

The Cartographic Knowledge Base in formulating the linguistic trend of map semiotics

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The algorithms of the Cartographic Knowledge Base must be based on procedures of information exchange and on the similarity between the map language and a natural language. These two issues are described in detail because during the process of designing the algorithms, both currents appearing at present in cartosemiotic – linguistic and classic – must be taken into consideration. The linguistic current concerns the general rules of the map language, including the principles of creating the cartographic communiqué and the principles of dividing the mental image into separate communication units. The classic current concerns the technical rules of creating the basic communication unit, in other words, it explains the rules constructing the cartographic sentence on a map surface. Therefore, during the process of editing the cartographic communiqué, it is better first to use the linguistic current and then the classic one. Thus, it is advisable to investigate the cartographic editing as a two-stage process.

Key words: cartosemiotics, map language, linguistic current of map semiotics, Cartographic Knowledge Base, Cartographic Design Expert System, automated map editing

INTRODUCTION

The cartographic editing is a complicated process. Its improvement resulted in modern desktop mapping systems and GIS. As a consequence, many map authors avoid expending time and money on involving a cartographer. It does not, unfortunately, appear to have led to a more widespread knowledge of cartographic design, and the large number of poorly designed maps is constantly bemoaned by cartographers. The mapping systems that help the user to produce better maps or at least maps that do not break the fundamental rules of cartographic representation and design are required. The Cartographic Knowledge Base as a set of algorithms helpful in the process of map making is the first step in this direction. The implementation of this set of algorithms in the computer software used in the process of cartographic design will guarantee the editing of correct maps.

CARTOGRAPHIC COMMUNICATION AND CARTOGRAPHIC WRITING

Communication is a process that allows organisms to exchange information. Exchange requires feedback. The word ‘communication’ is also used in the context where little or no feedback is expected, such as broadcasting, or where the feedback may be delayed as the sender or receiver use different methods, technologies, timing and means for feedback. Communication can be defined as the process of meaningful interaction among human beings. It is the act of passing information and the

process by which meanings are exchanged so as to produce understanding.

Communication can be seen as a processes of information transmission governed by three levels of semiotic rules:

- a) *syntactic* (formal properties of signs and symbols),
- b) *pragmatic* (concerned with the relations between signs / expressions and their users),
- c) *semantic* (study of relationships between signs and symbols and what they represent).

Therefore, communication is a social interaction where at least two interacting agents share a common set of signs and a common set of semiotic rules. In a simple model, information or content (e. g. a message in a natural language) is sent in some form (as spoken language) from an emisor / sender / encoder to a destination / receiver / decoder. In a slightly more complex form, a sender and a receiver are linked reciprocally.

Communication between machines with the artificial intelligence and human beings is achieved with the help of a code which has a structure very similar to the structure of a natural language.

In order to find means of editing a short, more clear communiqué and at the same time one of an increased content copiousness, ideographic signs were reached for the appreciation of their independence of a spoken form of language. The conventional ideographic signs and special logical-mathematical rules enable to live up to this task in a greater degree. Thus, *the cartographic writing* was born. The signs of the cartographic writing, *cartographic signs*, are characterized by a thrifty graphic (or

plastic) expression, albeit with a large semantic potential. A communiqué fixed with the help of the cartographic writing may be defined as *a map*. Its perception in an uncomplicated and at the same time unambiguous way enables the transfer of information about the surrounding geographic environment between the author of a map and its user.

THE GENERAL PROCESS OF CREATING AND TRANSMITTING INFORMATION AMONG PEOPLE

A substance conceived in the mind and also processed and stored there is referred to as *a psychic (mental) substance* (Kurcz, 1992). So far, science hasn't been capable of defining satisfactorily what the psychic substance actually is. The memory trace, an "engram", has become a hypothetical unit of storing the previously received sensations or the reactions of human senses for the scientists engaged in those matters. What the nature of this trace depends on is not clear yet, and a dispute over this subject has been continued to this day.

People, having no possibility of a direct transmission of a mental substance (their thoughts) amongst themselves, have learned to utilize a physical notion for that purpose (Fig. 1). Broadly speaking, the said notion is referred to as a channel of transmission (transmission channel, connection channel). It is utilized in two ways. In the first case, the sender organizes a material substance of a transmission channel in such a way that the attained creation would be of a closest resemblance to a mental image, e. g. a picture of a painter. In the other case, a material substance of the transmission channel is organized into a set of signs of a given code, with the help of which a mental image is depicted. Thus, the mental image appears in an encrypted form. The signs are treated as notions of the mental substance, and the code is understood as a system of signs serving the means of communication.

The codes can be either natural or artificial. The *natural codes* are a biological equipment of different species of animals and serve as a means of intra- and inter-species communication. All human societies created and improved natural codes on their way of evolution too, with the help of which they communicate well. These are the so-called natural languages. *Artificial codes*, on the other hand, are exclusively a human creation, and they serve both the means of interpersonal communication and communication with inanimate information processing systems, such as computers. The natural codes can only be discovered and researched on. The artificial codes can be created in an infinite number (Kurcz, 1992).

