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Methodological aspects of designing topographic map symbols

Investigations have been performed with reference to the Pierce ternary concept of a symbol and to rules of semiotics. Methodological rules concerning designing of symbols for topographic maps, which refer to digital and analogues forms of cartographic visualisation. Each of the assumed rules is amended with practical guidelines and examples of solutions, appropriate for the Polish topographic maps of the new generation.

1. *Presentation of topographic data*

Topography is a branch of geodesy, which deals with surveying and modelling the basic components of the natural environment. Each of geo-components consists of many elements – objects, which have been usually distinguished with respect to a given level of generalisation. In Polish topographic cartography that level reaches the scale of 1:10 000, which is the scale of the, so-called, base map, covering the entire country. That map is the base for development of map in smaller scales. A being is interesting in topography — *a geographic reality object* – which exists in the field and which is the landscape element, indivisible into objects of the same order. Following definitions developed in 1987 by the US National Committee for Digital Cartographic Data Standards, *a topographic object* may be defined as such model of a real being, which expresses position and basic useful features of that element of the geographic reality. We are for naming topographic objects in the same way as objects of reality are named. They consist of three elements, which are mostly distinguished [2]:

- geometry – which results from position and shape of a modelled being; through the function of transfer of topographic relations between objects; it is connected with locating function of a map,
- attributes – the are non-geometric features of a topographic object, which appropriately characterise that object (sufficiently from the point of view of potential utilisation of a developed model),

- values of attributes – values of the above features for particular topographic objects (numbers, texts, images, sounds etc.), which are recorded in the database as descriptive elements in various forms.

The topographic object correspond to a *database object,* which is its numerical representation, included in structural frames of the database. A model representation of a real object also contains definitions of attributes (characteristic for the given being) and record of values of those attributes.

Topographic cartography deals with processing, modelling and presentation of topographic data. Topographic cartography successfully utilises geographic information systems, as a method of modelling and as programme tools. It should be assumed that, in order to perform topographic cartography tasks, a topographic information system will be developed (SITop), which will become the best environment for modelling, analyses and presentation of that data.

The most important element of the topographic information system, which is distinguished from the physical point of view, is the topographic database (BDT), which is the basic source of spatial data for other elements and users of the SITop. It contains records of position and values of attributes of topographic objects in an assumed scale, with the level of details, which corresponds to the scale of 1:10 000. It should be stressed that the first stage of designing of such database, concerning terms definition of database objects and their features and relations, does not depend neither on the assumed application nor on selection of a particular GIS software product. Only the last stage, which is called "a physical level of designing" has the nature of application; the database management system should be selected then.

Cartographic visualisation of data concerning topographic objects is used for presenting information processed in the process of cartographic editing to the graphical model form, for which the system of topographic symbols is a mean of information transfer.

3 levels of cartographic visualisation, related to the level of graphical image processing, should be distinguished:

- the level 1 – presentation of unprocessed data (the so-called, "skeleton presentation"), which presents position of database elements in the simplest graphical approach,
- the level 2 – simplified presentation, which consists of utilisation of cartographic editing elements, as, for example, dislocation in order to avoid collision of symbols, elementary differentiation of graphical forms of symbols and disclosure of parts of names and descriptions of objects,
- the level 3 – full presentation, which requires that all laws of optical perception and harmonious graphical composition are met, which is therefore useful for electronic reproduction or conventional printing.

The level 3 of cartographic visualisation of topographic data will be of interest. Presentations of the first two levels, using a vector data model, are often called Geographic Information Systems, due to the developed system of tools, related to, for example, the functioning of maps in electronic form. It should be noticed here that, besides data and data analysing methods, tools and users are contained within a geographic information system.

T a b l e 1. Levels of cartographic visualisation

Stage of modelling	Presentation
Database	skeleton
Structural generalisation	
Cartographic image	simplified
	full

The second direction of visualisation – the demonstrative direction, creates such images, which use non-symbol means of information transfer for presentation of the basic geo-components, without utilisation of methodology of cartographic visualisation and generalisation. Demonstrative presentations, including aerial photographs, photomaps, satellite images, block diagrams, 3D models etc., are generated as a result of remote registration of geographical objects (photogrammetry); they may also be results of classification of raster data sets and analyses, characteristic for Digital Elevation Models (DEMs).

2. *A model of a topographic symbol and its graphical components*

In cartography the most important mean of transfer remains the system of cartographic symbols, which is sometimes identified with the so-called *map language* [7]. There is no direct imilarity to a natural language, however, it is obvious that semiotics laws are fully applicable in cartographic visualisation, where three types of mutually dependent semiotic relations are distinguished:
- semantic relations, referring a symbol to a presented object (phenomenon),
- syntactic relations, determining mutual relations between symbols,
- pragmatic relations, resulting from a map user's perception of symbols.

