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Use of image data in rapid mapping

Józef Sanecki[1], Andrzej Klewski[1], Grzegorz Stępień[1], Krzysztof Beczkowski[1]
Robert W. Bauer[2]

[1] Maritime University of Szczecin
70-500 Szczecin, ul. Wały Chrobrego 1–2
[2] Military Geographic Center

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Abstract
The topic of the publication is the presentation of the method of rapid mapping performation. Rapid mapping are performed in special situations, if a terrain is subjected to significant changes or a quick human reaction is needed. Such performation can be available both in paper and digital versions, published on on-line websites – depending on the needs. For rapid mapping almost every type of image data can be used. In rapid mapping different editorial rules are applicable, it is acceptable to make imaging legible with materials of much less detail. A scale of the design is determined based on the interpretation possibilities, and not on the base of predetermined resolution of the design.

Introduction

Rapid mapping issues mostly concern an urgent necessity to monitor a terrain where dynamic changes were noticed. The changes may refer to natural disasters, terrorist activities or have an anthropogenic nature. Standard cartographic designs do not include this dynamics, because they are developed in a long-term data evaluation process. Mainly, data is collected and saved in spatial databases. Those bases, especially vector data, accurately reflect object's location in the terrain and are a good source for geospatial analysis. A map printed from such topographic (vector) database will not meet many of cartographic editorial requirements. This is why separate cartographic databases are created, based on which the editorial is performed. For the above reasons, when it is necessary to quickly develop an analog map, we get most often a print-out of a topographic database or a print-out of a cartographic database. However, things get complicated, if there are no such data available for an analysed terrain.

In exceptional situations, an alternative for the above procedure is to perform a fast cartographic design, including necessary vector layers where a base layer is image data. The image data can be obtained from various sensors or can be processed in a simplified method, for example without an orthorectification. In the following publication, the aim of the authors is to develop methods to create such type of special designs. In this paper will be presented their sources, design methods and situations, in which they are useful.

Rapid mapping issues

An implementation of the purpose set in the introduction requires an answer to the problems of research developed in the following questions:

1. What is the rapid mapping? What is their nature, and when are they useful?
2. What kind of image data are used in special cartographic designs?
3. How can be used and processed image data to the rapid mapping?

An answer for the first two questions will allow to understand the issue. Whereas, their mutual connection will lead to building a methodology for image data development, in special situations where time is the main limitation. Such proceeding will

allow to propose a method of solving the above problems what will result in realization of the assumed purpose.

Rapid mapping – image maps

Rapid mapping are performed in special situations, if a terrain is subjected to significant changes or a quick human reaction is needed. Such designs can be available both in paper and digital versions, published on websites – depending on the needs. In the following publication, the rapid mapping are considered as a subset of special cartographic designs. Special designs, that use image data, are created in special situations, such as floods, fires, antiterrorist activities, critical infrastructure analysis. They also have a documentary nature, especially when the analysed terrain has no large-scale maps, or they are outdated (example in Fig. 1).

Another factor determining the use of image data are the limitations in access to a terrain. The situation takes place when the access to a terrain is difficult or impossible, and changes' dynamics makes it impossible to show a current terrain's data picture without gaining any additional data. Then, the best solutions are remote gaining data techniques from air photos or satellites imageries and they become the main information source with a map nature. Usually, the obtained data are subjected to various geometric and radiometric corrections, such as orthorectification, georeferencing or strengthening the information content of images. Common results of such processes are hybrid designs – image maps. Image maps are developed on the base of imaging gained after the changes. In this way, the current status, which is a base information when preparing for repair or rescue activities, is presented. Rapid mapping are found useful in operational activities areas where the main factor limiting their performance, additionally to poor access to a terrain, is time. In extreme situations, there are only single hours to develop the product. Therefore, image maps are increasingly used in areas of humanitarian actions and military missions [2]. A genesis for this is a timeliness of such type of designs, short time necessary to perform them, and lack of large-scale and current maps of an analysed terrain (disasters). For this reasons, image maps are the primary source of operational data for military units located in areas covered by military activities. These solutions are getting common not only in armies of NATO but also in geospatial units of UN (UNITAR) and EU (CS, EU).

