CARTOGRAPHIC PRINCIPLES FOR STANDARDIZED CARTOGRAPHIC VISUALIZATION FOR CRISIS MANAGEMENT COMMUNITY

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Abstract
In the Czech Republic, Integrated Rescue System (IRS) is coordinated by regional emergency centres. Operators of these centres use the geographic information system for spatial analysis and visualization of the situation. It is obvious that the used cartographic visualization (colours, cartographic signs, etc.) should be unified in the whole Czech Republic to assure effective communication and organisation of emergency response – especially in a case of large disaster where IRS units from several regions need to be coordinated. The project "Geoinformatics as an instrument to support integrated emergency and rescue operations of state" aimed to develop a methodology of unified cartographic symbology for IRS. It consists of the recommended basic principles for the construction and definition of a symbol set, scaling range and standardized description of individual symbols to be used for maps in the analogue and digital forms. The presented paper describes the basics of the aforementioned methodology and experience retrieved during the IRS practice ZÓNA 2015, where the proposed cartographic visualization rules were used.

Keywords: *integrated rescue system, 112, cartographic symbology, methodology*

INTRODUCTION

Nowadays, geoinformation technologies are more and more often used in various human activities. Therefore, they naturally more frequently appear in areas where the analogue approaches, in the form of paper maps, have dominated. Crisis management is no different.

In the Czech Republic, emergency response is coordinated by regional emergency centres that deal with various emergency situations occurring in their part of the country. In addition, the operators of these centres use the geographic information system for spatial analysis and visualization of situation. In a case of any emergency situation or incident the regional emergency centre is alerted through a 112 emergency phone call (similar to 911 emergency calls in the USA). The operator in a regional centre mobilizes the required emergency service: fire brigade, police, or ambulance, which together form the basic parts of the integrated rescue system (IRS). Organisation of the Integrated Rescue System (IRS) in the Czech Republic is described in detail e. g. in Kubicek and Stanek (2006).

During most of the local incidents each IRS part works independently, although they communicate to each other at the incident spot. It is obvious that the used cartographic visualization (colours, cartographic symbols, etc.) should be unified in the whole Czech Republic to assure effective communication and organisation of emergency response – especially regarding regional or larger disasters where all IRS units from two or more regions must cooperate.

Modern technologies allow faster and more efficient communication. On the other hand, introducing technologies brings drawbacks, e.g. energy dependence, when the designed system may be affected by a blackout putting its operation in danger. The field of crisis management is very sensitive in this respect, since its systems must particularly be active in cases of crisis situations, when energy supplies are cut and other system fail. Therefore, it is necessary in the field of crisis management to take into account of all back up variants, including the potential of traditional use of paper map version and keeping manual marking of designed symbols.

The project "Geoinformatics, as an instrument to support integrated security and rescue operations of state" aimed to develop a methodology of unified cartographic symbology for IRS. The produced methodological guidelines (Stachon et al. 2015a) are primarily intended for authors and users of cartographic visualizations across the crisis management community. It consists of the recommended basic principles for the construction and definition of a symbol set, scaling range and standardized description of individual symbols to be used for maps both in the analogue and digital forms. The presented paper describes the basics of the aforementioned methodology and experience retrieved during the IRS practice ZÓNA (Czech word for "zone") 2015, where the proposed cartographic visualization rules were used.

THE EXISTING SYMBOL SETS FOR CRISIS MANAGEMENT

Cartography disposes of an extensive methodological background focused on the visualization of spatial phenomena of different nature. The visualization aspects can be found in a wide range of publications. The following can be used as examples as traditional cartographic approaches: Robinson (1995), Bertin (1973), Krygier and Wood (2005). New visualization types, e.g. 3D visualization (Herman and Reznik 2015 or Bandrova, Zlatanova, Konecny 2012), visualization of uncertainty (Kubicek, Sasinka, Stachon 2014) or contextual visualization (Stampach, Kubicek, Herman 2015) are becoming more and more common. Approaches to cartographic visualization in the field of crisis management can be found in Konecny et al. (2011), Friedmannova (2010), Stanek et al. (2010), Reznik, Horakova, Szturc (2013 and 2015) and other publications. The description of symbol set proposal can be found in Burian, Brychtova and Vavra (2015a), practical use of designed symbol set is in Burian et al. (2015b).

