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LOGICAL AND SEMANTIC PREMISES FOR DESIGNING A SYSTEM OF CARTOGRAPHIC SIGNS

THE NUMBER OF CARTOGRAPHIC SIGNS AND THE INFORMATIVE EFFECTIVENESS OF THE MAP

Universal automatization of all the aspects of scientific and practical activity has also entered cartography, both in the field of its theory and methods, as well as execution. Some cartographers even assess the modern character of cartography according to the level of utilization of electronic computation technique in the entire cycle of elaboration and making of geographical maps.

The logical consequence of this situation is the need for a quantitative evolution of cartographic presentation methods as a prerequisite for transition to map designing and using computer cartography methods.

Assuming that the detailed representation on topographic maps of characteristics of geographical landscape is rendered by the number of individual information, encoded in the entire system of cartographic signs for topographic maps, we may calculate how many pieces of information are encoded in the given sign, as well as how many graphic elements compose the drawing of this sign.

Numerous observations and practical use of topographic maps by non-professional users indicate that they remember solely 30% of the so-called principal cartographic signs depicting the entire characteristics of objects and phenomena. The significance of other signs is shaped in their minds most often due to supposition based on association with other signs kept in mind.

Thus, topographic maps, no doubt, contain an "excessive number of signs". This stems from the lack of a homogeneous conception of the way of construction of the particular signs, as well as their role in a homogeneous system of cartographic signs for topographic maps. Therefore, it seems useful to undertake the work to minimize the number of cartographic signs for the entire series of topographic maps, thereby improving their effectiveness as a general dynamic information system. The work aimed at automatization of the designing and executing process of topographic maps should

start with elaboration of theoretical assumptions of the pattern of a modern topographic map. Thus, the universal system of cartographic signs - or the topographic code — for this map should be worked out in the first place.

A topographic code is commonly understood as the system of conventional cartographic designations representing on the map field objects and phenomena, their features or their correlation. They are used to express briefly scientific notions and inferences, as well as enable gathering, recording, storage and transfer of knowledge of the objects and phenomena in geographical space. Cartographic conventional signs are usually divided into guide (line and point) signs, which give rise to derivative more complex signs (Fig.1), i.e. singatures.

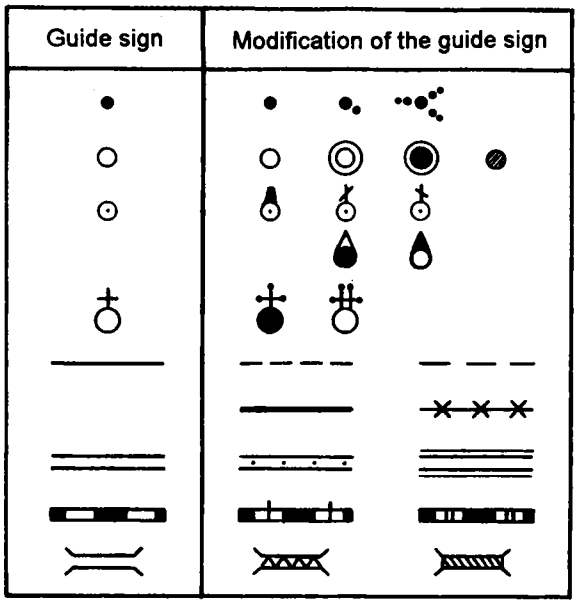

Fig. 1. Examples of guide sings and the ways of their modification

A signature, in a cartographic sense, is a conventional sign used to show on the map either individual, unit field objects or collective notions, giving global information about homogeneous objects whose representation on the map as separate signs is impossible or useless. Thus, in the former case signatures occur as proper signs, while in the latter — as natural signs i.e. indices (Fig.2).

According to the adopted classification of non-linguistic signs, and the corresponding classification of cartographic means of expression, signature signs are divided into iconic signs and symbolic signs.

Iconic signs express relationships between *signans* and *signatum* by the relation of similarity. This indicates that the sign and the object are identical in some respects, especially in the sense of sensory perception. Symbols, on the other hand, are certain modifications of iconic signs, whose relation-

Signature as the indicator	Application	Explanation	Signature as the real sign	Explanation
•	• 114,5	Spot height		Enclosure
		Vegetation boundary		Deciduous tree
		Improved road		Coniferous tree
		Tufts		Windmill
				Single boulder
o		Road lined with trees		Triangulation point
		Orchard		Water-mill
				Small bridge
		Shrubbery		Gallery
"		Meadow		Small power station

Fig. 2. Examples of signs-indicators. Indicator — a conventional sign the meaning of which depends on the context in which it is used

ship with their objects has been established by virtue of cartographic convention. This does not permit any free interpretation of symbols. The theory of sign says that the symbol is the only full authentic sign. The concept of the symbol in this meaning can be identified with the term "symbol" in the sense it has in the so-called symbolical scientific languages, where the term is tantamount to the term "sign". Such signs often compose artificial languages and codes.