According to Bauer, Piotrowski, Stepień [2] when creating rapid mapping (image maps) for operational purposes, an important fact is that the particular design is dedicated only for particular purposes and in particular time. This results, inter alia, from a limited accuracy of the object's location in this type of designs. The maps are not desig-

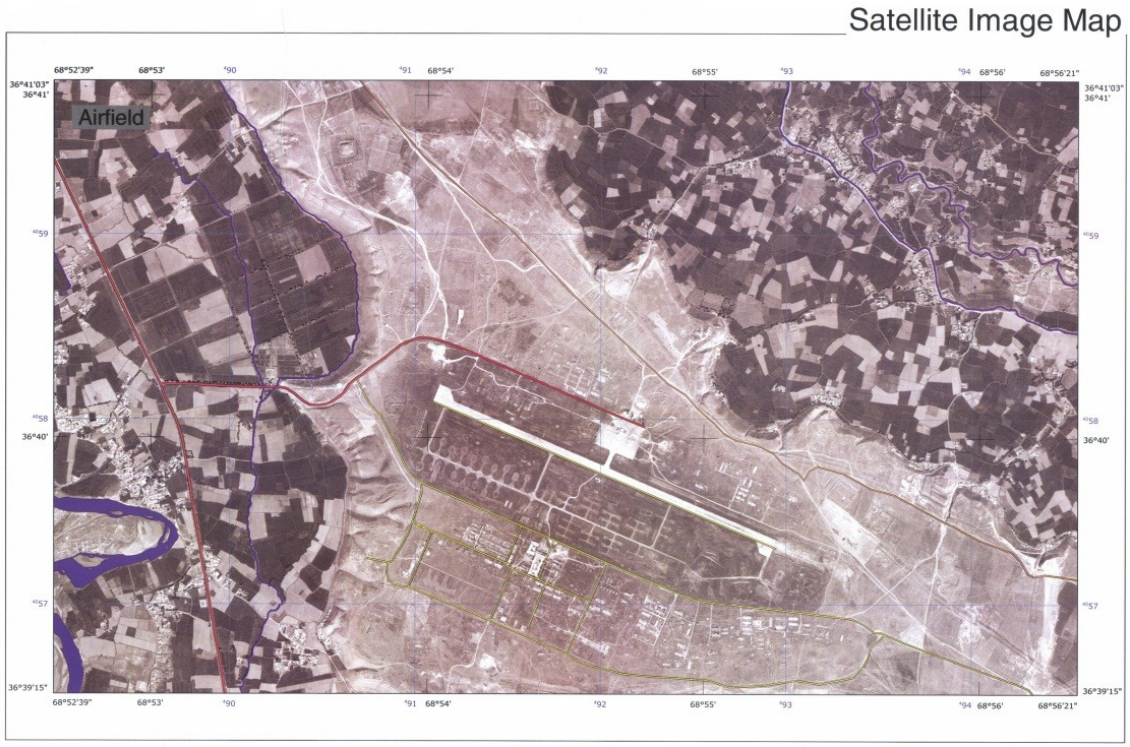

Fig. 1. Image map (fragment), imaged in 1:10 000 scale [1]