A simple and a compound is yet another form of the division of codes. A simple (directly defined) code is a group of signs as material objects and meanings corresponding to them. This means that this code includes two components of each code: the material structure (physical form) of signs and their meanings (semantics). So defined, a code is perceived as *single-articulated*. When to these two components of code a third – syntax – is added then such a code will prove to be able to produce new signs in infinite numbers. It becomes a compound (hard to define) code. This code also contains two kinds of formal units with different functions, i. e. units which have meaning (signifying units) and units which distinguish meaning (distinctive

units). However, there is a difference between these two kinds of codes. The minimal signifying units of the compound code can be decomposed into distinctive units. Such code is perceived as *double-articulated* (Chandler, 2007).

All natural languages consist of two classes of system signs. One of them is a finite set of elementary signs called the vocabulary (lexicon) of a given language. The other is an infinite set of combined signs created on the basis of the basic signs. The first class of system signs – the vocabulary – contains two kinds of formal units. Words with their meanings are signifying units. The spoken or written components of words (so-called "elementary forms") with their vocal or graphic substance are distinctive units. The second class of system signs – the infinite set of sentences – also contains two kinds of formal units. In this case, syntactic rules of natural language enable to join words (elementary signs) into sentences, producing in this way combined signs. Each separate sentence expresses a predicate (judgment). This means that its semantic contents differ from a simple sum of the meanings of its individual elementary signs. We can say that combined signs are signifying units. From this point of view, elementary signs can be perceived as distinctive units and a natural language as a double-articulated code. Linguists treat double articulation as a specific feature of natural human languages.

Apart from these two classes of sign systems, one might well look out for a third one which may be defined as an infinite set of complementary signs. A complementary sign is a textual composition, a group of sentences adequately arranged, joined by a common leading theme. The meaning of a textual composition is not a simple sum of the sentences assembled, but it results from the applied organizing rules (editorial guidelines) and may be treated as a certain semantic unity.

A conclusion can be drawn from the foregoing text that in order to recognize a given code as a double-articulated code (regardless of its being artificial or natural) one should look for a mechanism within a code, that would allow creating an infinite set of combined signs from a finite set of elementary signs. In other words, it would be a mechanism bearing the features of a syntactic component. One can, therefore, characterize such a code as 'language'.

As mentioned above, information transmitted among people constitutes a mental substance which is equal to certain observations. Broadly speaking, one can speak of a certain *mental image*. Therefore, with the aid of a textual composition (an amalgamated sign), an *entire mental image*, with the assistance of a separate sentence (combined sign) its *fragment*, and with the help of a separate word (an elementary sign) an image of a *single element* are transmitted. Hence, a certain hierarchy of the units taking part in the communication process comes out depending on the role that they play in that process and on the capacity and sort of transmitted semantic contents:

- *an element of a communication unit* – a semantic content composing a separate commonly accepted basic concept is transmitted;
- *a communication unit* – a singular predicate (judgment) is transmitted;
- *a set of thematically interrelated communication units* – a set of predicates merged in a thematic unity is transmitted.

Attempting to answer the question in what way a map transmits information about the surrounding reality to its users, one must first ask a question: What the image of a map really is? The intricacy of the answer will result from the point of view. Actually, one can promptly reply that it is *a construction of graphic (or plastic) elements* drew up on a flat surface. This construction, however, does not constitute a model in the sense of a material (physically perceptible) model. As long as we

don't learn the meaning of particular elements of this construction, the image of a map will remain a meaningless puzzle of lines, geometric figures, tinted spots and letters of different size. As soon as we realize the meaning of particular constructional elements, the image of a map will turn into *a mathematical-semantic construction* to us, since the semantic content is included within the shape, size and location of graphic (or plastic) elements on a flat surface. Thereby, it can be stated that the