The possibility of the gathering and processing of information about field objects and phenomena, though limited to the handling of only conventional signs representing these objects and phenomena, gave rise to one of the greatest intellectual revolutions. Previously, it was connected with cartography, but today it is supported by such disciplines as theory of information and theory of communication, whose fundamental concept is a signal.

In a wider meaning, each conventional sign is a signal. In this sense, a cartographic picture is symbolical and may consist of one or more elementary signs, or signals, which are an inseparable shape of information. A set of symbols subordinated to the information of a given set of information is called a code.

The alphabet of the cartographic code is a set of conventional signs and graphic symbols, lines or points, as well as **inscriptions** conveying information about objects and phenomena of geographical space. The meaning (sense) of the particular signs and graphic symbols is explained in the table

of conventional signs. The attributing of appropriate symbols (sings) to the particular pieces of information is called encoding in the theory of information, while the reading of the information (e.g. map contents) written by use of these signs is called decoding.

In the topographic practice we usually have to do with encoding of the information presented in the code of one language, such as the observed reality, or a map elaborated in a different code, or machine carrier of information etc. In this sense, map elaboration is the process of recoding, i.e. translation of information (map contents) from one code and its presentation in another code.

The quality of the encoding operation (map making) and of the decoding of information (map reading), i.e. the value of the map, is entirely dependent on accurate and univocal character of the cartographic code.

The map content emerging during the editing process is not an ordinary picture of the fragment of the surface of geographical space under investigation, but first and foremost it is a scientifically-based, using measurements and experiment, material transmission of information in the convention of a cartographic picture. In brief, the map is a model of geographical reality

Shape of variable	Measurement features
Dot	No size - conventionally - - diameter of the dot.
Dash	Length. Conventionally also thickness of the line.
Flat figure	The area. Conventionally- - length and width.

Fig. 3. Principal designing elements (elementary construction variables) of the system of cartographic signs

represented by conventional signs on a flat surface. The definition emphasizes two peculiarities of construction of the map contents. The first one concerns geometrical structure of the cartographic picture, while the second one applies to the cartographic symbols.

The investigations aimed at discovery of structural regularities of construction of map contents made cartographers conclude that the map, being a specific technical product, is, however, an authentic scientific work in the first place. As a product of scientific thought and technical work, the map is subject to general laws (norms) of scientific and technical designing, according to the requirements of commonly binding — at a given time — scientific concepts and technologies of map elaboration and production.

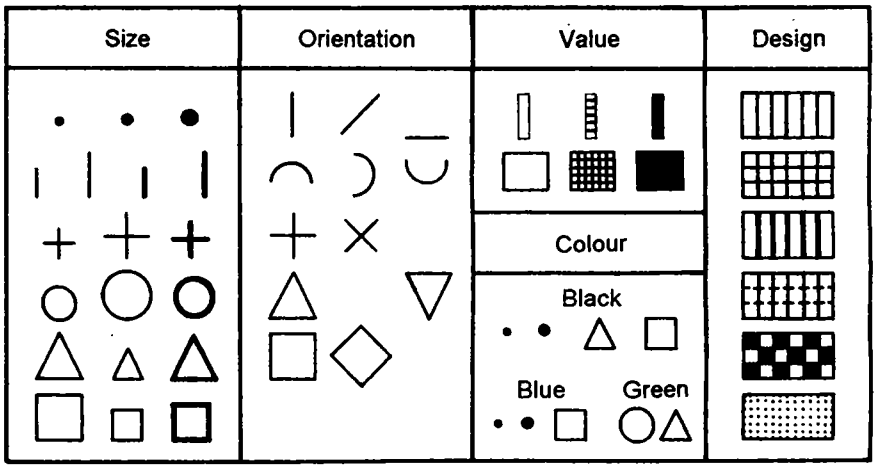

Fig. 4. Graphical characteristics of construction variables

One of the most important tasks in the process of designing map contents, as well as its graphic form is, therefore, to elaborate a uniform system of cartographic signs, i.e. a cartographic code. The system of cartographic signs, regarded as a certain set of interrelated graphic elements, may be divided into two groups: 1. more important, i.e. the so-called principal designing elements (guide signs) (Figs.1 and 3), and 2. additional or complementary construction elements.

Additional construction elements have to explain specific properties (features) of the objects and phenomena represented.

Experiences in map making prove that the information from the map is obtained both by visual perception of the picture of cartographic signs and by additional measurements on the map. The correctness of visual perception, one should add, directly depends on the visual character of the picture of the particular signs and of the cartographic picture of the map contents as a whole.