The ternary conception of symbols has been assumed in considerations, which is based on The Peirce's "model" of symbols, in which three elements may be distinguished:
- a medium of meaning – here is the graphical expression of a symbol, existing on a map (the symbol form). It should be added that this symbol is often identified with a medium of its meaning, although it is only a mean of information transfer for a symbol. The graphical expression of a symbol itself, without an interpretant or a subject, which is included in a symbol, would not be a full symbol, and only a graphic with potential symbol abilities,
- a subject – this is the layer of a real object, which is transferred by means of a symbol and which selected features may be received by means of perception and interpretation. A real subject remains outside a symbol and it may be recognised by means of a symbol to the level, which depends on adequacy of a symbol subject (called an internal subject),
- meaning – an interpretant which refers a mean of transfer to a given subject. In the case of a topographic symbol the meaning is usually widely considered – as a relation combining the mean and the subject, giving an idea what the operator looks at, how it is expressed and how to refer the graphical form of a symbol to a real object.

As it turns out from the assumed definition of the topographic symbol, the *meaning* of a symbol, considered as an element of a triad of symbols, will influence the correctness of perception of a semantic relation, which occurs between *a medium of* meaning and *a subject* of a symbol. It may be clear that for symbols of a topographic map all semantic relations may be analysed with respect to *subjects* being topographic objects only, which have been distinguished at the stage of the database development and which represent real elements of the landscape. Each subject of that kind has its unique features, which are, in majority of cases, recorded in the form of attributes of a spatial object; one or more symbolic representations are assigned to such a subject adequately to those features. Such representations should be characteristic for the same type of topographic objects only. This is explicitly unique, since one symbol always corresponds to the same real object. This proposal, which is simply obvious, does not correspond to existing solutions, in which the same symbol, depending on the scale of presentation, could stand for various types of objects on one map, or it could stand for different objects.

The task of a symbol model is, among others, to transfer relations occurring between modelled beings by means of mutual symbolic references. The prerequisite required for readability of those references is compliance of ontologic categories, distinguished at the stage of the database development and syntactic classification inside the system of cartographic symbols. Such compliance may be only achieved when graphical features of symbols are adapted to the nature and attributes of presented objects.

In the human mind, as the direct observer of the landscape or as the map reader, a mental spatial image is created, which is also called a mental (or memory) map. Since most perception related experiences are generated as a result of analysis of direct perception of the surrounding environment, memorised details of the landscape have direct relations to a view of the object from the close perspective. The image of a topographic object, which is best known to a man, is not connected with an aerial photographs or a satellite image (a bird's eye view); it is connected with a view from one side, which is observed during a close terrestrial observation. Therefore, a map user's expectations, which should be followed, are connected with a set of image symbols, which refer to such views of topographic objects. In general this relates to point symbols; in case of European maps many symbols, not connected with a map scale, of low association with the real object physiognomy, are introduced for those symbols. The entire image should not be transformed at any price to a vie similar to the bird's eye view of the landscape, since small landscape elements may be recognised on such "orthogonal" presentation only by an experienced interpreter of satellite or aerial images.

Every cartographic symbol consists of two basic elements: a contour and filling of geometric figures. In the process of forming a symbol, graphical attributes of those elements are diversified, which are called graphical components of symbols.

The point symbols is composed by 2 types of graphic components: lines and fillings. Lines create contours of figures and have the following attributes: size (thickness), orientation, focus, transparency, colour. Fillings are interiors of figures, which create a symbol, limited by contours; their features may be: transparency and colour. The term "graphical component" has been reasonably used here, in order to stress that a symbol consisting of lines and fillings of different graphical features may exist, e.g. with the fully transparent filling or with the filling containing figures of invisible outlines. The arbitrary number of both graphical components may occur and it is related to the number of figures, which create the symbol. The whole symbol, determined as a point symbol, may be a graphical component of symbols of successive classes.

The line symbol consists of 2 groups of graphical components: lines and patterns. Lines have the same attributes as components of the point symbol, but the graphical components of a line symbol have the additional feature, which is called a space, which specifies the distance of the component to the symbol axis. Many line symbols consist of several lines, lying apart from the symbol axis and of fillings of spaces between edge lines, which are also lines (of appropriate thickness and lightened colours). The second graphical component of the line symbol – the pattern – means point symbols located along the lines symbol axis in a specified order. Therefore variables of that component will be all features of a point symbol (lines and areas which create it). It also has additional parameters: step, i.e. the space between successive repetitions of a point symbol, measured along the base line (the symbol axis) and the distance between the first and the last occurrence of a point symbol on the base line, from the starting and ending points of this line. This allows to design such a pattern, which will consist of two occurrences of a point symbol – located at the start and at the end of the base line section (the line symbol axis). In a general case, a line symbol may consist of several superimposed patterns (created of various point symbols).

