IN SEARCH FOR MODELS OF CARTOGRAPHIC REPRESENTATION
(Language Oriented Approach)

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Abstract

The last four decades have seen extensive efforts in development of spatial modelling concepts and theory. Different and highly automated visualizations of spatial data are now possible, up to photorealistic dynamic representations. However, cartography nowadays also faces a risk of being replaced by automated visualization of geospatial data. Instead of some universal principles of cartographic design, map makers are offered sets of standard visualization tools, which come with all GIS packages and are easy to use. Some of them even have underlying theories; that implies that the outcome will be correct in terms of perception, interpretation and usability. In this paper, we point out the differences between communication of spatially referenced data and cartographic representation, examine the models of transformation between the two sets of data, and identify the points where information is lost or distorted in the process.

Keywords: map language, models, cartography, cartographic communication, spatial communication
1. INTRODUCTION

Development of GIS and other information, design and publishing technologies during the past several decades have made an essential impact on cartography. Irrespective of the long tradition of this discipline, its concepts and theory have to be revised against what computerization, spatial modeling concepts and visualization technologies have already brought to cartography. Even though it is almost impossible to imagine modern mapping without GIS technologies, there is a significant difference between the processes that create geographic database and retrieve information from such database and the processes that create and retrieve information from a map. As the processes of both categories usually intertwine when maps are created, it is natural that concepts and stereotypes migrate from one field into another.

Unfortunately, judging by quality of common printed and electronic maps, it can be stated that the existing theories of cartographic representation are still insufficiently integrated (or too weak to be integrated) into rapidly developing theory of spatial modeling and technology of spatial information management. Thus even though need for maps was one of the main factors that stimulated the development of geographic information technologies, at this stage development of geographic databases and analytical functionality is still given priority to the problem of quality of maps produced. More than that, scientific research in modern cartography is also more oriented into effectiveness and improvement of methods of maps’ production and use, thus overshadowing the fundamental research. For that reason many cartographic works published demonstrate a lack of uniform methodological background that should have been used to compile them or in the worst case are simple graphical reports generated from one or another geographic information database.

On the other hand, impact of geographic information technologies on methodology of traditional cartography positively manifests in new concepts, models and methods of information management in cartography. Of course, this impact has positive and negative sides. Hereunder we discuss only methodological issues, while the benefits from GI and IT technologies to the performance of the standard mapping tasks do not need to be advocated.

Positive impact:

- A single GIS database containing all necessary data and formal data structures beyond the map image require much better understanding of the represented information. Reassessment of information described in terms of classes, attributes, domains etc. helps to avoid (though not completely eliminate) some common errors (e.g., inconsistency of attribute information, classification errors, missing symbols in the legends, etc.).
- Enforced need and provided possibilities to apply system-engineering methods (due to the large amounts of diverse cartographically represented geographic data and variety of their formats and sources). Different models have been developed to tackle the complexity problem and most of them can be successfully applied for management of cartographic information. Use of such models makes modern cartography more systematic and facilitates understanding the process of mapping itself. Some applications of modelling techniques (life cycle and dataflow modelling, structured diagramming techniques, quality evaluation schemes and other) for cartographic transcription have been discussed in several previous publications [1, 3].
- Concept of meta information (data about the data) can effectively be applied to describe different semantic aspects of cartographic sign systems.
- Growing demand for cartographic production is related with spread of geographic information systems. As people know that it is easy to compile a map (not necessarily a good quality map) as geographic data are available, they want to see more information presented in a convenient form of maps. Naturally, demand for maps motivates more intense theoretical research in cartography.