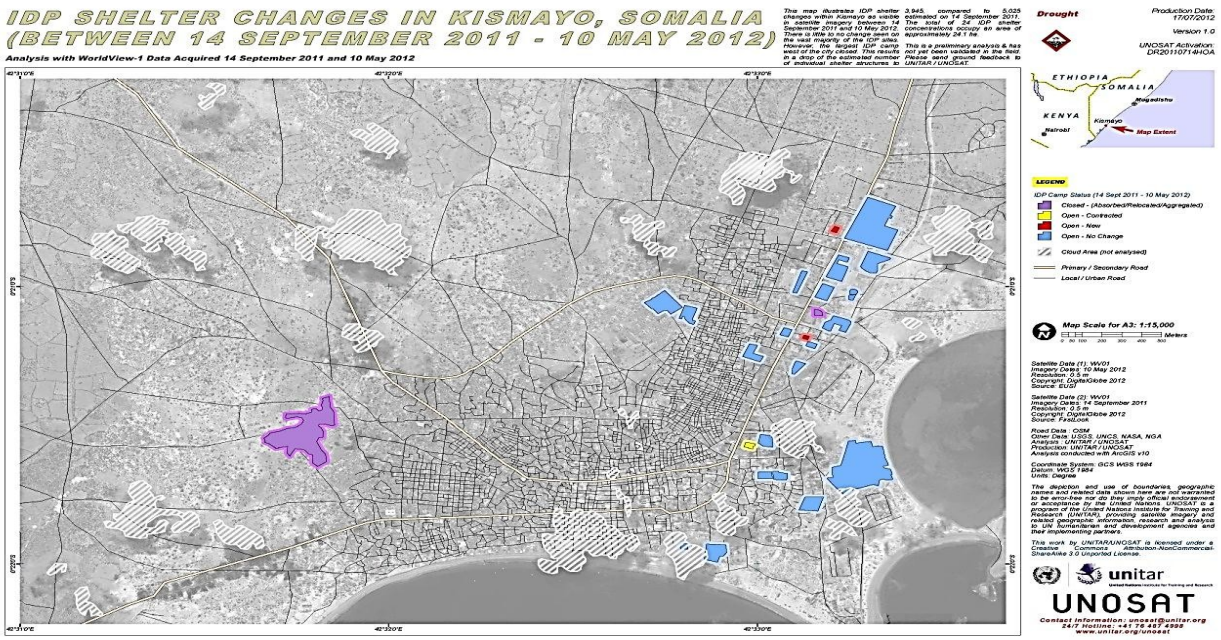

Fig. 2. Map of changes in shelters and camps arrangement (source: http://www.unitar.org/unosat/node/44/1661, as of 24/06/2012)

nated for an accurate navigation, and on the sheet there is an appropriate warning regarding the restrictions on the use of the design.

Image data sources

The rapid mapping can be used almost every type of image data, assuming that their source are:

- high-resolution satellite imaging systems;
- UAS – Unmanned Aerial System;
- aerial photos;
- non-metric photos, including photos from commercial digital photo-cameras, as well as
- various types of cameras (including television camera).

Additional sources are image data gained in various ranges of electromagnetic radiation, e.g. radiolocation range (radar images) as well as data acquired from a number of spectral channels, such as hyperspectral images. All of these depend on a purpose of the design developed, and consequently on expected photo interpretation properties and an indicating objects localization accuracy. Photo interpretation properties are rather connected with the analytical aspect of the image selection. Therefore, geometric accuracy is important for precise navigation but according to the authors of this study, has no direct meaning for an operational use of image maps in the field. At first, the accuracy is not the most important. Perhaps more important is a very accurate indication of the image with low resolution radiometric where the objects are not visible? Or perhaps, more important is the location of the mitigation requirements of precision. Such a situation takes place when we use satellite images. Images obtained with those systems are characterized by a high radiometric resolution what allows a better interpretation of the objects compared to conventional air photos, and a slightly less precise object's location indication, compared to conventional air photos. According to Klewski, Sanecki, Stępień [3] when using an orthophotomap for operational purposes, a precious object's location indication at the level of 10 m which is approximately coincident with accuracy of manual satellite navigation receivers, is sufficient. Simultaneously, Kurczyński, Wolniewicz [4] seem to confirm that the factors limiting the usefulness of satellite images are not their high measurement properties, but limited possibilities for interpretation. At the same time, in the opinion of the authors of the following study, low precise object's localization indication on the satellite images does not disqualify a measurement potential of those images. Neither the width of the road, water tank, the building will not change but the absolute position in space will be. However, this will still allow a precise analysis and assessment of an infrastructures and the problem may be relevant when in case of using this picture to update topographic maps. Still, an image map is an independent special design and in fast cartographic designs the problem of high accuracy of the absolute location of objects does not affect their operational use.

Additionally, the image data can be a primary source of information on a map, or be it a valuable