The surface line may be created of 4 types of graphical components; they are: contour, filling with colour, symbol pattern and tone pattern. The first element is a line symbols and it consists of lines and patterns. Filling with colour is the graphical component, identical with components of a point symbol (the same name is used) and it has identical features (transparency and colour). As the maximum, the area symbol may consist of one edge and one colour filling or a tone pattern; additionally a symbol pattern may occur. The symbol pattern consists of point symbols, which are appropriately distributed inside the symbol. The features of the pattern (besides graphical components of the point symbol) are texture and order. Additional parameters specify the pattern density, i.e. intervals between point elements, being the pattern elements, thus defining its rhythm. In an extreme case one point symbol may occur inside a area symbol, e.g. a symbol located in the centre of the area. In practice, it is possible to use several pattern symbols at the same time – in the same symbol, but such complicated solution is not required, since the level of complexity of an element, which creates the pattern, may be always increased, leading to the more sophisticated pattern. The last graphical component, which may be the element of the area symbol, is the tone pattern, i.e. the image recorded in the raster data model, which covers the interior of the symbol. The definition of the tone pattern is based on the pattern of an element, which is regularly repeated (of the determined shape and colour), recorded in the form of a raster file. Filling of the area with colour and the tone pattern occur as alternative elements in a symbol. The list of discussed graphical components is presented in diagrams below:

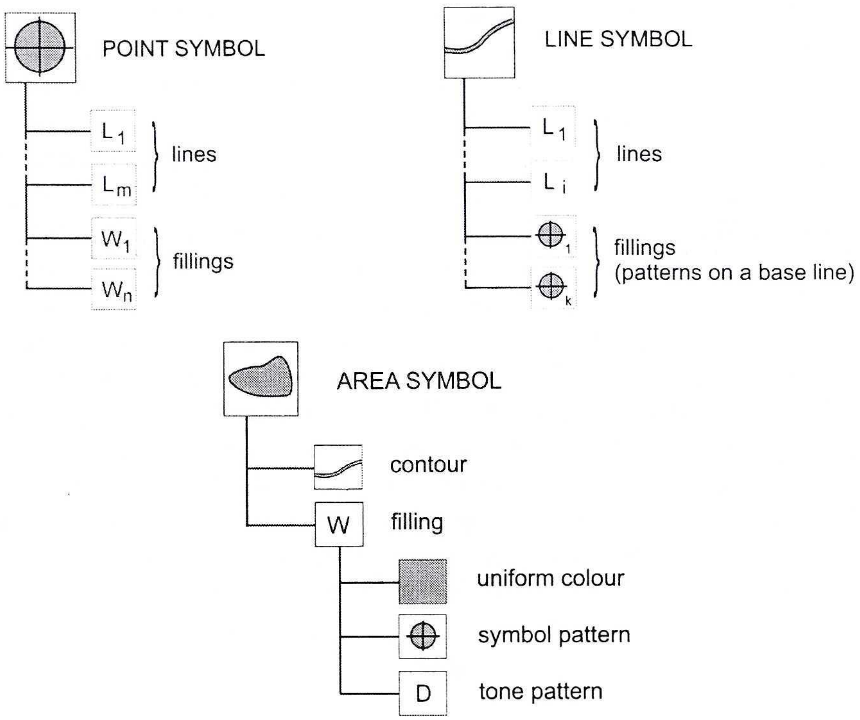


Fig. 1. Graphical components of symbols of various geometric types

As it turns out from the above Figure, point symbols, together with additional parameters, are used as graphical components of line and area symbols, and line symbols, without any additional features, may be the graphical component of area symbols.
Graphical variables are assigned to the elements of topographic symbols, which have been distinguished in such a way (following [3]), according to their natural ability to transfer relations at various levels of surveys:

- position – connected with the transfer of the object position by the symbol, depending on its geometric features; the variable dependent of the map graphics designer with respect to required dislocations, resulting from conflicts of symbols and cartographic generalisation,
- size – the feature identical to the feature occurring in Bertina set; for area symbols it may be the feature of the pattern element; in the case of lines – it corresponds to its thickness,
- orientation – pointing to the positions of the medium of meaning, with respect to a defined direction (frame, the North direction); this feature also characterises a complex variable – pattern, considering its elements; in the case of symbols which use lines as media of meaning – this feature corresponds to the direction of elements of the line pattern (e.g. with respect to the frame of map),
- shape – the feature compliant with the Bertina shape definition; in the case of pattern this is the property of its elements,
- texture – the feature which corresponds to the Bertina texture,

- ordering – the level of ordering of symbol elements; this variable may reach two limit values: the highest level of ordering – the symbol is regular, and no ordering – for a irregular symbol (e.g. the pattern),
- focus of details – the attribute which distinguishes blur and focused outlines (contour) and areas (fillings); this feature allows to distinguish graphical elements of focused contours and elements, which are gradually sunk into the background (or surrounding objects),
- transparency – or the level of blur, which allows to measure the visibility of layers located below in the hierarchical structure; this feature differentiate symbols with respect to the level of their penetration through elements existing below in a set of layers,
- resolution – the feature is connected with the accuracy of information notation; in the case of raster data it means the direct transfer of this image feature (spatial resolution); in the case of vector data it is determined by the precision of its recording or readout,
- colour – the three-attribute feature of graphics (attributes of colour: brightness, colour and saturation); it is totally perceived as a sensual impression, in which one may distinguish variations in colour (tone or hue of colour) and colour intensity – the feature which combines the attribute of brightness and saturation.