When designing the symbol set, it is necessary to use the existing standards from the field of safety and crisis management. This allows faster understanding, remembering and use of the created symbol set and its easier acceptance by users from different forces participating in crisis management. The design needs to take into account the national as well as international standards. The situations when the cooperation activities of task forces from different countries are less common, but they are usually of larger size and thus more demanding for the coordination of individual forces. Then it is in such cases when the joint symbol set becomes more and more important which allows at least partially simplify the complicated international coordination.

The key, already existing, document with a relation to the cartographic visualization in the field of crisis management is the standard for creation of military topographic symbols NATO APP-6A (NATO APP-6A 1999), representing one of the few existing standards focusing on cartographic visualization, mapping symbols standard – American National Standards Institute - ANSI INCITS 415-2006 (MacEachren et al. 2010) and its further optimization. The Police of the Czech Republic have available a catalogue of objects of the Basic police map, version 1.0., which is however primarily focused on basic topographic data and fails to include thematic extension of symbols for crisis management. The mentioned standards are described in more detail below.

1) APP-6A Military symbols for land based systems – "This standard provides common operational symbology along with details on its display and plotting to ensure the compatibility, and to the greatest extent possible, the interoperability of NATO Land Component Command, Control, Communications, Computer, and Intelligence (C4I) systems, development, operations, and training … The standard applies to both automated and hand-drawn graphic displays." (NATO APP-6A 1999, 1).

2) ANSI INCITS 415-2006 - Federal Geographic Data Committee (hereinafter referred to as FGDC), Homeland Security Group have published and further developed a set of mapping symbols intended for geographic support of forces involved in crisis management as well as for informing public in cases of emergency situations (Homeland Security Working Group 2012). The unambiguous advantage of this set is the fact that it has been implemented and its version for use in geographic information systems is available. On the other hand, the analysis of the symbol set shows that its content and cartographic visualization reflect different cultural environment of North America, i.e. USA and Canada.

3) Basic police map version 1.0 (hereinafter referred to as BPM 2014) is the first attempt to standardise cartographic visualization to support activities of the Police of the Czech Republic. The catalogue of BPM objects and its overall conception is still under development and technological implementation.

Regarding the use of American FGDC in the Czech Republic, the set seems unsuitable since there are considerable differences in approaches and perception of cartographic visualization in different cultural environment, cf. Stachon et al. 2015b. BPM is of Czech origin, but it is still under development and primarily focused on the production of general materials. Therefore, the conclusions based on the standard NATO APP-6A were mainly taken into consideration for the preparation of the methodology.

BASIC PRINCIPLES OF DESIGNING SYMBOL SET FOR CRISIS MANAGEMENT

The performed analysis of the existing approaches to cartographic visualization shows that the currently applied approaches to cartographic visualization of geographic support for the needs of crisis management and related fields are extremely varied. Based on the available documents, generally applicable recommendations were designed which were focused on thematic contents of maps and applied on selected pilot map projects. However, it is not a complete overview of all objects and phenomena which may occur, but rather an illustration of the application of the designed basic principles of cartographic visualization. The majority of examples are illustrated in the selected case study produced for the needs of eth Police of the Czech Republic. The stress on the thematic extension and particularly on point symbols was put on the basis of using the basic police map as topographic material in colour and black and white (grey and white) version for the selected case study.

In order to reach the given result, several principles which allow more effective use of the designed visualization were used:

- Principle of significance – spatial objects significant for a given situation are visualized more distinctly than objects providing secondary information.
- Principle of composition – assumes that the properties of a displayed object or phenomenon are reflected differently in its cartographic visualization design. The advantage of this approach is potential elimination of the necessity to study and remember extensive map legend.
- Principle of intensity – higher intensity of the same phenomenon is displayed more distinctly, e.g. number of inhabitants of the endangered areas.
- Principle of dynamics – the majority of phenomena in the real world are not static, their states change, which can be particularly taken into consideration for electronic maps, e.g. in the form of vehicle location record monitored with the use of GNSS (Global Navigation Satellite System).

Visualization design of tactical elements

The shape, as the most effective graphic variable, was primarily used in order to distinguish tactical elements. Apart from the obvious distinction of geometric shapes, the basic advantage of shape is its relatively easy integration in a paper map as well as independence on the colour form of the map. The information carried by shape stays independent even in case of black and white print (Fig. 1).

Fig. 1. Example of types of objects and phenomena with the use of shape based on analysis of symbol sets. Adapted from: Stachon et al. (2015a, 29).