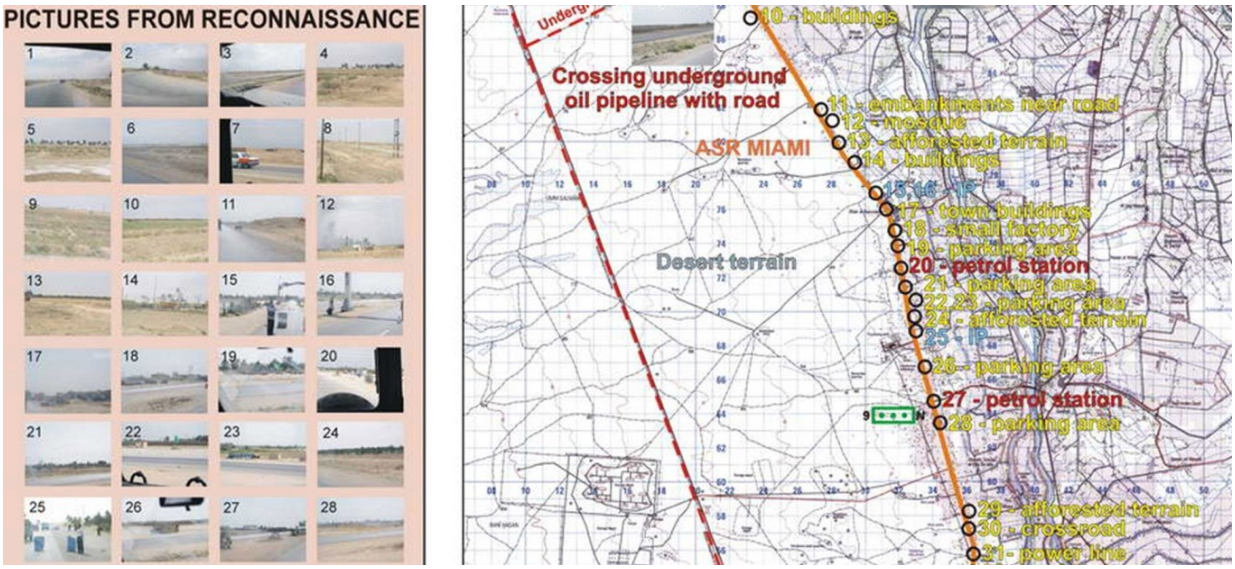

Fig. 3. Description of the road, and photos of dangerous places

addition. Such situation is presented in figure 3 where the photos are additional information layers of a special cartographic design.

Methodology for use of image data

A methodology for use of image data in rapid mapping was designed in accordance with the scheme in figure 4.

The first issue is to obtain the task that is a result of the occurrence of a specific problem which shows the method illustrated in figure 4. Another issue is to assess the situation and calculate time. Base on this, an information range of the design and its interpretation purpose are developed. Both issues are connected with expectations with respect to the final cartographic product. An information range depends to information, that should be supplied and its accuracy level (information resolution). Detail affects the interpretation purpose of the design. Another data type will be possible to gain from an image with a resolution of 0.4 m than from an image with a resolution of 1 m. Similarly, in the case of radiometric and spectral resolution of imaging which regarding the scope of information are critical here. The next issue will be to determine the system sources of supply. This element is a variable resultant of possessed time to develop the product, possibilities of obtaining the data and an assessment of own data resources. In case of having too many data sets, it is useful to catalogue them in spatial databases combined with graphic visualization on indexes. Base on such calculation the data is obtained and processed.

Another important issue is to determine the editorial rules. If there is only a little time (i.e. dozen

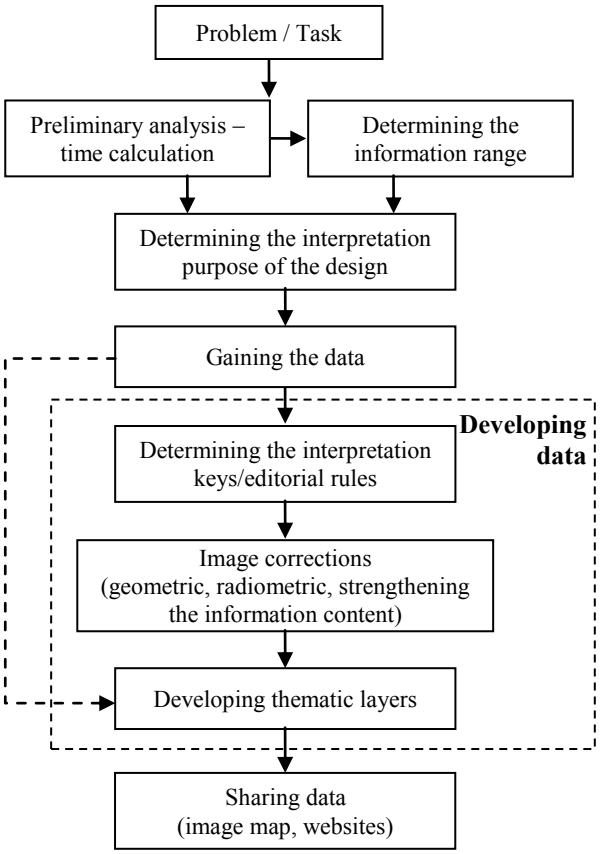

Fig. 4. Method for creating fast cartographic designs using image data

hours), the rules should be maximally simplified. For operational use, it is acceptable to combine data of various resolution by making an orthophotomap legible from vector databases with a much lower information resolution. The rules are simplified, and sometimes inverted, i.e. opposite than in standard topographic map designs. Further issues are