Negative impact is mostly related with transference of GIS technology stereotypes into cartography:

- Sometimes mapping is equated to automated creation of a map from geographic database (whatever results in producing a map, is mapping). Instead of principles of cartographic design, map makers are merely offered sets of standard visualization tools which come with all GIS packages and are easy to use. Use of such tools indirectly implies that the outcome will be correct in terms of perception, interpretation and usability. It’s scarcely surprising that cartography now faces a risk of being expelled from the domain of geo-spatial information sciences at all. Fortunately, more and more GIS users and distributors understand, that cartography can not be replaced by just automated visualization of geographic data: “… extracting a map report from an information system is not mapping, just as formatting and printing a document is not writing. (...) While some mapping capabilities are available in many geospatial technologies, great mapping is an art unto itself.” [4].
- The problem of quality in technological context is often deescalated to problem of accuracy and topological consistency of data. As theoretical problem, efficiency is usually given priority. Dependence on limitations of particular technology is often perceived as natural and inevitable (people first think of whether it is technically possible/easy to do what they would like to).
There is still no completely consistent theory of spatial data or spatial models that would effectively combine the two aspects of spatial information management: data (information, knowledge) management and cartographic representation in respect of the underlying theories of both disciplines – geographic information science and cartography. We assume that geographic and cartographic information flows do not have to be examined after the same model. Neither mechanical merging of two different schemes is acceptable for it usually results in some parts of either scheme underestimated. Thus, the classical communication schemes, which have been commonly accepted by cartographers first and by GI scientists later, must be revised. Comprehensive models of transformation between spatially related data and their cartographic representation would be a significant input into such theory, assuming that human visual perception and cognition issues are considered. We believe it is possible to combine the two models of information communication and merge the information systems (that of geographic data management and thematic mapping), which in terms of their functions are the implementations of the communication models.

Before the two models can be successfully merged, it is necessary to point out the major differences in the communication of data, possible collisions of goals at different stages, points where information is at the biggest risk of distortion or misinterpretation. It is also important to show how different information is communicated between different levels. Hereunder we attempt to unify approaches of language, modelling and communication comparing the two schemas of geographic information communication (encoding and retrieval) and models (formal and informal) used at different levels of abstraction and at different stages of communication.

A general scheme of both geographic and cartographic information modelling (an extension to the famous Ratajski’s model [7]) should allow more systematic approach to cartographic design, and facilitate understanding of geographic data communication to cartographers as well as that of cartographic information communication to developers of geographic information systems. It would also be useful as a framework to identify possible problem areas and weaknesses and to plan the data flows without mixing up data- and representation-related tasks.

2. MAP LANGUAGE IN THE COMMUNICATION PROCESS

As we have stressed before, a need for methodological background for cartographic works and fundamental research in cartography, map language must be mentioned as it plays an important role for understanding cartographic information communication and may be considered one of the keystones in development of cartographic theory.

2.1 Brief Overview of the Previous Research

The concept of a map language has been intensely developed during the 7th–9th decades of the 20th century. Map language has been in one or another way represented in different theoretical schemas of cartology/cartographic communication/metacartography: as a mean of the cartographic communication (Kolačny 1969, Ratajski, 1976), as an instrument for cartographic modelling (Aslanikashvili, 1974), as a tool for cartographic cognition (Berlyant, 1978) etc. Maps were perceived as communicative devices and compared to written texts in some natural language as they similarly express mental concepts [5]. Different researchers investigated into various aspects or elements of map language: semiology of graphics (Bertin, 1967, 1983), morphology and syntax (Ratajski, 1976), hierarchy of its structural parts (Pravda, 1982).

J. Ramirez pointed out the limitations of digital maps from the viewpoint of visualization and described an extended representation model for geospatial information as a framework for future (multiple source, quality, and media) mapping. Even though such approach seems innovative and promising integration of both cartographic theory and geographic data models, it still needs to be developed from implementation-oriented to more general. The author has also made attempts to present the fundamentals of a more general cartographic theory, combining existing theories of cartography and the more modern ones of geospatial data. Cartographic language, which appears to be a central component in this general theory, is presented as a set of formal structures.

