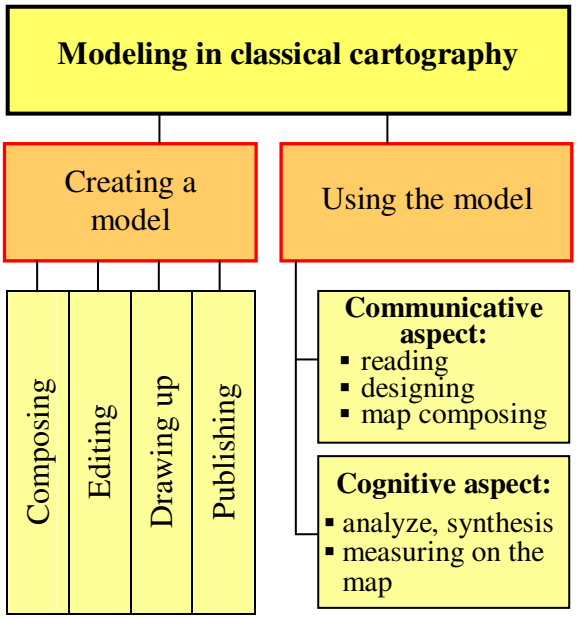

Fig. 3 Scheme on the modeling in the manual way of work

2.1. Hand-written modelling

In the traditional cartography modelling includes two basic stages:

2.1.1 Creating a model

The object is the mapped territory. The model is the map of the territory. According to the existing facts and to the way of modelling, the model is more or less exact, contemporary or valid.

2.1.2 Using a model

The using of the cartography models could be viewed in two aspects; communicative and cognitive.

The main aim of the communicative aspect by usage of the maps is to give information, so they can read on the map the information put there by the authors. Mainly they use the visual reading as well as some measuring on the map. Projecting on the map (roads, canals, buildings etc.) belong to this case of using the maps.

The cognitive aspect of the usage of the maps is considerably more complicate from epistemological point of view as well as from practical one. The models can be studied with two aims: for research of the depicted territory and for investigating of the model. The aim is to receive new data which is not given from the creator of the models. Different kinds of graphic and graphic – analytic analysis, morphometric measuring and conception (profile, diagrams etc.) are used.

2.2 The cartographic modelling in digital environment

In digital environment appears a new stage between the creation and usage of the model. At this stage the information in the model is illustrated (fig. 2).

The necessity of this new stage exists because a man can not directly communicate with the digital model. This is not simply a stage of illustrating, such as development of the picture where the information, given in advance, becomes visual. It is possible to make different transformations of the data in the model by illustrating the content of the digital model. We can not make these transformations by manual making of the maps.

We will define the transformations as impacts on the digital cartographic model, at which the new model with different kind, content, precision of the data etc. is created.

The seven main kinds of transformation is shown on the fig. 4. Other, specific transformations can also be applied depending on the kind of the cartographic models.

2.2.1. Change of the symbol system

Visualisation of the data is made by this process. In most of the digital models the user can choose a symbol system by which can be represented the cartographic information. This kind of transformation can be made faster and easier and it is possible to try several variants and choose the most appropriate of them.