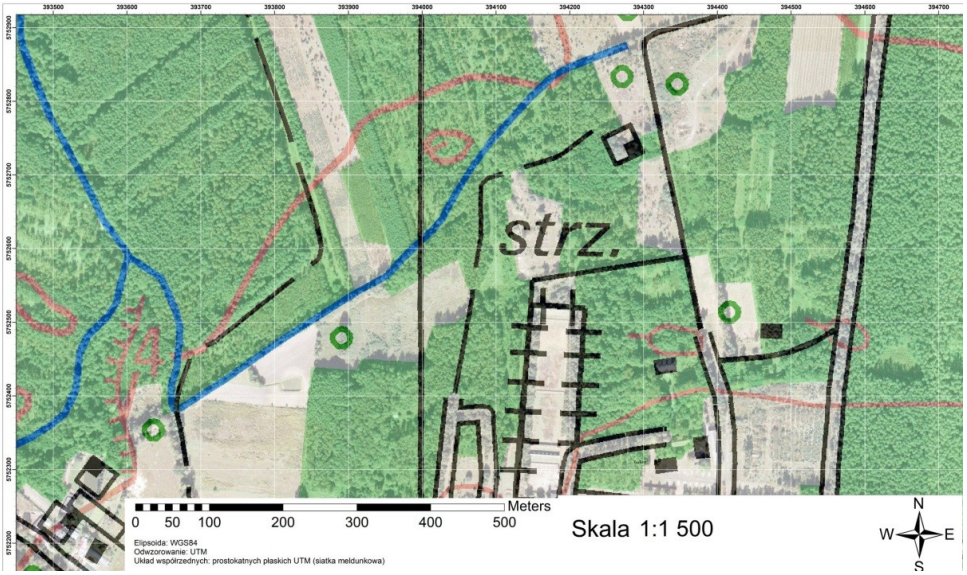

Fig. 5. Fast cartographic designs – example

geometric and radiometric corrections and strengthening the information content of images. All this issues can be simplified, even omitted in extreme situations. The most important issue in this set of processing is georeference. If time necessary to develop data is very short, or there is no Digital Terrain Model, the photo-map can be developed in a central plan view (central-orthogonal), on a non-othorectified image. Such proceeding, in extreme situations, is acceptable in NATO.

Developing thematic layers can be a result of importing data from diffuse sources, such as spatial databases or their independent development. Another issue is to share the data. Sharing is possible in two forms – digital or analogue. In case of publishing data on websites, as access from different world regions, will be possible. This can be useful in situations of natural disasters and the destruction of critical infrastructure (roads, bridges, energy networks). A fast data development will allow engineers, regardless of their place of residence, to familiarize with the scale of the problem and to develop immediate solutions. If it is necessary to take a map or provide it in a paper versions, a determination of scale of a resultant design will be necessary. In case of special designs this scale is given by Klewski, Sanecki and Stępień [3] based on the empirical coefficient (*d*) developed by both authors.

Table 1. Determining a scale of cartographic designs in dependence to the image type (sensor) [3]

Image type (sensor) / spatial resolution [m]	Empirical coefficient *d*	Maximum scale	Optimum scale	Minimum scale
Ikonos/1	1.8	1/1,800	1/3,500	1/7,500 – 1/10,000
Quick Bird/0.6	1.5	1/1,000	1/2,000	1/7,500 – 1/10,000
Word View-2/0.5	1.5	1/800	1/1,750	1/7,500 – 1/10,000
Quick Bird/2.4	1.2	1/3,000	1/5,000	1/7,500 – 1/10,000

In figure 5 an example of a fast cartographic design, created base on an orthophotomap with a spatial resolution of 0.5 m and radiometric resolution of 8 bits, is presented. The image was made legible base on the vector data with an information resolution of 1/25,000–1/50,000. Time of preparing the design, including a printout assuming having a database and an ortho-image, is 2–4 hours.