H. Schlichtmann during the past two decades has touched upon different aspects of cartographic language constructing a coherent framework for thematic mapping (oriented to cartographic visualization). The framework for cartographic visualization revealing the three general functions related with transcription: signification, clarification and emphasis appears a major input into cartographic theory [8]. A. Liuty in his exhaustive study on map language (“Map language: its essence, system and functions” [6]) summarized the results of the previous research and presented a consistent theory of map language as of an objective phenomenon. He brought forward the importance of research into map language as a setoff to the prevailing paradigm of cartography as an applied science. Liuty also pointed out the dualism of map language, i.e., two subsets, one of which describes location of the objects in space. Such approach implies that cartographic information models cannot be treated as parts of geographic data models, i.e., cartographic signs are much more than just additional attributes of represented geographic objects.
It is evident that the research into cartography, exhaustive in particular aspects and revealing diversity of viewpoints, has not yet resulted in integration of the two major trends – cartography as visualization science and geospatial information science. Concept of spatial communication language for describing spatial data/information/knowledge at different levels of spatial representation may become the connecting element, as it is essential in the both theories.

2.2 Languages of Spatial Communication

In the process of spatial information communication, we deal with different basic types of languages (there is some overlap in the following classification):

1. Natural languages, such as spoken/written, visual or gesture language. They objectively exist as they have formed historically, in order to satisfy human need to express and share the mental concepts, images and ideas. It is possible to translate the “texts” from one natural language into another as long as there are common concepts beyond. However, as the laws of such languages are not completely known (they develop), lots of information is lost or distorted in the process of translation. It is even impossible to translate a text from one spoken language into another without any changes in meaning, leave alone visual rendering of a written text or vice versa. Research into natural languages is basically oriented into finding out the existing laws and using them to improve communication.

2. Formal (or partially formal) languages, which are based on limited standards or other artificial rules, but have potential to develop depending on the phenomenon, for description of which they are used (mathematics, music, high level semantic models, and symbols). Bertin’s system of graphic variables can be examined as a subset of some formal map language.

3. Artificial languages, such as computer languages (computer simulation of human language e.g. output of a machine translation system), standards and data transfer protocols. They are created on purpose, as more or less flexible standards used to describe the concepts of a particular field. Generally, translations without information loss are expected to be possible between artificial languages, as long as they are based on the same object model and standards. Thus, the process of translation can be automated. Research in artificial languages is always engineering-oriented (standards, methods, efficiency, data loss, application of the constructed rules, and technical quality are the major issues).

The three figures represent the “texts” in different languages: a natural visual (a fragment of a drawing where the actual meaning of possible symbols are known to the author alone, Figure 1); a (maybe) semi-formal visual, for abstractionists often assigned specific meanings to different graphical elements of their paintings (Figure 2) and an artificial programming language (Figure 3). It is practically impossible to make a translation of drawing in the Figure 1 into the language of the painting in Figure 2, because underlying concepts are too complex and too different. Even though the code in a programming language may be interpreted as instructions that technically create an image like that in Figure 2, such “translation” cannot be compared with the original neither in semantic richness nor in value.

It is practically impossible to provide a clear set of instructions how to create an abstract painting expressing what is on the author’s mind, or even an abstract painting of good quality. It is almost opposite with the third example. As long as meta-information is provided and the syntactic rules of the programming language are obeyed, the piece of code is correct and uniformly interpreted everywhere. Maps find their place somewhere in between, depending on which approach to map language is accepted.
So what actually is the map language? Extending the approach of Liutyi, who proved objectiveness of map language at the highest level, we propose to examine it as a set of models applied at different levels of information communication: from completely natural visual language, which is used to render the mental images, through semantic models (where written language is used as intermediate tool for formalizing the concepts) to data description languages. Such approach allows connecting cartographic and geographic data modelling schemes at least at the lowest level of data description languages (see Chapter 3).