3. *Unambiguity and separate classification of cartographic symbols*

The amount of information carried by the cartographic symbol depends on the features of the meaning medium itself, relations occurring between neighbouring symbols and knowledge of meanings, which are transferred by the symbol interpretant. The condition of unambiguity of perception of symbol information is the separate classification of media of meaning. Presentation of topographic objects is influenced by the attribute of unambiguity-ambiguity with the respect to the reality, since particular media of meaning, which occur on a topographic map, always point to a certain class of element of the reality. One medium of meaning presents many various real objects, classified in the database (at the stage of modelling) as an object of the same type and defined under the same name. The condition of separate classification of symbols requires that ranges of terms of presented beings do not overlap and that those ranges are defined at the stage of the database design.

The system of cartographic symbols should include all symbols applied on topographic maps for the entire scale range. Designing the form of symbols for all topographic maps, which are to be developed in a topographic information system, is the only way to avoid classification inconsistencies, repetition of symbols in another context and other misunderstandings. In order to ensure the clarity of map perception it is proposed to use the same colour palette (of various ranges of colours for various ranges of scales) for presentation of all symbols. This recommendation is partially met by the two recent maps developed by the Head Office of Geodesy and Cartography (GUGiK) according to the Instruction [8] and [9], where the majority of graphical solutions are coherent with the discussed respect.

The necessity to record a double, alternative geometry of some topographic objects in the database will appear – e.g. as a point and an area, as well as their other features, which

simplify generation of graphical presentations. Differences in the graphical form of maps at various scales are required due to obvious reasons, such as, the necessity of assuring the correct transfer of information. Therefore – for the unified graphical form of symbols marking the same objects for all scales, it is required that the following demands are met:
- high number of symbols which are interactively scaled, which will distinguish the biggest scale maps (1:10 000 and 1:25 000) from other maps. This will result in increase of surface covered by symbols, since objects presented by means of scalable symbols are presented (and interpreted) identically as objects, which are presented by means of outlines,
- utilisation of only a part of the designed colour palette for presentation at each of scales; this will contribute to making the graphical form of maps more individual. In the case when differences in colours occur for scale changes, it will be possible to ensure analogy between assumed colours of the same symbols, as well as to combine those colour in families of colours.

At the stage of classification of the topographic database content, distinguishing and hierarchic division of attributes of topographic objects is performed. Then, relations should be pointed (within their ontologic types), which met those features; this leads to disclosure the scale of measurements, which may be used for measurements of values of those attributes. Each relation, distinguished in this way, should be then assigned an individual graphic variable, which should be referred to elements, which create the symbol (its graphical components). For example, the graphical variables *size*, and *colour intensity* present the relation of order, which may occur between the object features (as classification aspects) in the best, natural way, according to the examples below:
- hierarchic division of roads (with respect to types – classes of roads) – the variable width of a line symbol (thickness of component lines),
- classification of vegetation with respect to its height (trees, bushes, grass areas) – variable intensity of colours.

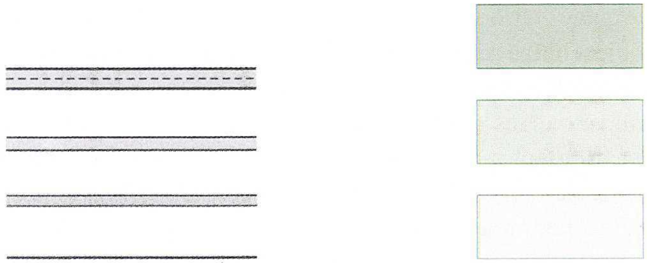


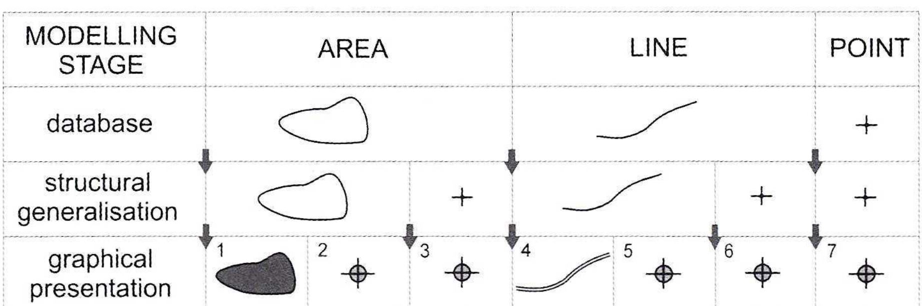
Fig. 2. Examples of transfer of order relations in hierarchic division of roads and vegetation types

4. *Clear associations and readability of meaning media*

The database objects are the model notation of the geographic reality and hey consider only selected features of real objects, which are used, first of all, for proper position of those objects. Generalisation, which occurs as early as at the stage of generation of the first model of the reality, which is the database, allows not to record many features of described objects. In most cases they are those attributes, which are called sectoral or specialist attributes. The relation of meaning, which connects a symbol with an object, is similar. Through interpretation a symbols points to the given external object – a being, which may be recognised to such a level, which is allowed by the symbol meaning. Cartographic modelling runs from the beings, through database objects, to graphical symbols, and interpretation and analysis lead directly from symbols or database objects to beings (their form, which is accessible by means of the map content perception and interpretation). In this context, differences in geometric structure of symbols and corresponding database objects, becomes an important issue.