In order to distinguish from task forces, more distinct colour combinations were used. The designed colour representation of task forces of the Police of the Czech Republic (PCR), Armed Forces of the Czech Republic, Fire and Rescue Service of the Czech Republic, Emergency Medical Service, Unit for protection of nuclear power plant are shown in Fig. 2. The selected colour scheme was optimized so that the usability was guaranteed on different topographic materials, e.g. on a topographic map (e.g. BPM), together with the use of ortophoto, which is heavily coloured.

	C	M	Y	K	R	G	B
Police of the Czech Republic	72	20	0	0	71	204	255
Armed Forces of the Czech Republic	60	0	80	0	102	255	51
Fire and Rescue Service of the Czech Republic	0	90	65	0	255	26	89
Emergency Medical Service	0	0	0	0	255	255	255
Unit for protection of nuclear power plant	0	20	100	0	255	204	0
Other	0	0	0	40	153	153	153

Fig. 2. Designed colour scheme to distinguish task forces. Adapted from: Stachon et al. (2015a, 27).

In order to use the technological platform Intergraph Planning and Response (IPR 2016), the selected graphic format for designing mapping symbols was the standardised vector format for web environment SVG (Scalable Vector Graphics). The size of symbols was tested on a square shape with the edge of 10 pixels (hereinafter referred to as px), 16px, 24px, 32px, 36px, 40px and 48px. The selection took into account the fact that the outline shape would contain another symbol. A square with the edge of 48px was selected as the most suitable. The mentioned size reacts further to the specific scale of the cartographic visualization.

The use of the principle of composition assumes that the properties of a displayed object or phenomenon are reflected differently in its cartographic visualization design. It was used in practice in the design through the combination of the map symbol colour (marks the affiliation of symbol to IRS force) and shape (marks the type of symbol). The green colour in Figure 3 below stands for the Armed Forces of the Czech Republic, the diamond stands for unit or vehicle. The result is the information that a green diamond stands for vehicle or unit of Armed Forces of the Czech Republic. The principle of the composition of colour and shape can be extended through an infill symbol, textual description, or other graphic variables.

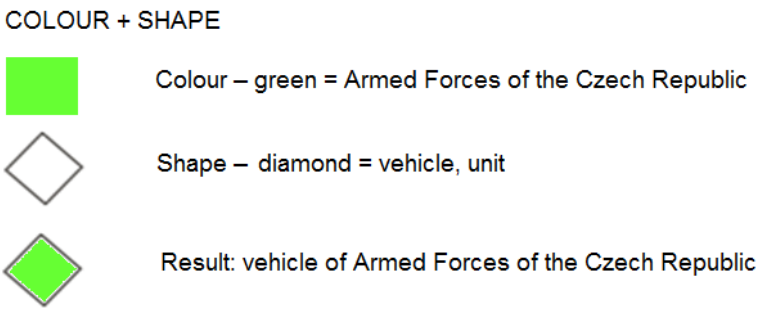

Fig. 3. Design to distinguish between basic objects and phenomena based on shape and content. Adapted from: Stachon et al. (2015a, 30).

FIELD EXERCISE ZÓNA 2015 – INTRODUCTION OF SYMBOL SET IN PILOT PROJECT

The system supporting selected forces of PCR within the inter-resort exercise ZÓNA 2015, held in the autumn of 2015, was introduced in order to verify system functionalities and effectiveness of the symbol set. The main goal of the exercise was training of activities and check of the processes of central administration bodies, regional bodies, integrated emergency system forces, including PCR and other entities involved in External emergency plan of Temelín nuclear power plant (JETE), in order to deal with an emergency situation related to a simulated accident in JETE. Furthermore, just the part of geographic support is considered.

Mapping projects

Mapping projects (contextual cartographic visualizations in the sense of Konecny et al. 2011), which took into consideration the activities of PCR within ZÓNA 2015 exercise, were produced as a preparation for the exercise with the use of the designed symbol set. The input data with displayed source, type and visualization functionality (operator vs. direct visualization of terrain data when the data were transferred by mobile devices) and the final output integrated in the IPR system, including the designed symbols, were identified for each individual project.

An example of the realized mapping project is a mapping project of an emergency situation – discovery of an aerial bomb in the zone of emergency planning. In contrast to pre-prepared and planned projects, one of the data sources was the emergency line 158, which is in responsibility of PCR and runs independently on the crisis situation in progress. In the course of the exercise and on-going evacuation, the emergency line received information on a discovery of an unexploded aerial bomb, which required a police bomb disposal expert. The information on the discovery was provided by IPR to all forces of IRS and in the real time the movement of individual IRS forces was visualized, protection zones were marked, and the bomb eventually disposed. The provided information included mapping materials of the current situation as well as multimedia documentation of the discovery site and the PCR intervention. The bomb discovery site was located near the temporary accommodation and the local crisis headquarters in Tabor and had an immediate impact on the course of the exercise. The mentioned mapping project was directly integrated in the real situation and provided access for IRS forces to the situation and course of events registered by emergency line 158 (Fig. 4).