2.3 The Specifics of Map Language

The concepts of natural (spoken) language are commonly used for construction of high-level semantic models. Therefore, it seems sensible to look for the structures in the visual map language, which could be mapped into the concepts of natural language. Such elements (syntagmas, sentences, and communiqués) could be translated from one language to the other. As practically all semantic models are based on natural language concepts, a universal scheme of translation would be very helpful for efficient cartographic database creation and for making the automated mapping process more intelligent. At the highest (human) level of abstraction, map language has often been compared to a spoken language. However, it is more an illustrative analogy, used to reveal the objectiveness of visual language, than an essential similarity. Some specifics of map language that distinguish it from other visual and spoken/written languages are discussed below.

Map language is used to describe the same geographic objects and relationships (assuming possibility of the universal spatial object model) using different media and different signs in analogy to alphabet and lexis of a written language. That means, multiple map “dialects” exist, among which changes of cartographic representation method and media are common. The two very different representations of geographic objects depicted in Figures 4 and 5 can be interpreted, assuming that the user has some basic knowledge on what types of geographic objects can be on the map and how different types of objects are represented in each case. Then the translation from one map dialect to another is possible. In the worst case we need to complement the vocabulary so that it includes the words (representations that have to be designed employing the tools and rules of the destination set) to denote the objects that come from the source map.

![Figure 4: Inlay map of Madaba, Yordan, 6–7 centuries BC](image)

![Figure 5: Bamboo stick map of the Marshall islands](image)

If we are to agree on overall objectiveness of the map language phenomenon, maps are closer to objects of visual art and their interpretation should be considered a process highly influenced by the specifics of human perception and cognition. On the other hand, if a map is examined as a result of impersonal cartographic transcription, which is true for the map models, described in formal languages (especially geometry), correctness of interpretation is mainly based on quality and coverage of the existing standards (lexis of the formal languages).

Based on Liutyi’s statement that map language has been naturally developed to complement spoken language (which is likely to be true), two conclusions can be drawn:

- Map language, as based on spatial perception, is more universal and requires less specific knowledge to understand its different dialects; it is even more powerful communication tool as it was claimed to be;
- Direct translation will never be possible from the natural map language into any formal model, for all the semantic models are based on the concepts of a spoken language. It justifies development of formalized map

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* Source: Senovės pasaulio paslapty. Alma Littera, Vilnius, 2002
** Photo: M. Govorov.
languages as intermediate systems that prevent loss of information in successive translations all the way down from mental map image to the storage data models. Bertin’s graphic variables, object model and various models describing semantic relationships have to be considered as possible frameworks of such intermediate languages.

- Another side of the same, when map images are retrieved from the stored data (formal descriptions): they are interpreted as texts in much higher-level language. It means, additional information can be generated, unanticipated in the formal models. This characteristic is related to the “knowledge construction” phenomenon.

Dualism is another characteristic of map language that manifests in presence of two subsets of the language: one for registration of the spatial object position, another for rendering of the characteristics of the object [6]. The two subsets are not completely independent, for instance, real location of the objects determines some characteristics of the signs (size, type, etc.) at particular scale. On the other hand, depending on the specifics of the signs, location of the signs can be adjusted in order to preserve the topological relationships. Difference between spatial and non-spatial may fade in some cases, e.g., arrows in historical maps (the central line may not represent actual path of some movement at all). It means that even though the models of encoding spatial information (information about location) coincide with the models of cartographic information at some parts, they cannot be completely isomorphic. Thus, we will examine cartographic communication process as a series of translations of “description” of the subject area from the highest level map language through different formal (semantic models, mathematical, computer and other) languages to formal description of data and backward.

3. SPATIAL INFORMATION COMMUNICATION REVISITED

3.1 Process of Cartographic Communication

As it was mentioned above, we conceptualize cartographic communication process as a series of translations. The key concept is the service model of a protocol layer. Layer n-1 is said to offer services to layer n via a protocol. In our case, a layer is a “description” of the subject area on the correspondent level of cartographic (or spatial) representation. A protocol of communication is “the format and the order of messages exchanged between two or more communicating entities, as well as the actions taken on the transmission and/or receipt of a message or other event”[10].

