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GENERAL PROCEDURE OF THEMATIC MAP PRODUCTION USING GIS TECHNOLOGY

Vladimir KOVARIK[1] and Vaclav TALHOFER[2]

SUMMARY: The paper deals with a general procedure of thematic map production and focuses on using GIS technology. It defines thematic maps as one of important geographic products within geospatial support and compares them with with other types of geographic products. Application of general principles of thematic map production for web technologies is mentioned. The paper presents the standard procedure of thematic map production from a customer requirement to creation of a cartographic project. Then a scheme of thematic map production using GIS technology is presented and the fundamental steps are described in a detail: data preparation, data model creation, cartographic design, map layout, quality control, print and dissemination. Although the cartographic principles and rules are general, they should be respected during production of each map, including the thematic map produced using sophisticated software tools. Specifics of thematic map production in military domain are emphasized and also the copyright issues are mentioned.

Keywords: thematic maps, geographic information systems, cartographic project, cartographic design, map layout, adaptive cartography

Introduction

Despite the predictions that with the technological expansion the printed maps will become obsolete, those are still indispensable within geospatial support and they supplement the digital geospatial products. However, the process of their creation is digital nowadays. There are many types of maps and geospatial products participating in geospatial support and thematic maps belong to absolutely essential products.

The standard procedure of map production has evolved over the years and was transformed to a general scheme that is presented in the paper. Presenting these products on the internet brings possibility of applying the adaptive cartography and new ways of creating of thematic visualizations, but there are certain specifics of the web environment that are mentioned in the paper.

Thematic maps

Like other maps, thematic maps are composed of standard content elements such as mathematical elements, geographic elements, socioeconomic elements, and auxiliary and additional elements [1]. Mathematical elements represent a design basis of a map and they include projection, map scale, grids, map frame, etc. Geographic elements define geographic components of the landscape, such as hydrosphere, atmosphere, biosphere, pedosphere, and

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so on. Socioeconomic elements define socioeconomic components of the landscape, such as settlements, transportation lines, borders, etc. And finally auxiliary and additional elements supplement the map content with items such as map lettering, composition elements, and so on.

Specific feature of the thematic maps is their content and purpose variety; and graphical and scale diversity [2]. Unlike topographic maps, whose content is composed of planimetry and hypsography, the content of thematic maps comprises topographic background and thematic content. The topographic background is used for spatial localization of the individual elements of the thematic content. The thematic content is then a complex of elements of a map content forming a theme to be mapped.

Production of thematic maps is not a simple or a straightforward mechanical process. Although it is possible to set the rules and provide the sophisticated tools, the thematic maps are generated through the creative process in which the experience and skills of a cartographer/mapmaker are of a great importance. There are certain principles that should be respected during the process, otherwise the maps might be degraded to pictures only looking like maps.

Basic requirement for the maps that are produced within geospatial support (and for all the maps in general) is fulfilling their purpose. This is achieved only in case that the requirements of practice (i.e. the customers or users) are fulfilled [2].

The general principles of the production of thematic maps can be also applied for thematic visualizations within web services. Unlike printed thematic maps the web technologies can have their content defined exactly according to specific user requirements. Also the map content can be modified with respect to the circumstances under which the thematic visualization is used. The sum of all the circumstances (time, user role, day or night time, etc.) is called a context. Using the context the thematic content of a map can be precisely modified with the help of adaptive cartography, i.e. by selection of map symbols and their colour. The prerequisite of this solution is the creation of high-quality data and communication infrastructure. In principle, it is possible to use the data and communication scheme such as the NATO CoreGIS project, which could be complemented by appropriate modules for controlling the process of adaptation of the thematic content of geospatial data visualization and information employed in the command and control systems.

Technology of thematic map production

Standard procedure

Over the years the standard procedure of map production has evolved and it was common for all the map types. This procedure was published already in the 1970's by Lauermann and it was copied by many authors since then. It started with customer requirements for a map title, map purpose, geographic extent, map content, formal map arrangements, and so on. Then these requirements had to be clarified by the mapmaker (or the mapmaking organization) in order to refine specification of a thematic focus, map scale, cartographic projection, map frame and a structure of map series, draft of a map content, draft of a symbol set, etc. After that the cartographic project was elaborated into the detailed technical project laying out the detailed specification of individual steps within the whole technology. And then the production of the map could finally start.