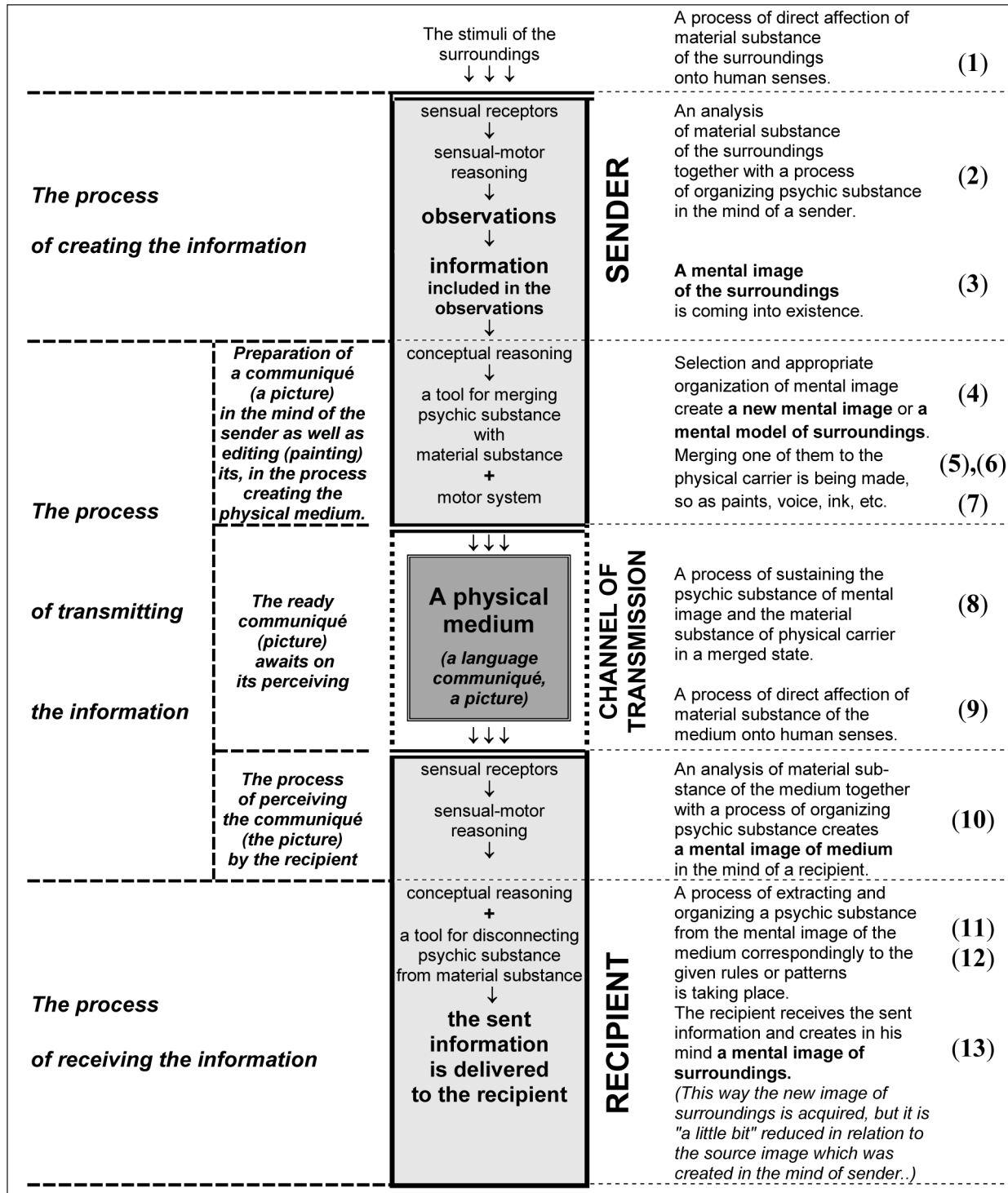


Fig. 1. A scheme of generating and transmitting information among people
1 pav. Informacijos kūrimo ir perdavimo principų schema

image of a map contains certain information in an encrypted form.

The structural relations among the constructional elements of the image of a map are defined by the existence of simple and compound semantic connections. Simple connections emerge during the assignation of the psychical content to elementary constructional graphic elements. In other words, they emerge at the very time of assigning a meaning to the cartographic signs, i. e. during the process of creating the legend of a map. Compound relations, as far as they are concerned, are expressed in the emergence of a psychical content representing certain predicates as a result of transforming the psychical content of the elementary graphic elements at the very moment of recognizing them as superior constructional elements. If, for instance, the cartographic signs specified in the legend of a map are located on the surface of the map, in accordance with the mathematical-geometric relations of the accepted map projection they become superior constructional elements. Also, if the cartographic signs already located on the surface of a map are merged into a semantic unity on the basis of logical reasoning, they become superior constructional elements as well. Eventually, all the superior constructional elements are ultimately amalgamated, depending on the editorial requirements, into a constructional unity in the form of an integral, thematically determined image of a map.

To people familiar with the principles of structural relations (in this case semantic, mathematical and editorial), the psychical substance included in the image of a map will bring about in their minds *a spatially measurable and thematically determined mental model* of a fragment of the geographic reality. This model will be *thematically determined* by the applied simple and compound semantic relations. Simultaneously, this model will be *spatially measurable* by reason of the applied mathematical relations among the constructional elements of the image of a map and the geographical environment. Such relations are, on the one hand, the size, the shape or the location of the constructional graphic elements on the surface of a map in accordance with the factual state of the actual objects represented with their aid. On the other hand, the mathematical relations are also the quantitative and qualitative characteristics

which are represented with the assistance of other graphical assets of the constructional elements, such as colour, the width of a line or the kind of the sign's pattern.