<table>
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<th>Language vs. protocol:</th>
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<tr>
<td>Language: A system of symbols and rules for expression or communication.</td>
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<tr>
<td>Protocol: A set of rules used to specify the format of an exchange of data.</td>
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Our two-way layer model, representing cartographic (spatial) communication process is shown on the Figure 6. It starts at human mental application layer and works its way down towards the machine physical layer (top-down approach). The retrieval part represents different steps of the reverse process of cartographic communication.

This model has dualistic network nature. From one side, it is an n-tier network model, which transmits author’s (cartographer’s) information top-down and back. The author’s mental map may be distorted during the transmission. From the point of view of the map user, this client/server model provides collection of map (spatial) services. The user can gain new information, distort, or support the encoded vision of mental space. Such layer communication model possesses unique characteristics. It is distributed and heterogeneous. Thus, different protocols (languages) have to be used to accomplish different communication tasks. The entities exchanging messages and taking actions are human, hardware or software components of a heterogeneous network. The communication system is very complex.

With layered protocol architecture, each protocol belongs to one of the layers. Several protocols or their combinations can be used within one layer, with the condition that all the protocols belong to the same layer level. For example, the instruments of vector or raster graphics, or a hybrid one can be used as a protocol for the cartographic representations. A protocol in a layer n is distributed among the entities, which implement that protocol. For example, the software and hardware components can implement the visual graphical display of a map.

Another characteristic of distributed applications is that the cartographic communication layer model contains connection-oriented services and connectionless services at the same time. What can happen to information as it travels from its source to its destination? The layer n-1 might guarantee that the n-protocol information unit will arrive without error to the layer n in the destination, or it might only guarantee that the n-protocol information unit will arrive at the destination without any assurances about the error. Along the path of communication, information can be lost due to different reasons and in different amounts at each node. Therefore, the performance at a node can be measured in terms of the probability of information loss. At the level of mental map, the protocol of transfer is very subjective, so information is not only probably lost, but can also be gained as new “knowledge”. The layer of logical representation can support connection-oriented service: information (data) can be transformed to and retrieved from the conceptual or
physical representation levels without any loss. The loss of information can be minimal and estimated at the conceptual representation layer; for example, loss due to spatial or semantic generalization.

The model of communication can be shorter or longer in terms of intermediate nodes (layers). In traditional cartography it has just three layers: reality (A) is transformed by cartographer through his mental model (B) into a map (C) which is read by a user (C’) and interpreted in order to build user’s mental model (B’) of the reality (A)” [7]. In computer environment, the chain of transformation is longer and may have branches. Now we can analyze the communication layers by examining the correspondent protocols and scenario in which information loss occurs.

3.2 Models for Encoding the Cartographic (Spatial) Data

The top (human mental) layer of the communication-encoding tree (Figure 6) is a protocol that combines natural languages and human protocols of spatial perception and communication. Here we can speak about the inner expression languages.

People use inner languages (semiotic systems) to interpret the geographical space or its existing models – maps, images of the space and measurement results (the map language at the highest abstraction level, discussed above). The images can be combination of the physioplastic (“high grade naturalistic”) and ideoplastic (coming rather from the mind) representations [15]. We can see space in our mind as natural photographic images, as abstract symbolic representations (e.g. image of a street map seen before), or as their combinations. Elements of spoken and mime languages can also be used to enrich the inner spatial imaginations. “The meta-symbolic insight is therefore an implicit understanding that a symbol not only has meaning but is at the same time an object with a physical presence in the real world” [16].

The next (language) level consists of the structured representations of the mental images. People use language(s) to express their interpretations of the mental maps. The concepts can be rendered orally or in written form, as well as using gestures. It has to be mentioned, that not genetic (‘innate’) factors, but cultural conditioning and training fundamentally determine individual modelling abilities of spatial representations [Meyer Fortes, 1981], i.e., people more often draw what they know, than what they see [16]. The ‘fortuitous realism’ can be a method of cognition: “in that the meaning of the scribble is discovered in the course of creating it” [13].  The spatial representations, both mental and rendered in some structured language, may generate ‘multiple representations of similar knowledge’. Karmiloff-Smith [12] refers to certain brain circuits, which may have been biologically selected, resulting in the mind splitting into separate modules. In time, these modules may have ‘co-operated’ again resulting. More recently, the cognitive scientist Dan Sperber [14] postulated a module in the mind, which he calls the module of meta-representation. Another reason of meta-representation is dynamism of thinking. Outcome of mental interpretation is dynamic; the final outcome can be changed with further thought.