The cartographic principles and rules are general and should be respected during production of each map. They describe the ways of selecting the elements of the map content; their classification and visualization; their relation to the topographic background; the ways of

generalization; requirements for the map layout and its fundamental elements; requirements for a legend; etc.

It is important to consider that this applies also for production of thematic maps based on digital technologies. These technologies allow producing maps very easily virtually to anyone which leads to enormous amount of poor maps that we see in our daily life.

GIS technology

There are basically two possible ways of the thematic map production using digital technologies: the technology employing various tools of geographic information systems (GIS) and the method using so-called desktop publishing (DTP) applications. Only the former will be presented in more detail in this paper.

Let us consider that the phase of clarification of customer's requirement has been completed and also the cartographic project has been created. The cartographic project describes the product to be created in detail by specifying issues such as main theme, title, scale, projection, map content, composition, symbol sets and so on.

Then we can focus on a process of map creation using the GIS technology. Various authors see this process differently. For example Voženílek [3] suggests the following steps: data collection and analysis; design; layout output; evaluation and validation; layout confirmation; manufacture; test and duplication. Kraak and Ormeling [4] present the scheme comprising the five steps: setting map objectives and specifications; data collection and combination; creating the map image; adapting the map to the medium; dissemination. Robinson et al. [5] focus solely on the design process and it contains only three steps: graphic ideation; specific graphic plan; and detailed specifications. The individual steps of a procedure presented by Slocum et al. [6] are relatively broad: consideration of the phenomenon real-world distribution; determination of the map purpose and its intended audience; data collection; design and construction of the map; and receiving the user feedback.

As it can be seen, all the abovementioned procedures overlap only partially. The reason is that the authors do not focus on the same part of the thematic map production problem. Considering the standard procedure, recent solutions and the specifics of the GIS technology, the general scheme of the thematic map production technology can be created (see Figure 1). The technology comprises the following steps:

- data preparation
- data model creation
- cartographic design
- map layout
- quality control
- print
- dissemination

Data preparation. This step represents the data collection and its analysis, sometimes also creation of new data. According to the customer requirements and the type of the map that will be created, the suitable data should be collected. Basically, it is geospatial data, imagery, and thematic information. Geospatial data can be collected from the existing geographic products, either digital or printed; from geospatial databases; or from the internet. Imagery can be used as a topographic background or it can serve as a source of newly created data through ditizing. Finally, the thematic information is often provided by a customer. If not, it has to be collected from other sources. When collecting data it is important to assess its accuracy, completness, currency, a level of detail, utilization efficiency, etc. [7]

Data model creation. Through creation of a data model the geometric base of a map is set. The map projection, coordinate system, map scale and data layers are determined. If the data model is set properly it makes easy to generate not only other editions of the same thematic map but also various variations and similar products without necessity to start that "from scratch".