Relations described in such way are *a result of the functioning of a code* which defines the manner of assigning mental contents to the respective structural elements. A psycholinguistic analysis (Neytchev, 1996; 2001) reveals that this code is very similar to the double-articulated code (like a natural language) and the name of the **map language** can be applied to it. From the psycholinguistic point of view, it constitutes a tool of a human mind with the help of which the so-called *cartographic composition, a cartographic communiqué*, to be more precise, is formed, and that is a **map**.

The concept of language is realized in three different aspects:

– *of a system*: a language is a system in respect of a set of the formal-functional units existing within it, opposing to each other on a scope–content basis and in this way mutually determining one another within the range of the whole,

– *of an act of a speech*: the application of the language occurs in a given social circumstance and constitutes a certain organized whole originating from an inception and conclusion and an inner structure,

– *of a text*: a language is a text in the sense of a linear sequence of linguistic units created in the process of communicating (speaking–understanding), based on a certain relational combination of those units.

Linguists state that the smallest linguistic unit that makes up a channel of transmission in the process of information transmission is a statement. A *statement* is understood as a concrete act of the usage of language for the communicational purpose. It is expressed with the help of *a sentence* which simultaneously is its material realization (verbal or written), and a realization of an act of speech as well. *The act of speech* expresses intentions of the speaking person. It is the very motivation lying at the foundations of a given statement. Uttering a sentence, a speaking person directs his statement to somebody and he does it for some or other reason.

A table (Fig. 2) depicts the division of linguistic units appearing in the aforesaid aspects in accordance with the functions presented above. A layout of the proposed units of the map

| Units of the natural language | | | The function of linguistic units in the communication process | Units of the map language | | |
|-------------------------------|--|------------------------|---|-------------------------------------|---|-------------------------------|
| in the system | in the text | in the act of speech | | in the act of map language usage | in the text | in the system |
| Elementary sign | Word | Component of statement | Component of communication unit | Component of cartographic statement | Cartographic word (cartographic sign located in the legend of a map) | Elementary cartographic sign |
| Combined sign | Sentence | Statement | Communication unit | Cartographic statement | Cartographic sentence (a cartographic sign or a set of cartographic signs located on the map's surface) | Combined cartographic sign |
| Amalgamated sign | Textual composition (literary composition) | Set of statements | Set of communication units (communiqué) | Set of cartographic statements | Cartographic composition (map, cartographic communiqué) | Amalgamated cartographic sign |

Fig. 2. A resemblance between the units of a natural language and those of a map language
2 pav. Verbalinės ir kartografinės kalbos struktūrinių dalių palyginimas

language from its linguistic concept point of view is presented in the table, too.

The complete scope of the activities related to creation of a textual composition is arranged by structural principles (semantic, syntactic and editorial) of a natural language. The entire spectrum of the activities related to creation of the image of a map is arranged by the structural principles (semantic, mathematical-logical and editorial) of the map language.

AUTOMATION OF THE PROCESS OF CARTOGRAPHIC EDITING

In the past, map authors, upon examining the available data and perhaps producing a rough, hand-drawn map, would then collaborate with a cartographer to produce the final image. The

cartographic editing is a complicated process. Therefore, cartographers try to automate this process. The result of their effort is modern desktop mapping systems and GIS (Fig. 3) which have the ability to produce high-quality linework, colour fills, complex point symbols, and a legible text. As a consequence, many map authors see no need to expend time and money on involving a cartographer. The increased availability in recent years of inexpensive computer mapping facilities has led to a great increase in the number of map authors who are able to produce their own maps of a high technical quality (Fig. 4). It does not, unfortunately, appear to have led to a more widespread knowledge of cartographic design, and the large number of poorly designed maps is constantly bemoaned by cartographers. Such maps are not the fault of the computer systems; most systems are perfectly able to produce well designed maps when used by