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The concepts of any natural language can be translated into a formal language (semantic formal model) and backwards. As natural and formal languages are not isomorphic, the loss of information takes place. Several formal languages are used for spatial modelling. Object-oriented notations such as entity-relation, sequence and other diagrams have been implemented in some GIS and mapping packages for descriptions of spatial data structure and behaviour and spatial modelling, according to, for example, Unified Modelling Language specification [11]. The mathematical language operates symbols and formulas that are often used for functional modelling of fields and surfaces.

Information transfer between the mental and semantic model of cartographical representation is eventually accompanied by information loss. Information loss and distortions may occur due to cartographic generalization. For example, the geometrical model can be richer before transformation into sign representation, requiring more “media space.” Symbols’ omission or movement can affect geometry. Misinterpretation of the semantic relationships between the objects and the signs is another common problem. Information loss also occurs when the syntax of a formal language is not rich enough to render the map information.

The cartographic symbolism can be translated into conceptual model of geo- and cartographic database representation (system of signs) and be enriched with additional attributes. Language of vector or/and raster geometry with corresponding tools for description of semantic, topological and behaviour attributes can be used for spatial modelling. Cartographic representation is usually separated from the spatial representation. According to our scheme, cartographic elements can be represented as symbol sets with specific attributes, linked to the corresponding attributes of spatial objects. In more advanced cases, cartographic behaviour rules can be enforced to control the rendering order of layers and symbols, text placement, and cartographic zoom-dependent generalization.

Translation from an analogue cartographic representation into a conceptual digital layer is accompanied by spatial information loss due to precision and errors of digitalization or scanning process. Geometry and topology of a feature
can be distorted. Iconic view of corresponding analogue and digital signs may be not identical as well as the correspondence between visual variables. Attributive information can be preserved. Information loss control and estimation can be implemented with some level of probability.

The next representation level is logical model, which is an intermediate between the conceptual view and the data storage model (e.g. relational, geo-relational structure specific to a particular vendor’s format etc.) or computer-readable text formats (e.g. XML (GML) etc.). Exporting conceptual model and UML object model into a logical model may not introduce information loss unless due to incompatibility of standards and data types. The language of relational algebra in mathematical (variables and operators) or graphical forms (table structure and relations), programming and scripting languages (e.g. XML), spatial descriptive and query languages (e.g. SQL) can be used for logical spatial modelling. Symbolization data can be represented as separate computer-readable text structures (e.g. .lyr) or are stored as a part of the relational schema together with the spatial data. The formal languages of computer graphics are used to represent the spatial features and the signs in library. Languages of predicate logic and other artificial languages can be used for description of the attributes and behaviour.

Logical model is translated into file organization form and secondary storage format (binary machine opcodes) of physical layer. No loss of information occurs unless due to machine errors during data translation into this layer or incompatibility of storage formats. Computer language of the binary system of impulses is used for communication.

3.3 Models for Retrieval of the Spatial (Cartographic) Data

Data retrieval process from the physical storage through logical and conceptual layers is relatively safe. Data loss will not occur if fully compatible data formats and interoperable standards are used. Thus, data encoding and retrieval between the physical and logical levels can be controlled. When different data standards are used, they may appear not fully compatible. For example, geometry often can be preserved during transformation between different logical formats and conceptual representations, what is not always true with physical formats (loss of precision can occur). Behaviour information can be lost and the layer organization can be modified during the translation between the physical formats.