Following the known typology of symbols, classification of their types, referred to geometry of represented objects, may be developed (table 2).

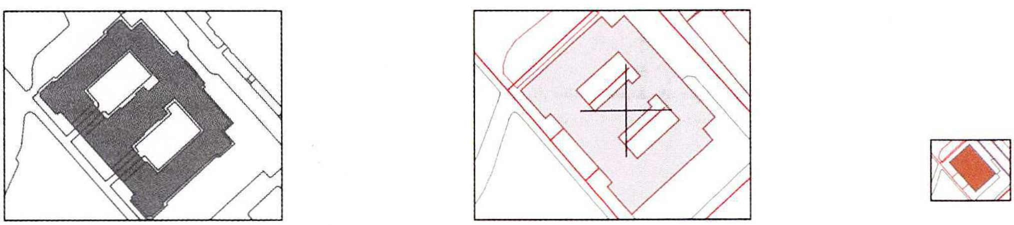
Table 2. Geometric types of topographic objecs and corresponding symbols



It turns out that objects recorded as areas (slices of a plane) in the database, may be – at the stage of structural generalisation – represented by surface and point elements. Each surface element of the geometric model may be presented on a map by means of an area symbol (1) or a point symbol (table 2). Point symbol may represent, among others, such surface objects of the database, which have been reduced to a point at the stage of structural generalisation (3) or such objects, which are reduced in size at the editing stage (2). A point, which determines the interior of an area symbol (a centrode), will point to the interior of the area symbol, what is important when its graphical components are defined. The centrode points to a part of the plane, being the interior or a figure, since it is not explicitly defined by its shape or size. Symbols in a line form are always referred to line objects of the database, which are recorded as lines in the geometric model (e.g. sections of broken or curve lines) (4). Corresponding point symbols, similarly to the case of surface database objects, represent the result of size reduction (5), or they are the result of structural generalisation, where a line has been reduced to a point (6). An important parameter of a line object – besides its position (which determines the symbol axis, called the base line) – is the direction of that object (sense of a vector). As z result we obtain three geometric types of cartographic symbols: points (2, 3, 5, 6, 7), lines (4) and areas (1).

The symbol, through its form – with its components, the graphical variables – is the medium of a structure of the presented topographic object. This takes place both, in individual references, as well as in semantics of the entire system of symbols, when the form of particular symbols allows to read complete structures of data. Maintaining the, so-called, structural skeleton, which is guaranteed in geometric models by their structural correctness, is presented by means of the following media of meaning in the case of graphical presentations:

- utilisation of regular geometric figures as graphical components of point symbols; the figure centre present the object position in the database,
- utilisation of a regular figure or a section of a straight line, located at the base of a point symbol, which centre points to a proper position of the presented object,
- disclosure of a base line (an axis) of line objects, which is mostly performed by axial placement of an entire line symbol, or (if possible) minimisation of its size (line thickness),
- utilisation of recording centrodes of surface objects, for the needs of locating corresponding point objects (the so-called, reduction of symbol dimensions).



1 2 3

Fig. 3. Presentation of a building at successive stages of modelling: 1 – database, 2 – structural generalisation, 3 – graphical presentation

Cartographic symbols are developed with maintenance of the high geometric precision, with consideration of the human perceptual possibilities. Important limitation of that precision are related to technical parameters of equipment used for distribution of the final form of the map. Three methods of map distribution should be considered (e.g. Internet), high resolution plotters and offset printing.

Table 3. Accuracy requirements for the graphical presentation of topographic maps, based on [1,6] and tests of graphics of contemporary maps

Feature	Value [mm]
the minimum line thickness	0.1
the minimum space between symbols of various objects	0.2
the minimum space between symbols of the same objects	0.3
the optimum size of symbols	2 – 2.5
the minimum size of breaking points (a side of an angular drawings)	0.6

However, in the process of graphical forms of symbols a reference should be made to theoretical considerations, which may be then influenced by various technical limitations. Below the most important accuracy requirements, concerning the size of media of meaning, which ensure their readability, are listed.

The above values have been approved with the assumption of a uniform, dark colour of contours and fillings of symbols. In the process of setting the size of symbols, the neighbourhood of the considered symbol: the number of details, similarity of neighbouring symbols, background colours etc., should be considered.

5. *Coherence and order inside a system of symbols*

Coherence of the system of symbols is expressed by such selection of their graphical components, which leads to a logically systematic set of meaning media, allowing for detection of common features and combination of presented objects in groups of meanings. The first and the most general division concerns distinguishing natural landscape elements from man-made objects. Symbols which present topographic objects, which are natural landscape elements, should be characterised by a relatively developed form and irregular *shape*, by the low level of *arrangement* and by harmonised, bright *colours*. Symbols which present man-made objects should have regular and symmetric *shapes*, they should be highly *arranged* (as, for example patterns for visualisation of orchards) and they should use darker colours comparing to colours of natural elements: brown, red, black and grey.