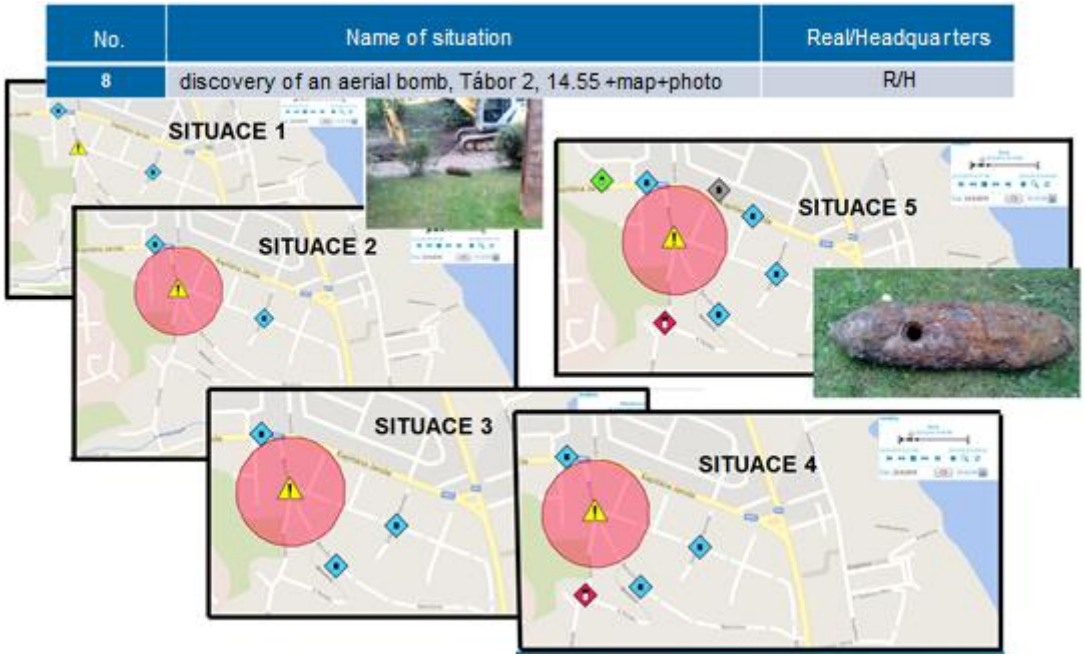

Fig. 4. Example of visualization of aerial bomb and sequence of events of IRS intervention. Translation: "Situace" is Czech word for "Situation".

FINAL SUMMARY

The main aim of the produced methodology (Stachon et al. 2015a) is to provide principles of designing a symbol set for mapping outcomes in compliance with the current practice of bodies and methods of crisis management and theory principles of map designing used in the Czech Republic and in Europe. The whole document was primarily produced for the needs of geographic support of activities of the Police of the Czech Republic. The methodology included

recommendations regarding the structure of the symbol set, scale range, and the standardised description of individual symbols usable in analogue as well as electronic environment. The designed principles are documented by a final presentation of a use of the symbol set in selected emergency situations.

A partial aim of the methodology is to simplify further designing of planned and ad-hoc symbols for geographic support of activities within crisis management and create a basis to unify procedures of their design. The methodology is conceived and produced on a conceptual level, i.e. as a general manual to design the mentioned symbol set, which is platform-independent and which can be used in electronic as well as in analogue environment.

Based on the experience gained during the exercise ZÓNA 2015, the following recommendations were designed:

- Preparation of cartographic materials into the form of mapping projects – the use of specific mapping projects in practice proved effective and it is recommended to be use further in combination with selected geoinformation tools (particularly spatial and attribute surveys).
- Comprehensibility and simple nature of symbol set – the conceptual design of the symbol set can be further developed in several ways. One of them includes the extension of the symbol set in other thematic fields of crisis management, where the joint use of the symbols across IRS, e.g. critical infrastructure visualization, is expected. The development and specification of the symbol set may also take into account the specific features of individual types of electronic devices (desktop, web and mobile applications) and printed outcomes, where a certain role is played by the used colour models and specific requirements for the format and behaviour of symbols.

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