Many spatial formats do not contain cartographic information within them at all; therefore cartographic data incompatibility between different logical formats is common. Often information about map representation is stored in separate files (e.g. .lyr, .apr etc). Translation between different cartographic representations is not fully compatible or not supported (e.g. between .apr and .tab). Symbol palettes (especially vector graphics) also often are not compatible, even in the software packages of the same vendor (e.g. between .apr and .mxd).

Retrieved conceptual schema can be considerably altered if transformation of format occurs within the logical layer. Information loss can also occur in the next level of modelling (symbolic representation). It can be due to several reasons – e.g. rasterization and resampling of geometry on a monitor, discrepancy of the colour schemas, dynamic visual generalization, limitations of computer graphic formats (e.g. SVG) etc. In general, the conceptual model can contain more information that it has been retrieved for a view. Visual rendering process is dynamic in terms of recognition of information, encoded in a spatial database. A set of attributes can be visualized in different ways and combined with the results of analysis of the same data.

Several languages can be used for visual cartographic representation. It is often a language of computer graphics, but also it can be written, schemas notations, mathematical and even spoken (e.g. computer sound).

The process of translation information from symbolic representations to mental images can be different for analogue and computer maps, although the principles of immediate interpretation may be similar. Computer image can be interactive and richer in terms of its graphic/multimedia expression tool set. Possibility for dynamic interpretation of computer images can be much bigger compared to interpretation of hard copy maps. The final outcome of interpretation of map image may depend not only on user’s knowledge, associations, and preferences but also on his computer skills.
4. CONCLUSIONS

The language used to represent the spatial knowledge – the “map language” – can be analysed as a series of communication systems, starting with the language of visual perception as an objectively existing phenomenon that helps us to form mental maps, through equally natural, but better structured spoken/written language, then through semi-formal languages and conceptual and logical schemas, which are already formal languages and closing the set with the Nyerges’ “deep spatial structures” [9] (close to physical representations). Such approach may prove more efficient than discussions on existence and diversity of different map languages as it can be practically used for construction of spatial information communication models, identifying possible communication problems and for planning the data flows. Such models, in turn, help to unite the geo-database and cartographic communication (neither of them subdued) viewpoints striving for quality, efficiency and innovations.

Rendering of spatial information at different levels (mental, conceptual, logical, and physical) according to this approach can be examined as successive translations from one language to another within the set. Naturally, we strive to minimize the loss of information in the process of each translation. Nevertheless, there is a big gap between formal and natural languages, which is responsible for distortions or loss of information as well as for generation of additional information, which can manifest in useful insights as well as in simple “noise”. The commonly accepted spatial
information modelling and cartographic information modelling schemes have common parts (at least at data description level); however, they never coincide completely.

The process of map making will always require human intervention – as natural languages require smart interpretation. Therefore, it is impossible to fully standardise the methods or processes of thematic cartography, nor to provide universal rules of information generalization. Conceptual differences between cartographic and geo-database modelling languages do not allow such thing as 100% efficient automated cartography information systems. It is, however, possible to make the cartographic communication from geo-database more efficient due to partial congruity of spatial and cartographic information communication models. The processes of problem solving and the methods of quality improvement can be same or very similar at some stages.

The further research could focus on particular schemes of “translation” between different scales, time sections, purpose (target groups), and methodology allowing to quantify the information loss and thereby to estimate the data quality. Structural analysis of the languages participating in the cartographic communication and equivalence of their structural elements also can be interesting to investigate. Clarification of the concepts of the natural visual (map) language would help to improve the process of geographic information visual encoding and retrieval as human perception and cognition issues are concerned. It would also allow developing the methods of exchange between cartosemiotics, map aesthetics, stylistics and data modelling fields in cartography.

An undivided approach to a map (map as information system itself) has many advantages against splitting it into elements for database purposes. As in natural language good and correct words/phrases are not necessarily combined into what can be called a good sentence (and vice versa), correct use of the elements (e.g., visual variables) one by one does not yet guarantee a quality of the representation.

5. REFERENCES

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