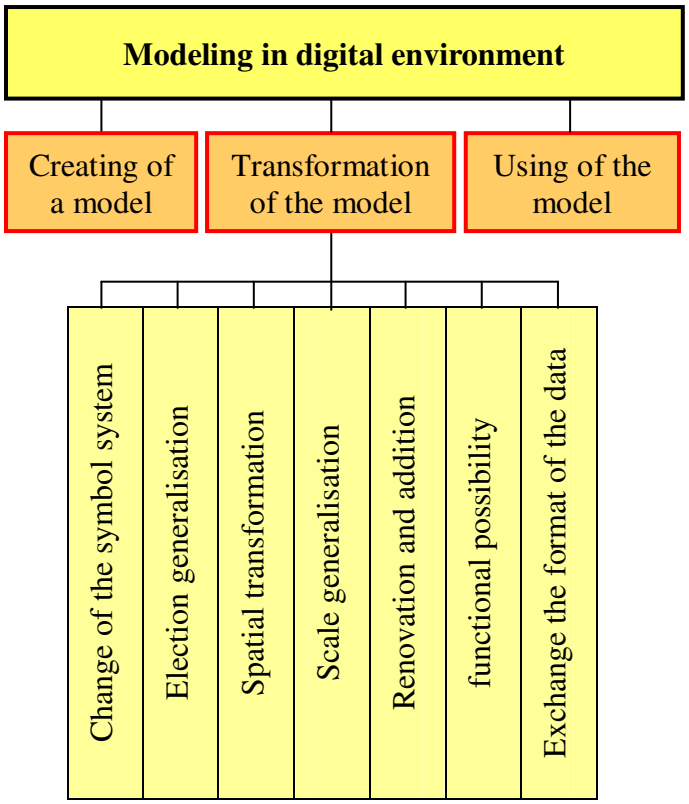

Fig. 4 Scheme of cartographic modeling in digital environment

2.2.2. Election generalisation

The limitation of the content of the model is made, according to a definite condition or group of condition, as the user wishes. The condition can be:

- *taxonomic* – according to belonging of the objects to definite class or element of the content;
- *spatial* – according to the situation of the objects – absolute (according to coordinates) or relative (according to proximity to the other objects);
- *attributive* – according to quantitative and qualitative characteristics of the objects from the reality;
- *graphic* – according to attribute of the graphic entities with which the objects are represented in the model: kind of primitive, colour, layer etc.

2.2.3. The spatial transformations

They are connected with the change of the space of the model: scale, projection, symbol system, limiting of the space of the model etc. By the manual created maps each of this transformation requires the creation of a new model and takes much time and efforts. These operations are made automatically in the digital environment. For example AutoCAD Map allows keeping the data in a definite scale, coordinate system and projection. The user can make a preferable transformation in the mathematical base and in the end of the working session can save the data in the original format (Sybex Inc.1999).

2.2.4. Scale generalisation

This type of generalisation is connected with impossibility to depict the data in the model by the chosen symbolic system and in concrete scale. The following operators are used when there are very close objects, the objects with small or irregular area or with too many curves on the contour: moving of the objects or a part of them, eliminating the objects, turning the area in line or point, correcting of the shape of the objects, smoothing of the contour etc.

2.2.5. Renovation and addition.

It is made a change in the content of the model. As a result of that the model becomes more complete, exactly and actual. These are two different processes:

- *renovation* – replacement of the data for extant object in the model with more exact and more actual facts;
- *addition* – induction of the information for new objects or for additional characteristic of the extant object, multimedia illustration, for example.

2.2.6. Addition of functional possibilities

Addition of the cartographic model with animation, multimedia, interactive and other abilities. Through them the domain of usage of the cartographic products is extended. The functional abilities of the digital model are considered in part 5 of the paper.

2.2.7. Exchange of the format of the data

The transformation of one file format in another one, by it a part of information is lost in the most of the cases. Some transformations are convertible, for example by transference of the data between two raster or vector formats. Other kind of transformation of the data is connected with the change of the base of the data (manner for depicting and keeping the data) without changing the file format.

The transformation of the cartographic model, described above, should be differentiating as a separate stage of modelling in digital environment. They are used in the creation and usage of the models, but can associate neither with the creation neither with the usage of the model.

3. The digital model content more information

Increasing of the information contented in the digital model can be considered in two directions: as increasing of the volume of the data and as including of the new kind of the data, which is not characteristic for manual created maps.

3.1. Additional information for the objects

Besides graphic information, the digital models can content the following kind of data which missing in traditional models:

- *attributive data* – text and table information for quantitative and qualitative characteristic of the map objects;
- *illustration of the objects* – audio - visual thematic information for modelling objects and phenomena (pictures, charts, video, animation etc.);
- *topological information* – open description of the spatial relation between objects and between graphic, attributive and illustrative base data.

3.2. Bigger volume of the data

The cartographic models in digital environment are not limited, like the traditional ones, in regard to the graphic load. The creators can include in them heterogeneous information without limitation in quantity. The information can be situated on thematic layer. Anytime it is possible to visualise only a part of information or use large scales for considering the data.