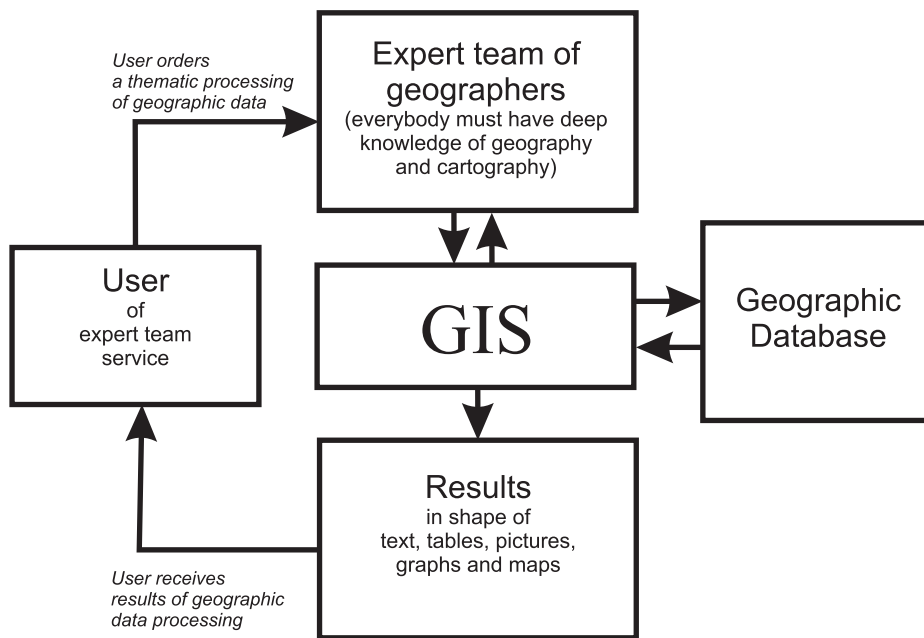


Fig. 3. General structure of expert team in geographic data processing
3 pav. Ekspertų dalyvavimas kuriant geografinių duomenų struktūrą

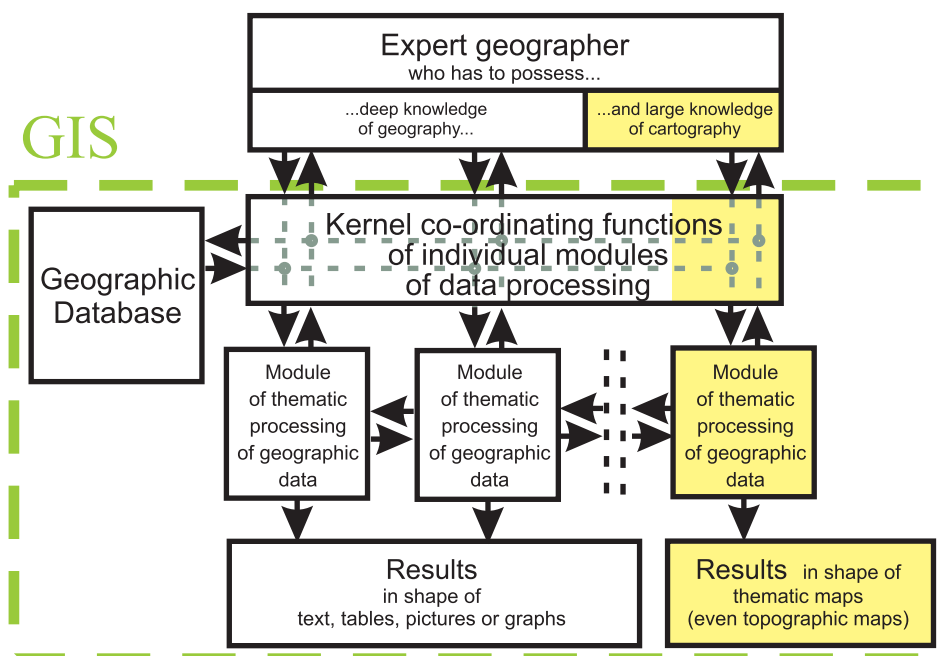


Fig. 4. General structure of Geographic Information System (GIS)
4 pav. Geografinių informacinių sistemų (GIS) struktūra

cartographically aware users. The problem lies with map authors who have little knowledge or understanding of the basic principles of map design and presentation.

If cartographic education is not likely to improve, what are cartographers to do other than bemoan the increasing numbers of poor maps being produced? What is required is the mapping systems that help the user to produce better maps or at least maps that do not break the fundamental rules of cartographic representation and design. The area of computing science devoted to producing programs that include knowledge of how an expert solves a problem is called Expert System. An Expert System is essentially a program that includes a codified form of the rules used by an expert to solve a problem. Thus, a carto-

graphic design expert system would include the rules a cartographer uses when designing a map (Forrest, 1999).

The first step in this direction is the creation of the Cartographic Knowledge Base (CKB) in which the set of algorithms useful in editing correct maps will be kept.

At the beginning, the Cartographic Knowledge Base can be implemented in the Geographic Information Systems as a separate module supporting the geographic data processing with producing maps that do not break the fundamental rules of cartographic editing (Fig. 5). The next step, in the near future, can be the process of co-operation between the Geographic Information System and the already separate Cartographic-Design Expert System (CDES) (Fig. 6).