Table 4. Primary colours of symbols for database objects, classified in particular thematic categories

Category	Primary colour	Comments
Built-up areas	Brown (fillings)	Contours – grey
Farm/business objects, social and culture objects	Clack	
Railroads and railroad installations	Black	
Roads and road installations	Grey	Outlines – red
Waters and hydrological installations	Blue	
Control networks and administration objects	Red	
Vegetation and soils	Green	
Terrain relief	Light brown	Shading – greyscale

In the case of more detailed classification – for particular categories of database objects, visualised on maps – it is proposed to apply the primary colour of symbols, which as a feature of the most visible element of the symbol (e.g. filling), will simplify fast classification of a given object into the appropriate category. Proposals of primary colours are highly compliant with the, so-called, canon of four colours: brown – the terrain relief, green – vegetation, blue – waters; one exception concerns the proposal to brighten the colour for planimetric features and to use the grey colour. The list of proposed primary colours for particular categories of database objects is presented in the table below.

The logical features of the system of symbols appears through their arranged perception, compliant with transfer from the general view and orientation concerning complex properties of the visualised area, to the level of details, where the user interprets features of individual objects and relations, which occur between those objects. Such perception is facilitated when one avoids "sharp" graphical accents, which destroy the graphical balance of visualisation and appropriate selection of symbol size, which guarantees their coherence and maintenance of accuracy indications (table 3). The colour, being the graphical variable, has the dominating importance, so it is necessary to develop the impression colour scales, which guarantee gradual variations for symbols, which are differentiated according to scale variations and which allows to use colour of the same depth for map content elements of the same meaning.

6. *Visual method and graphical balancing of symbols*

The tendency of excessive geometrisation of symbols, which were dominating in the past, has been rejected in some recent works; however two conflicting trends in development of a form of point symbols still exist: simplification of forms of symbols and their development (Fig. 4). Simplification leads to a certain geometrisation of a symbol, and development of the form – graphical improvement of a symbol, when exaggerated, leads to decrease of the symbol transparency. Geometrisation of point symbols seems to be the most useful in visualisation of man-made objects of symmetric, and often, regular shapes, such as wells, cylindrical tanks, chimneys, masts etc., as well as in visualisation of control network points, being the elements of surveying-and-cartographic constructions of maps. With respect to natural landscape elements, visualised by means of point symbols, such as a tree, scrubs, reeds, a stone, rocks, a spring, more developed media of meaning should be applied, of the more developed, asymmetric form, with the minimum utilisation of regular geometric figures.

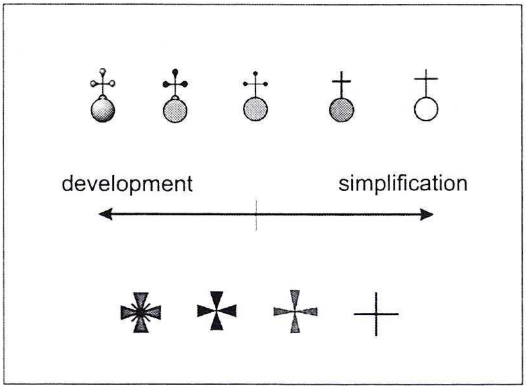


Fig. 4. Examples of development and simplification of graphical forms of symbols of a Christian church

Assurance of a proper interpretation of a symbol should be supported by its visual method [5], which is the derivative of the isomorphism of the symbol form. In the case of a topographic map, the visual method refers the shape and colours of symbols to physiognomic features of a visualised object, and designing of colour fillings and patterns of area symbols refers to the real form of those objects and their images on colour aerial photographs. It is incorrect to set the iconic nature of a symbol (often understood as image features) against its symbolic features, related to creation of associations of meanings. The iconic nature of the medium of meaning should be explained by a specific and required form generalisation, which presents a simple form of a symbol, in particular of a point symbol, which refers to the object physiognomy.

In order to achieve the proper perception of map information, following the map editor's intentions, its form should consider the rules of perception of graphical forms. In the process of image perception, the observer generalises and models information, what allows to remember and analyse a lot of information. Forms of cartographic symbols should be adapted to such perception of the map content, by means of visualisation – in the forms of symbols. Therefore, a symbol is a graphic model of an object, which easily leads a map user to realisation of that object, and – besides – to realisation of relations of that object with its neighbouring objects.

Selection of such values of graphical variables, which will guarantee the visual balance between all details visualised on a map, may be supported by:
- utilisation of harmonised colours for area symbols, of similar intensities (if they are not included in relations of arrangement),
- improvement of colour fillings of area symbols with patterns; for particular objects utilisation of tone patterns is also considered,
- minimising the number of symbols which are reproduced in black and application of small areas filled with that colour,
- visualisation of object edges (planimetric objects) in grey and elimination of contours of many area symbols of darker colours.