Conclusions

Creating the rapid mapping is useful in special situations, when time limit is the critical factor that determines the design. Maps of this kind are created in a situation of urgent operational need when a quick reaction is necessary and an access to the terrain is difficult. All of those cause that the image data became a basic material with a map nature in this kind of situations. In rapid mapping different editorial rules are applicable – for example, it is acceptable to make imaging legible with materials of much less detail. The scale of the design is determined, based on the possibilities of interpretation and not on the basis of a predetermined resolution design. All of this dictated by the need to gather the maximum data set, usually in minimum time. In case of multichannel connected information image or using non-ortho-rectified imaging, the proper name for such types of products is Area Image.

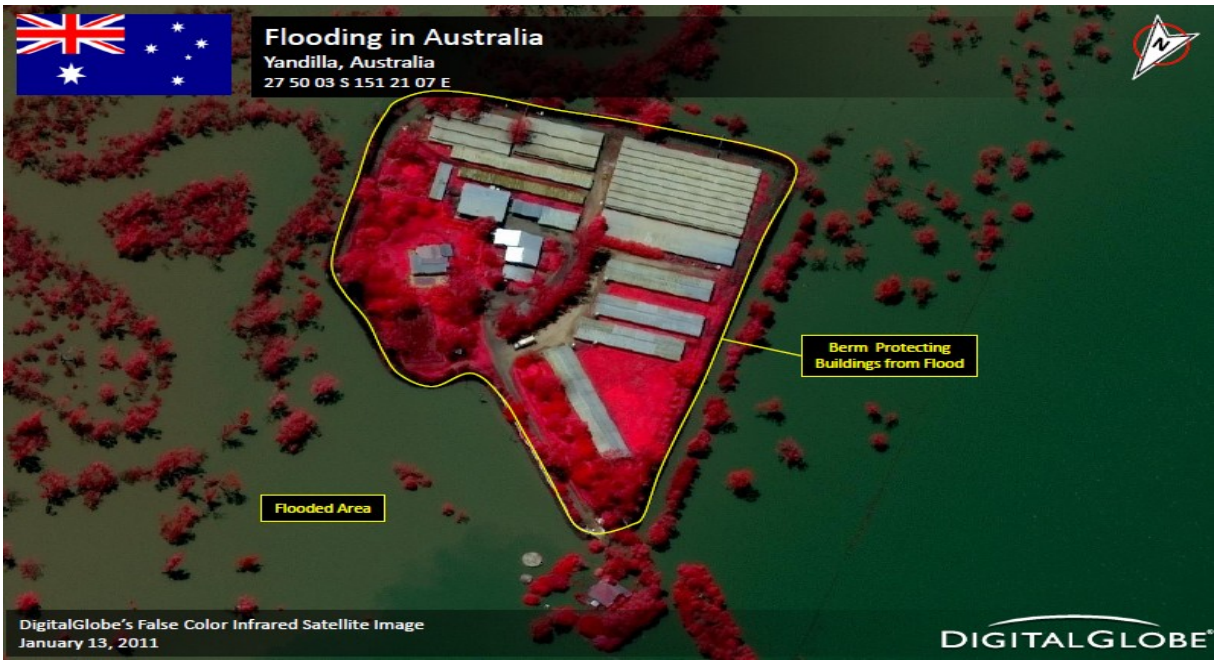

Fig. 6. Image map of flood in Australia – no coordinate grid in the document (source: http://www.digitalglobe.com – as of 15/03/2013)

This product is not a real map but it could be. It is some kind of a cartographic design with basic identification functions. An increasing number of incidents and their dynamics, causes that rapid mapping, usually in a form of image maps, are created by specialized geospatial units of NATO, EU and UN. Mainly, these designs cover areas which do not have large-scale maps and additionally current data is necessary. It can be assumed, that the number of those designs will increase systematically and limiting the time will influence cartometric parameters of the image or change the editorial rules of a map design. Additionally, it seems that a tendency to focus on the user and its purpose intensifies. At the same time, an availability of additional information sources which are combined into one environmental operational image, is increasing. All this causes that a dissemination of special cartographic designs should be expected in a short time.

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