4. The Scale of the Digital Model is Conditional

4.1. Scale of the space and scale of the content

Formally, the digital models have no scale of the space. They allow working in real units, for example kilometres from the reality. By visualisation the user can bring out the content of the model in arbitrary scale. The question is what information one can receive from a map with a wrong scale. Independence of digital models from the scale allows to consider definite details from the space of the model and to receive a general view for cartographic territory. The information in the model usually is connected with determined limitations, related with the accuracy of the initial data composing the model. That's why we consider the scale of the content of the model in respect to:

- geometric precision;
- circumstance (quantity of the object from each class in the model; number and kind of their characteristic);
- details of the data grade of scale generalisation (see 2.2.4)

For each of these characteristics we can define different scale of the content, but usually they are synchronised. Because of this we are generally speaking about the scale of the content.

On the maps, the paper, the scale is fixed and it determined the quantity, precision and details of the content, which can be inserted in them. The digital models don't have a determined scale of the space, but their content determines the borders in which one can change this scale.

Convention of the scale appears also in another way. The part of information on the maps is lost by generalisation when it is proceeded to smaller scale. The scale does not limit the quantity of information in the model as well as the precision and details of the data in digital environment.

4.2 The Scale and Territorial Span

By hand made maps, the scale is complied with the size of territory because the size of the used devices (printers, plotters, etc.) is limited. This relation does not exist in digital environment. One can create a digital model without comply the scale with territorial span. It is not valid if the model is made with the aim of creation the map on paper.

5. Additional functional potentialities of the digital model

The using of many new potentialities is possible in the digital environmental. This is not possible by the traditional maps. Below is shown only a part of these possibilities.

5.1. Interaction

The digital cartographic model corresponds to the definite user's actions, by which the part of the content of the model, described on the display is changed. The main interactive actions are two:

- visualisation of the multimedia information (text, charts, images, video-films etc.) for a pointed by the user object;
- navigation in the space of the model and "moving" on the terrain according to the requirement of the user.

5.2 Geographical analysis

This is a specific opportunity, characteristic for geographical information systems which allow more detailed study of the territory through the cartographic model. The geographical analysis can be divided into three types:

- *space analysis* – investigation of the mapped territory and creation of derivative cartographic models by creating of buffers; filtering and deriving of the data in space and attributive conditions; coalescence of the data etc.
- *network analysis* – solving of optimisation tasks in the space of the model, most often varieties of the transport task;
- *terrain analysis* – building of the digital model of the terrain and its research through profile, morphometric characteristics etc.

5.3 The relation with base of data

The connection of the space graphic data with attributive, topological and illustrative information is in the base of most of the additional possibilities of the digital models. One can assume text, table data, pictures, drafts and audio or video illustrations to each object of the model as well as to depict its relations with other objects.

The relation of the graphic base data with information gives a possibility to look for data in a definite condition: space, attributive, topological or connected with illustration of the objects.

5.4 Designing and measuring on digital models

In the digital environment the measuring is carried out easier, more accurately and doesn't require additional instruments. Practically the measuring is made without error (from operator and from instrument), because cartometric data are derived analytic and their accuracy depends only on the accuracy of the data according which the model is made.

There are very wide possibilities for projection on the digital models in comparison with the traditional. They are given from specialisation systems for projecting, for example InRoads by

Intergraph. The building of a trace with a determining slope, differentiate of the land sections, definite area, etc.

The differences between traditional and digital cartographic models, considered above show the advantages of the mapping in digital environment. At he same tame the digital models have their own disadvantages:

- they require the existence of a computer and an appropriate software to be used as well as special devices (scanner, digitizer) for its creation;
- often occurs limitation in the volume of the information because of the lack of disk memory or because of low speed by exchanging the data for Internet applications;
- it is necessary the creators and the users of the digital models to have a good knowledge about the computer hardware and software ;
- often there is contradiction between the file formats, in which the data are stored and some part of the information can be lost by transforming the data in the other format.

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