CONCLUSIONS

Independently on the final form, a map has the feature of durability of its content, which is performed by printing on durable materials, as well as by recording on mass storage media. Many graphical visualisations, which contain partial content of the graphical model, may be extracted from the topographic database; they may be also edited in another way – basing on the geometric model data or directly – on the database, with the use of Geographic Information System tools. They are such presentations, which may be the subject of further analyses or reproduction and which may be accessible as readouts from the computer operating memory. Therefore they are characterised by features of a momentary image. The topographic map, which is a complex map, is created according to the settled rules of editing (often settled by official bodies), which include patterns of symbols. However, many systems of topographic symbols may exist, which respect the laws of cartographic semiotics, methodology of visualisation and which are compliant with the proposed rules; so they should be considered correct. Automation of the map editing process enables simple modification of the map content, within the limits determined by the information content of the topographic database. This allows to obtain a map in many variations, dedicated to users of various expectations (a map for military purposes, a map for designers, for tourists etc.). Graphical presentation, which is developed by means of computer technology of a topographic map production, easily respects graphical changes, and every new visualisation may have the features of durability – after recording on the memory storage or after the process of reproduction.

The map form is always referred to cultural reality, with respect to both, temporal and spatial aspects. The temporal reality determines the development level of methods and technology, which may be applied for the map development; the spatial reality refers a map in the cultural context of the given society. The map graphics, similarly to other presentations, is a reflection of graphical culture of the society in which the map was developed; due to the growing influence it also plays a role of cultural development.

The system of cartographic symbols, referring to a properly classified set of topographic objects, may produce a certain added value, which is related to aesthetic impression felt by a map reader. The graphical composition of a map is able to stress that added value and to improve the form with a special spirit [4]. The form of topographic map symbols, as the material form of distinguished terms, is the result of creative process of analysis and research, as well as of utilisation of developed conventions, which respect the map aesthetics as its non-transferable value.

REFERENCES

[1] Chrobak T., *Badanie przydatności trójkąta elementarnego w komputerowej generalizacji kartograficznej.* AGH Uczelniane Wydawnictwa Naukowo-Dydaktyczne. Rozprawy, monografie, t. 84. Kraków, 1999.

[2] Forrest D., *Geographic Information: Its Nature, Classification and Cartographic Representation.* Cartographica, vol. 36 (1999).

[3] MacEachren A.M., *How Maps Work : representation, visualisation and design.* The Guilford Press, New York, 1995.

[4] Makowski A., *Artystyczne aspekty map topograficznych w świetle percepcji ich treści.* Polska kartografia map topograficznych, IX Szkoła Kartograficzna, Komorowo, 1994.

[5] Ostrowski W., *Zasady konstrukcji systemów znaków a praktyka kartograficzna.* Materiały IV Szkoły Kartograficznej, 1998.

[6] Saliszczew K.A. *Kartografia ogólna* (pod red. B. Horodyskiego), PWN Warszawa, 1998.

[7] Żyszkowska W., *Semiotyczne aspekty wizualizacji kartograficznej.* Studia Geograficzne LXXIII, Wyd. Uniwersytetu Wrocławskiego, 2000.

[8] *Instrukcja techniczna. Zasady redakcji mapy topograficznej w skali 1:50 000. Katalog znaków.* GUGiK 1998.

[9] *Instrukcja techniczna. Zasady redakcji mapy topograficznej w skali 1:10 000 – wzory znaków.* GUGiK Warszawa 1999.

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Metodyczne aspekty projektowania znaków map topograficznych

Streszczenie

Modelowanie obiektów rzeczywistości geograficznej, stanowiących geokomonenty, zasadza się na wyróżnieniu trzech składowych tych obiektów: geometrii, atrybutów i ich wartości. Uporządkowany zbiór elementarnych obiektów, zwanych tu topograficznymi, zawiera baza danych topograficznych, jako podstawowy komponent fizyczny systemu informacji topograficznej. Wizualizacja kartograficzna danych może odbywać się na trzech poziomach, związanych ze stopniem przetworzenia graficznego obrazu – od prezentacji danych nieprzetworzonych (szkieletowa), poprzez prezentację uproszczoną, do prezentacji pełnej, ukierunkowanej na spełniene wymogów percepcji wzrokowej. Przedmiotem zainteresowania jest tu poziom trzeci – prezentacja pełna, będąca najdalej przetworzonym obrazem mapy, powstającej wewnątrz systemu informacji topograficznej, jako modelu rzeczywistości. Przyjęto model znaku kartograficznego skonstruowany jako triada: nośnik, znaczenia, przdmiot, interpretant. Wskazano na rolę znaczenia, pozwalającego na poprawne odczytanie relacji semantycznych, pomiędzy nośnikiem znaczenia a obiektem rzeczywistości geograficznej. Znak kartograficzny składa się z dwóch zasadniczych typów elementów: konturów i wypełnień figur geometrycznych. W konstruowaniu znaku różnicowaniu podlegają atrybuty tych elementów, które określono jako komponenty graficzne znaku. Atrybuty te, zwane zmiennymi graficznymi, uporządkowano i scharakteryzowano na podstawie wyróżnień MacEachrena.