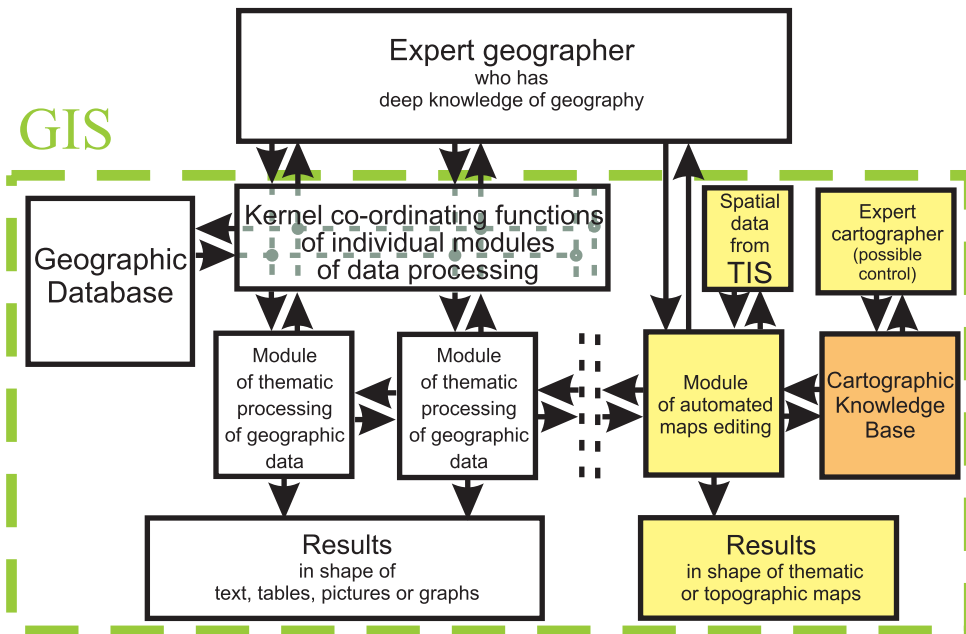


Fig. 5. Location of Cartographic Knowledge Base in the general structure of Geographic Information System (GIS)

5 pav. Kartografinių duomenų bazės vieta bendroje geografinių informacinių sistemų struktūroje

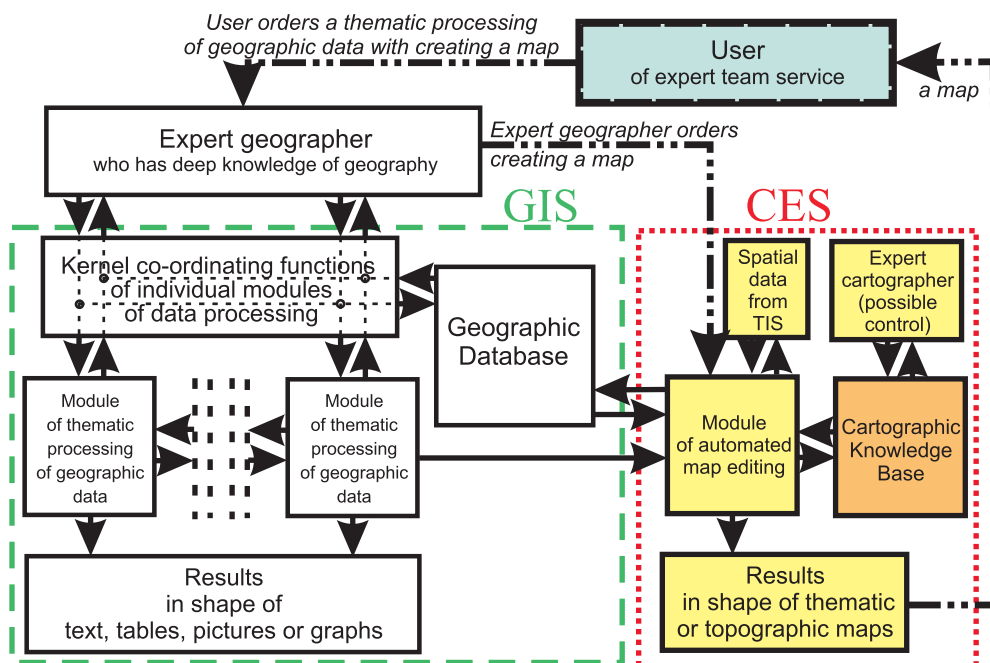


Fig. 6. Co-operation between the Geographic Information System (GIS) and the Cartographic-Design Expert System (CDES)

6 pav. Geografinių informacinių sistemų ir kartografinio dizaino ekspertinės sistemos sąveika

TWO CURRENTS IN CARTOSEMOTICS

The image of a map, according to the linguistic concept of the map language, constitutes a cartographic communiqué, i. e. a set of thematically related cartographic statements. A cartographic statement is understood as a concrete act of the usage of a map language. It is expressed with the help of a cartographic sentence which simultaneously is its material realization as well as realization of the act of map language usage. The mental model of a fragment of the geographical environment is hidden within

the set of semantic contents of those sentences. A user of a map (a recipient of information), in an opposite way, perceives cartographic sentences and recreates in his mind a transmitted mental model of a fragment of the geographical environment with the help of the map language (Fig. 7).