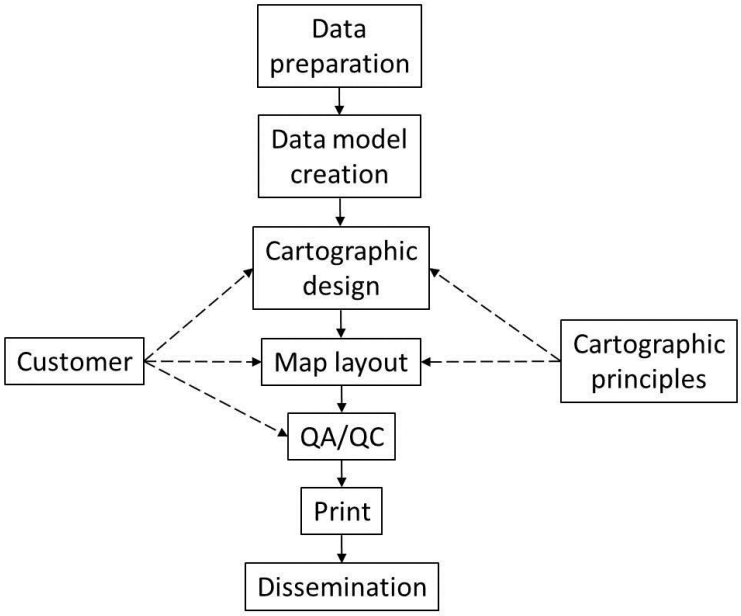

Figure 1. The general scheme of the thematic map production technology

Cartographic design. The main goal of cartographic design is to communicate the information in the map in the most efficient manner, with simplicity and clarity. Using the data model the concrete content of the thematic map is created within this step. Both the topographic background and the thematic content are built by particular map layers. They can be formed by vector data, raster data, or imagery. Layers of the topographic background contain all the necessary features for localization of the thematic content which forms a key part of the thematic map. The thematic content is set up accordingly to the map purpose and function defined by a customer [8]. Definition of the symbol sets for individual layers is a very important task within this step. Due to the fact that some thematic information can possess fairly different characteristics of accuracy and even different characteristics of reliability, this information should be vizualized using the tools that are able to express the uncertainty [9].

Map layout. Creating a map layout is the most complicated step of the process. Although a technical part of the process (i.e. placing, arranging and modifying map elements) is made easy by sophisticated tools provided by GIS applications, there is a number of cartographic principles that should be respected. All the basic and additional map elements, such as a map frame, title, scale, legend, marginalia, insets, etc., are created in this step. And they must be in a balance to provide aesthetically comfortable conditions for reading the map.

Quality control. Quality assurance and quality control is (or should be, at least) an essential part of any production process. Before printing and delivering the product a thorough quality control should be performed. All the elements of a map should be revised and a map proof should be printed.

Print. The content of this step is driven completely by the customer requirements. The map can be printed applying various printing techniques which would also depend on a number of copies requested. The map can be also produced in other forms rather than in a printed one, i.e. in a digital form. This would require other operations such as transformations, export and adapting to the final format.

Dissemination. The final step of the map production technology. Delivering the map in a printed or electronic form.

As already mentioned, cartographic principles affect cartographic design and map layout. Legibility, visual contrast, figure-ground organization, or legend generalization are the examples of the themes that are important for consideration during the thematic map production. Respecting these rules ensures that the result of a production is a good map even in cases when the customer has no idea how a proper map looks like.

A close cooperation with a customer is essential. The most important point is in the beginning of the process. Unless the customer's requirement is thoroughly clarified there is always a risk that the customer will not be satisfied with a product. In order to minimize the risk, it is also important to consult and review intermediate results of a design and map layout with a customer and to receive his or her approval. Prior to a final export and print of the product the customer should give his or her definitive approval.

Producing thematic maps using the technology presented here requires sufficient time. However, there are specific situations, e.g. during military operations, where the lack of time and suitable sources do not allow to apply this technology as it is. In such cases the technology must be adapted and simplified in order to provide a customer with a product exactly as required and, perhaps more importantly, when required.

Specifics of the web technology

When the thematic maps are published on web it is important to select the way of displaying the thematic information. The aim of this step is to minimize the amount of information serving solely for localizing the thematic features and for basic orientation in the particular space from which the map is created. On the other hand, the aim is to maximize the amount of thematic information being the subject of the thematic map. It is also appropriate to consider the way of making decisions by the commanders and staffs for which the thematic maps are created within the geospatial support.

For obtaining a quick and clear information concerning for example basic characteristics of the area of interest with respect to a particular problem it is possible to generate the synthetic maps (e.g. the cross-country movement map) in which certain complex characteristics are classified using a particular scale and depicted using areal methods. For example, the synthetic cross-country movement map can synthesize information about the relief, natural and man-made obstacles, soils, weather conditions, and so on. It is possible to add also operational information such as prohibited areas, dangerous areas, etc. The example of the synthetic map is in the Figure 2.

When the commander or staff needs a more detailed information concerning the individual features and phenomena, or their groups, that affect the overall situation, it is possible to create analytical or complex maps. For example, the analytical map can show the relief slopes or a drainage passability for various vehicle types [10]. A complex map can show the choke points in the build-up areas.