Rozłączność nośników znaczenia warunkuje jednoznaczność odbioru treści mapy. Elementarnym warunkiem poprawnej prezentacji jest więc nie nakładanie się zakresów pojęciowych wizualizowanych obiektów. Na etapie klasyfikacji treści bazy danych dokonuje się wyróżnienia atrybutów obiektów topograficznych. Następnie należy wskazać relacje, które tym cechom odpowiadają i ujawnić odpowiedni poziom pomiarowy wartości cech. Każdej z tych relacji (w sensie ontologicznym) przyporządkowuje się zmienną graficzną i stosuje się ją w odniesieniu do komponentów graficznych konkretnego znaku. Obiekty zapisane w bazie danych jako obszary (płaty płaszczyzny) mogą być prezentowane przez znaki powierzchniowe bądź punktowe. Redukcja wymiarów (również dla obiektów liniowych) może nastąpić na drodze uogólnienia strukturalnego lub w końcowym etapie prezentacji kartograficznej. Zestawiono własności nośników znaczenia, dzięki którym zagwarantowane będzie zachowanie tzw. szkieletu strukturalnego w prezentacjach graficznych. Pewien stopień uporządkowania odbioru grafiki mapy wprowadza pojęcie barwy nadrzędnej, przyporządkowanej kategoriom tematycznym poszczególnych geokomponentów. W artykule zawarto propozycję tych barw, wskazując jako najważniejsze odejście od prezentacji tzw. sytuacji w barwie czarnej. W zapewnieniu prawidłowej interpretacji znaku pomagać też powinna jego poglądowość, która jest pochodną izomorfizmu postaci. Przejawia się ona poprzez nawiązanie zmiennych graficznych komponentów znaku do fizjonomicznych cech obiektu, a także, zwłaszcza w odniesieniu do obiektów roślinnych, do rzeczywistego wyglądu tych obiektów na zdjęciach lotniczych. Sformułowano też wskazówki zapewniające taki dobór zmiennych graficznych, który zagwarantuje równowagę wizualną pomiędzy szczegółami prezentowanymi na mapie. Podreślając trwałość zapisu obrazu graficznego, a jednocześnie łatwość jego modyfikcji wskazano kierunki automatyzacji redakcji map topograficznych. Zaznaczono, iż mapa topograficzna, poprzez poprawnie skomponowany system znaków kartograficznych, ma poprawnie informować ale też ujawniać swoją estetykę.

Анджей Глажевски

Методические аспекты проектирования знаков топографических карт

Резюме

Моделирование объектов географической действительности, авляющихся геокомпонентами, основывается на выделении трёх составляющих этих объектов: геометриии, атрибутов и их величин. Упорядоченное множество элементарных объектов, называемых здесь топографическоми, содержит база топографических данных, как основной физичесий компонент системы топографической информации. Картографическая визуализация данных может происходить на трёх уровнях, связанных со степенью преобразования графичесого изображения – от предсравлемия необработанных данных (скелетная), через упрощенное представление, к полному представлению, направленному на выполнение требований зрительной перцепции. Предметом заинтересованности является здесь третий уровень – полное представление, являющееця наиболее преобразованным изображением карты, создаваемой внутри системы топографичесой информации, как модели действительности. Принята модель картографического знака, сконструированная как триада: носитель значения, предмет, интерпретатор. Указано на роль значения, разрешающего правильно читать сематичесие реляции между носителями значения и объектами географической действительности. Картографический знак состоит из двух основных типов элементов; контуров и заполнений геометрических фигур. При конструировании знака дифференцированию подлежат атрибуты тех элементов, которые определены как графические компоненты знака. Эти атрибуты, называемые графическими переменными, упорядочено и охарактеризовано на основе дискриминантов MacEachrena.

Рассоединение носителей значения обуславливает однозначность восприятия содержания карты. Элементарным условием правильного изображения является, таким образом, не перекрытие предело понятия визуализированных объектов. На этапе классифиации содержания базы данных происходит выделение атрибутов топографических объектов. Затем следует указать реляции, которые этим чертам (свойствам) соответствуют, и выявить соответственный измерительный уровень значения черт. К каждой из этих реляций (в онтологическом смысле) подгоняется графическя переменная и применяется она по отношению к графическим компонентам конкретного знака. Объекты, записанные в базе данных как пространство (часть плоскости), могут быть представлены площадными или точечными знаками. Редукция размеров (таже для линейных объетов) может произойти путём структурного обобщения или на заключительном этаппе картографического представления. Составлены свойства носителей значения, благодаря которым будет гарантировано сохранение т. н. структурного скелета на графичесих изображениях. Некоторую степень упорядочивания приёма графии карты вводит понятие главенствующего цвета, подчинённого тематичесим категориям отдельных геокомпонентов. В статье изложены предложения таких цветов, указывая в качестве самого важного отход от представления, так называемой, ситуации в чёрном цвете. В обеспечении правильной интерпретации знака помогать должна также его наглядность, которая является производной изоморфизма формы. Проявляется она путём привязки графических переменных компонентов знака к физиономическим чертам объекта, а также, особенно в отношении растительных объектов, к действительному биду этих объектов на аэроснимках. Сформулированы указания, обеспечивающие такой подбор графических переменных, которые гарантируют визуальное равновесие между деталями, представляемыми на карте. Подчёркивая стабильность записи графического изображения, а одновременно и легкость её модификации, указаны направления автоматизации редактирования топографических карт. Подчёркую, что топографическя карта путём исправно компонированной системы картографических знаков должна правилно информировать, а также проявлять свою эстетику.