The linguistic concept of map language is the main issue (the leading concept) of the linguistic current of cartosemiotics. Formally, two currents are being now identified in cartosemiotics: *classic* and *linguistic* (Fig. 8). The linguistic one concerns the general rules of the map language, including the principles

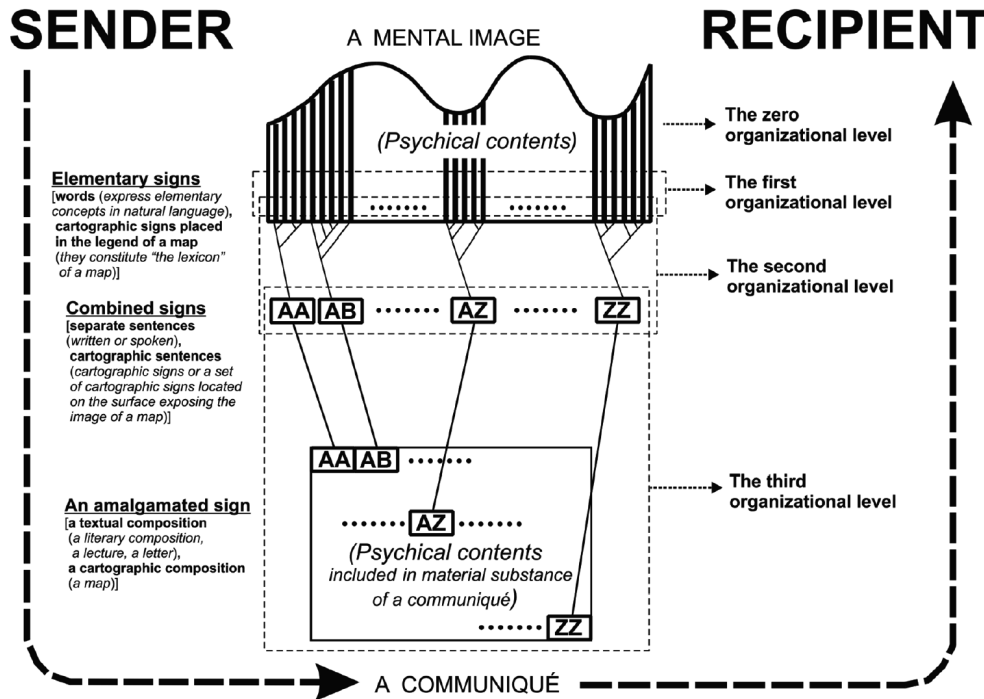


Fig. 7. A scheme of information transmission between sender and recipient
7 pav. Sąveikos tarp informacijos siuntėjo ir gavėjo schema

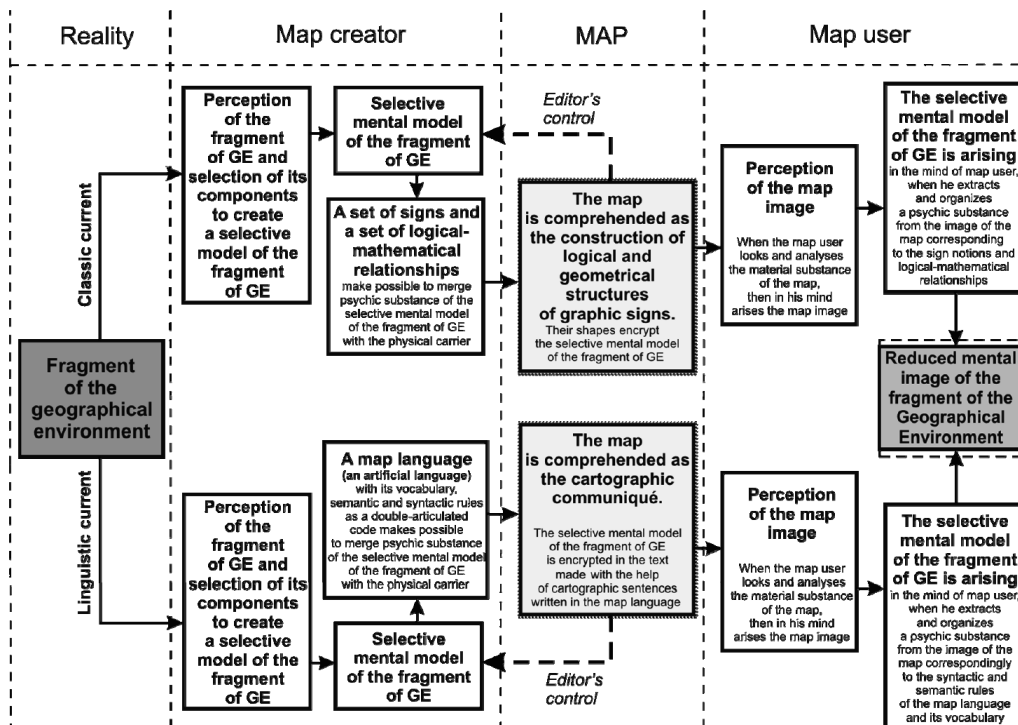


Fig. 8. Two currents in cartosemiotics
8 pav. Dvi kartosemiotikos kryptys

of creating a cartographic communiqué and the principles of dividing the mental image into separate communication units. The classic current concerns the technical rules of creating the basic communication unit, in other words, it explains the rules constructing a cartographic sentence on the map surface.