If we assume that the operations of encoding information "I" into language "A" are determined by relations R_1, this action may be described as interdependence IR_1A. Then the operation of the translation of information "I" from language "A" into language "B" will be determined by interdependence AR_2B. On the other hand, the coding of information "I" into language "B" will be expressed by relation R_3, being a product of relations R_1 and R_2, i.e. $R_3 = R_1 \cdot R_2$. However, it is well known that relations R are not symmetrical, that is $IR_1A \neq AR_1I$ because the decoding rules denote reverse relations, which are marked with letter $\overline{R}$. Thus the operations of reading (interpreting) of the map information are expressed by the relations: $A\overline{R}_1I$ and $\overline{R}_3 = \overline{R} \cdot \overline{R}_2$

The rules of encoding formulated in the shape of regulations regarding the principles of the use of conventional signs on maps are called the encod-

ing key, while the table of explanations of conventional signs may be called a vocabulary of cartographic code. In this sense the key is an algorithm of relation R_1, while the vocabulary is a stabilized relation $\overline{R}$ The above equations prove that in the system of cartographic communication there can be no univocal transformation of information, indicating that the message received, i.e. the map contents read, would strictly correspond to the inherent knowledge of the reality presented.

The general rules of construction of the individual cartographic signs, as approached by computer graphics, were described in my article (Grygorenko 1976, 1984). In the present paper, the analysis was made of some assumptions regarding the construction of cartographic signs as universal symbols of a topographic code demanding strictness and univocality as well as legibility and simplicity of codes. Thus, cartographic signs, beside the mathematical basis, constitute the main object of designing during the map making. Generally, this concerns a system of signs of objects and phenomena forming part of the major components of the map contents. But as regards details, account is taken of individual signs-symbols of the objects and phenomena.

The picture of cartographic signs, considered as geometrical constructions, is composed of smaller graphic fragments which are analyzed as elementary construction variables (Fig.3). Such interpretation of the cartographic picture is called structural. It enables a simplification of the drawing of the map contents, in the geometrical sense, so that automatic drawing or even reading the map contents may be executed by automatic device.

The problem of automatic map reading and drawing is related to an important problem of the so-called cartographic alphabet adapted to convey information about objects and phenomena of geographical space by use of some separate cartographic signs of elementary construction variables. The choice of elementary construction variables must be made in such a way as to make them express the largest amount of information about each field object and phenomenon regarding their distribution, external outlook, physical properties as well as quantitative and qualitative characteristics. At the same time, their number should be as small as possible, while its graphic form so simple as to make them form the largest possible number of cartographic signs without the need for their greater modification, i.e. without changing their elementary graphic form. In this instance, they might be imposed on cartographic originals of maps, even by the simplest mechanical drawing devices.

The mode of construction of syntactical (i.e. topological) and semantic graphic structures of signs of the topographic code is one of the most serious theoretical and technological problems in cartography, which has not found a proper solution as yet because the structure of signs includes their entire information potential, functionally connected with a number of other signs composing the system of signs of cartographic (topographic) code.

Elementary construction variables forming part of the graphic structure of cartographic signs may take the following shape: dot, dash or figure.

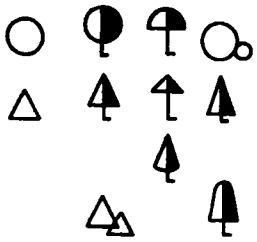

Fig. 5. Geometrical figure signs

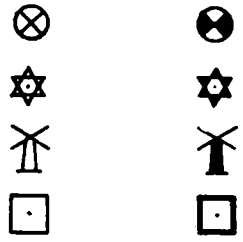

Fig. 6. Ordinary objects are represented by "empty" signs, while outstanding objects by the "filled" signs

These three chief graphic signs permit a realization of numerous combinations of topological systems within the entire system of cartographic signs, making them active information components in the structure of a cartographic message.

However, the semantic and informative structure of signs is mainly composed of the guide signs, evoking spontaneous, at firts look, univocal semantic associations. This structure is complemented with additional construction elements playing the part of signs-indicators, which expand and specify the sense of information conveyed by the shape of the guide sign.

The adding of graphic elements to the guide signs of the topographic code is expected to increase the amount of the informative character of signs by way of modification of their external outlook. What is meant here is differentiation of signs in terms of shape, size, orientation, clarity, colour and pattern (Fig.4).

Taking into account some theoretical and practical hints formulated here regarding the creation of systems of uniform cartographic signs, a variant of the table of universal signs of the topographic code was elaborated for topographic maps on any scale. In this example, stylistics of the guide signs was abandoned and they were replaced by geometrical figure signs (Fig.5). Attempts were made to give the particular signs, an appropriate perceptive aggressiveness. That is why, the so-called empty signs, whose optical infuence is insignificant, were intended to show general phenomena on the map. On the other hand, to show the remarkable objects, the "filled signs" were envisaged (Fig.6). Additional constructional elements, expanding the picture of the guide signs, were introduced very cautiously, considering the preservation of simplicity of signs. They were used solely to distinguish related objects, belonging to the same typological groups.

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