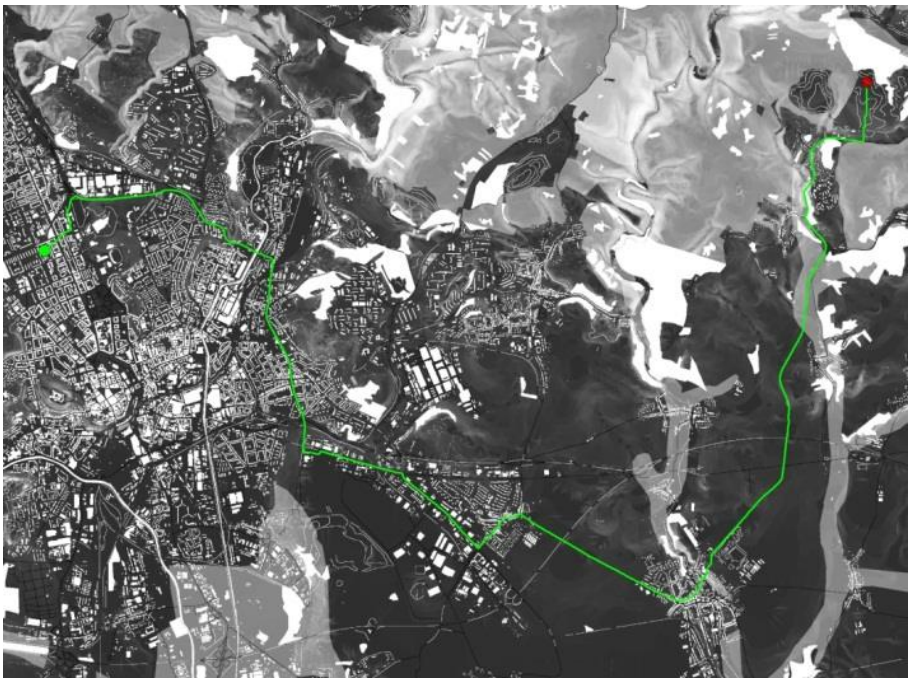

Figure 2. The example of a synthetic thematic map - the cost map.

The prerequisite of application of the general GIS scheme is the existence of procedures for generating particular map types. These procedures can be created using the GIS tools, such as the ArcGIS ModelBuilder or the ERDAS IMAGINE Model Maker. The advantage of these models lies in standardizing of both analytical and synthetic procedures and in possibility of creation of parametric methods.

For all the types of thematic maps, it is necessary to select proper means of expression that are user-friendly and using cognitive styles with a high-level association. The content of the synthetic maps should be depicted in a clear and distinct style. For the maps having the three basic classes - YES, NO, POSSIBLE, the three basic colours are recommended - green, red, orange. For the maps with the bigger colour scale to depict synthetic information it is appropriate to use different tones of one colour (e.g. dark tones for non-suitable locations, light tones for suitable locations) or different colours that are adjacent in the colour spectrum.

The analytical and complex maps should employ either the symbols standardized in the command and control systems or adapted generally known symbols, such as enlarged symbols of the topographic maps.

All the symbols and their parameters can be stored in the symbol databases from where they can be selected either automatically or manually. Also the process of assigning of the parameters can be either automated or manual.

Copyright issues

Using the existing geographic product as a topographic background or using existing data for creating a new product without a written approval of the author or the owner of the rights represents breaching the law. Even if a correct citation of the source or a reference is applied, this does not justify such misusing of the product of someone else. The absence of the copyright on the original product does not mean that the product is not protected in a sense of the intellectual property. These are the examples of a clear violation of the copyright: use of a

subset of existing map, adaptation of the original product, alteration of the original product, digitization of aerial or satellite imagery, etc. Free use of a cartographic product or geospatial data is allowed for personal purposes only [11].

As a precaution, in some cases certain inaccuracies, deliberate errors, or fictitious features are placed into the geospatial data and products by their producers. If necessary, these signatures might be used for justification of a property in case of a legal dispute.

However, it is honest to admit that fulfilling these requirements is not always easy, especially in certain non-standard situations such as during military operations or in command structures of NATO and EU, when responding to the customer request in a near real-time is of a highest priority [12].

Conclusion

The methods of thematic cartography that are employed in the GIS environment are proving to be very efficient tools to cope with a problem of a big amount of information entering the command and control processes. These methods allow sorting and classifying of information and their filtering so that only the information necessary for decision making are processed in a given time and for a given purpose. The cartographers and GIS specialists are more than in the past ready to create thematic maps and thematic visualizations on request and in a short time. To perform such operations it is necessary to have both the adequate database and operating procedures for generating particular thematic maps and thematic visualizations.

The aim of this paper was to partially generalize the procedures of thematic map and thematic visualization production and to show the trends of thematic cartography in the command and control systems.

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