Differences between both currents are not antagonistic. The linguistic current tries to represent “the pure technical” principles of classic map design by “more humanistic” linguistic rules of editing a cartographic communiqué. In this case, the cartographic communiqué is defined as a “discourse”. This method of editing maps is more similar to the mechanisms of human mind work. The map symbolism as a semiotic system is very similar to the system of the natural language. Therefore, we can say that the procedure of information transfer using a map image is very similar to a similar procedure using the communiqué of the natural language. During the process of editing a cartographic communiqué, it is better first to use the linguistic current and then the classic one. Thus, it is advisable to investigate the cartographic editing as a two-stage process.

CONCLUSIONS

The process of creating a cartographic communiqué, in other words, the process of editing a map, consists of two stages. A cartographic statement as the basic communication unit joins both stages. At the first stage, the cartographer splits the mental substance of a mental image in his mind into separate parts. Each of them will constitute the mental content of a separate communication unit. Editorial guidelines (or organizational-stylistic rules of the map language) regulate the content-related correctness of this division. At the second stage, the individual communication units are created. It means that the mental substance of individual parts of the mental image is being merged with the physical carrier. For the linguistic current, this is creation of separate cartographic sentences according to grammatical rules of the language of the map, as well as from general relations, resulting from the division of the mental image. For the classic current, this means creation of separate, semantically determined graphical structures based on an appropriate process of putting cartographic signs on the map surface according to the spatial location of objects or phenomena represented by them, as well as taking into consideration their quantitative and qualitative characteristics. The relations that appear among the neighbouring objects or phenomena are also taken into consideration. The material realization of semantic graphical structures should at the same time consider the construction of the graphical composition of the map image in which the mental model of a fragment of the geographical environment is encoded. On its base, in the mind of the user of the map, there arises a spatial, thematically limited mental image of the geographical environment.

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Pavel Neytchev

KARTOGRAFINIŲ ŽINIŲ PAGRINDAS FORMUOJANT LINGVISTINES KRYPTIS KARTOSEMIOTIKOJE

Santrauka

Kartografinių kūrinių redagavimas yra sudėtingas, todėl siekiant jį patobulinti buvo sukurtos modernios kartografavimo sistemos ir GIS. Tačiau daugelis žemėlapių sumanytojų nelinkę eikvoti lėšų ir laiko tobulų kartografinių žemėlapių kūrimui, tad net ir esant labai plačioms kartografinio dizaino galimybėms, naudojami tradiciniai, grafiškai skurdūs metodai. Rengiant profesionalius kartografus jų interesus būtina nukreipti į įvairesnių kartografavimo vizualizacijos būdų paiešką. Tai verčia permąstyti ir peržiūrėti kartografavimo būdų sistemas, padedančias kurti geresnius žemėlapius ir neignoruojančias pagrindinių kartografinio vaizdo pateikimo ir jo dizaino taisyklių. Kompiuterinių programų visuma leidžia kurti tinkamo dizaino žemėlapius bei tinkamai juos redaguoti.

Autoriaus nuomone, bazinės kartografinės žinios turi būti formuojamos remiantis tarp kartografinės kalbos ir natūralios verbalinės kalbos egzistuojančiais informacijos perdavimo panašumais. Straipsnyje detalai apibūdinamos šios dvi savokos ir atskleidžiamas jų turinys. Jis svarbus, kadangi kuriant kartografinius algoritmus vienu metu operuojama ir kartografinėmis, ir lingvistinėmis semiotinėmis kategorijomis. Lingvistinės kategorijos suformuoja svarbiausias „kartografinės kalbos“ nuostatas, nulemiančias kartografinį komunikavimą. Pastarasis yra paremtas mintyse suformuoto kartografinio vaizdo skaidymu į atskirus standartizuotai suvokiamus (komunikacinius) segmentus. Kartografinės semiotinės kategorijos apima taisykles, kuriomis remiantis kuriami šie standartizuotai suvokiami (komunikaciniai) segmentai. Kitaip tariant, kartografinės semiotinės kategorijos padeda konstruoti sudėtingus kartografinius vaizdus, lemiančius žemėlapio vaizdą.

Žemėlapių redagavimo metu veikia tokia pat schema: kartografinę komunikaciją pradžioje formuoja lingvistinės semiotinės kategorijos, vėliau – kartografinės. Visa tai leidžia kartografinių kūrinių redagavimą išskaidyti į dvi fazes ir kiekvienai taikyti atitinkamus semiotinius principus.